

P³ System- A robust inventory model for life saving medicines: A comparison with established inventory management system

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Abstract: This paper demonstrates the edge of P³ system over other established systems currently in operations specifically in case of essential life saving medicines. Several established systems such as VMI*, JIT*, and CPFR* have their own norms to operate from purchase of raw material, production to linking up buyers operations clubbed with inventory management. This paper discusses how P³ system provides a better platform specifically in the case of essential life saving medicines, especially in third world countries where the business entities, not equipped with on-line integration, causing 'out of stock' situations, a non-affordable and lethal for future operations, are most likely.

Vision: This write-up target at to strengthen profile of P³ system by performance optimization on the following important issues.

- (1) To enforce a fully secured of 'not on current stock - about to receive very soon- already on the way' situation for customers on emergency requirement
- (2) four- tier safety system by introducing a novel concept of 'Residual Stock'.
- (3) Achieving proficiency in production and soundness in service only by increasing customers level of satisfaction and continued support.
- (4) Planning to progress through innovation..

(1) Abbreviations*, Notations, and Key words:

(A) Abbreviations:

- (1) P³- Production, Planning and Procurement
(A total inventory management system close to Perfection)
- (2) VMI- Vendor Managed Inventory
- (3) CPFR- Collaborative Planning, Forecasting and Replenishment
- (4) ECR- Efficient Customers Response
- (5) JIT- Just In Time

(B) Notations:

Some of the mostly used notations used in the discussion and mathematical model are given below.

- C₁: Cost Price per unit amount of raw material
R₁: Raw material required for one unit production
S: Sale Price/Unit ($S = S_1 + \alpha S_1$; clarified in point (5))
F₁: Fixed cost of Production
F₂: Fixed cost of dispatch
h₁: Holding cost per unit per unit time
Q: Sum Total of Normalized Demand of all buyers
D: Harmonic Average of mean demands of all buyers
r₁: Fraction of % discount on Safety stock
K₁: Safety Index
K₂: Emergency Index
K₃: Lightning Index
K₄: Residual Index

(C) Key Words:

Safety Stock, Emergency Stock, Lightning Stock, Residual stock, P³ System, Gap analysis

(2) Assumptions:

- (A) Distributors and buyers can freely exchange information on markets trends, status of the present stock, future projections, and financial matter related to their business with the vendor
- (B) Maintenance and replenishment of reasonable stock level at buyers and distributors end is an innate in the set of responsibilities as a result of implications of P³ system..
- (C) Residual stock, its maintenance and timely supply, whenever asked for, to the buyers so as 'out of Stock' status shall be improbable.
- (D) As a virtue of its principles and accordingly formatted design, **P³ system** has interwoven fundamentals of sound and proof inventory system and inherits the major of ideals supporting the wide acceptance of VMI, CPFR, Consignment model system, JIT (for buyers and task force engaged in production line) and all attempt to achieve and maintain Efficient Customers Response.
- (E) Existing customers do not leave the system before completion of a cycle and as a policy matter of the company, to establish and enhance business, new buyers likely to join are responded and attended within a short period provisionally accepting implementation and operations of P³ system.
- (F) Except the aftermath of erratic events, demands remain within the close range of average annual demand of all buyers.
(One standard deviation on either side of the grand average sale of all the buyers)

(3) Introduction:

- (a) P³ system^{4,5,6} has evolved and refined to provide seamless supply chain through concepts like
 - (1) Safety Stock
 - (2) Emergency Stock
 - (3) Lightning Stock
 - (4) Residual Stock
- (b) The P³ system provides a multi-tier stock management at vendor's level, distributor (intermediate) level and point of sale (buyer) level in order to totally avoid "out-of-stock" situation in cases for the buyers dealing with essential life saving medicines.
- (c) The P³ system provides integration of the inventory management with the Production, planning and raw material procurement departments at the vendors end.
 - (d) Upon implementing P³ system in real life situations, reports and feed-back results obtained from interim survey from different public strata to study ECR(Effective Customers Response) distinctly identified felt need of including additional buyers either at the beginning of a new cycles or in the middle stage of a current cycle with an objective to reach end-users/ customers in a proficient way. Therefore, there was a need to incorporate an additional level of stock called residual stock at vendor's end. Over and above the three types of the stocks -Safety stock, Emergency stock and Lightning stock- a new concept of "Residual stock" has been developed that takes care of this additional need of goods. Contents discussed in this paper evolves thorough discussion related to residual stock.
 - (e) Several established companies encompass the most common and probably partially effective systems like VMI and CPFR. The P³ system, we feel, must be thoroughly tested and if needed be modified to yield better and effective results on implementation. This compels comparison of both the systems in cases of performances under extreme demand condition and market trends. The content in this paper highlights such probable issues.

(4) Origin of residual stock:

Upon implementing P³ system in real life situations, some agencies, working on the fundamental issues of protecting customers' interest by timely replenishing their demand of specific medicines which have already given them better results in improving upon their health problems, insist to incorporate some additional buyers in between the current cycle in operation with the motive of expediting customer services.

It is quite obvious and feasible that this prevailing condition may not look immediately feasible for implementation but P³ system has already dreamt of such probable consequences and has already provisioned to dispatch an initial lot of medicines as per reasonable demand. falling under normal limits.

Again it is likely that there may be some more buyers following the first one newly included but such requests can be granted to some fewer cases only. This supports company's policy of 'Mid-way inclusion' of new buyers.

The first decision may look hasty, untimely, and immature as the company has targeted at only the customer services and no other factors like buyer's establishment, long term business experience, and the most important but not the last is his intension to accept and abide by structural principles of P³ system.

All formalities one can meet at a later stage but the prime focus of supply of life-saving medicines on immediate basis must not be declined—this is what P³ system is designed for. In addition to the planned supply to the existing buyers and partial supply to the new buyers the company preserves stock of the items that may prove of immense importance for future purpose and other technical issues of government authorities deployed for maintenance of international standards for quality and composition of the medicine. All these factors thought on one line has forced to make an additional production for generating extra stock over and above to well defined safety stock, emergency stock, and lightening stock and we call it a '**Residual Stock**'.

Modern business models expect that vendor supply "Total quantity in one transaction" for all supplies ordered by buyer and also to commit that there are no incidences of shortage of essential life saving medicines under any conditions. The vendor has to consider various aspects such as cost, quality, planning of seamless supply chain, and lead time management.

The order size is a function of actual demand and some safety factors as the buyers have considered through his own experience but the P³ system, shouldering the responsibility with a label of 'maintenance of quality supply with no shortage' plans the total set-up of supply in its own way. Experienced designers of P³ system, considering factors like past records, market trend, probable order size of recent orders, number of buyers on current list, and entry of some new buyers, plan purchase of raw material with probable lead time, production time, packing and transit time etc.

As a policy matter of the P³ system, the first time buyers (new buyers) and those on the current lists will be treated at par, except that the new buyers will receive the goods through the local distributors appointed by the vendor. This policy is adopted in the trade which works as safe guard against new buyers' temperament like cancellation of order, postponement of order, change in order size or any technical issue that can arise at any point of time. In such cases, the vendor shares the responsibility of holding cost of additional supply that was sent to the distributor in anticipation. In some cases the vendor, on entry of new buyers placing order of sizable quantity, may raise claim for advance payment which may be squared off and converted to the payment scheme that buyers on the current scheme enjoy.

Furthermore, there are sound reasons justifying production and preservation of residual stock at vendor's end; some are

(A) It likely that data analyst have not confirmed about the purchase plan as they are not equipped with total information pertaining to market trends and sales records of some of the new buyers.

(B) Market trends are being studied and likely to change drastically in anticipation of aftermath of some change in government policy for life-saving medicines. It may cause the purchase price to shoot up or lower down within a couple of days.

(C) There may be an unexpected delay in the execution of the next production run liable to crash the system temporarily.

(D) Unexpected delay in transit period which may be out of control by the vendor.

(E) Small change and fluctuation in machine set-up, seasonal variants affecting the lot size production, human intervention and some other reasons may be liable to postponement of production or rejection of partly or fully the production lot.

(F) Unexpected lead time or extended lead time for procurement of raw material is a lethal factor which may paralyze the system. There are situations when the raw material supplier has to undergo some Corrective and Preventive Actions (CAPA) due to some audit incidences. Moreover each incoming lot is to be tested and incidences of 'Out of specifications' cases (OOS) are not new in pharmaceuticals. Thus the lead time of raw materials is often erratic.

Looking to the accountability of the company in the quality production, it is highly justifiable to produce and preserve a lot- Residual stock. On the top it is a lot which either may be forwarded to the new buyers or

to the existing buyers on special request or may be used as a part of new lot production. Under the latter case, it is going to save much on purchase plan of raw material or on utilization of that stock, new production lot will spare some of its total production which may be a residual stock for the next cycle. Thus the residual stock causes a little to storage but yield more return in terms of assurance against 'No shortage' plan.

(5) Why Buyers Tend to Adopt P³ System?:

The earlier papers on P³ system did not focus much in this aspect but as the set-up of P³ was implemented in the current market, attracting sound and responsible buyers, it received higher acceptability resulting in to floating many enquiries to join the system. Buyers' perspectives were multi-folded. The buyers in the system shared rights to

- (A) Free from planning and calculation of forecasting demands
- (B) Not to make immediate payments
- (C) All the registered buyers rightfully gets a pre-fixed discount on the cost of safety stock received along with the first lot size.
- (D) Buyers enjoy the facility to make payment during any time period from the receipt of the first lot but before they put requests for the emergency stock.
- (E) Buyers are not required pay holding charges for the emergency stock held by the vendor appointed distributor.
- (F) Buyers were totally free from any worry of 'out of stock' status.
Keeping in view of the rising flow, we planned to spare some more time, efforts to make radical changes and update the existing system by introducing the concept of 'Residual Stock'.

The residual stock is a part of total production lot which is held at the vendor's end and efficiently serves as a safeguard against the additional lead time in procurement of raw materials, satisfies new buyers by providing them total or a part of the first order size, and many more factors discussed in the above paragraph..

(6) P³system-A chain:

In connection with the previous papers on P³ system, we add , in brief, some basic operational procedures of the new updates. We begin with

- (1) Based on data and coded information on market survey and business forecast, analyst decide production lot from the immediate run and accordingly direct production department and purchase department for procurement of raw material. During this incubation period, management of the residual stock, if any, left over and above lot size required for retention and preservation purpose, is managed either by sending to the distributor or production lot size will be adjusted accordingly.
- (2) Buyers' expected demand along with past sales record is duly considered and an amount of the size of normalized demand plus safety stock to be sent to each buyer is calculated. Each buyer on the current list is informed about the lot size receivable in a short period. The distributor is also informed about the buyers' receivables. Packing and forwarding department at company's end and logistic unit responsible for multi-folded operations is informed so that it can plan its schedule of transshipment.
- (3) During this critical period a close watch on the sales record of each buyer is kept in order to study the sales rate which enables the vendor decide the time schedule of dispatch of emergency stock and also plan attend new entrants' requests . In parallel to this, lightening stock is kept ready to trigger off on or before either the buyer or the distributor is likely to send request for. The reason being that the distributor gets a lot over and above the total emergency stock size is that the first transaction, as per the joining terms and mutual agreement duly signed previously, interrupting an on-going cycle be made to the new buyer be only en-routed through the distributor.
- (4) Immediately to these set of activities what follows is a crucial job of managing residual stock. Future trends, price fluctuations and availability of raw material, lead time, buyers' present stock conditions, constructive suggestions from buyers' side, and reports from liaisoning agencies studying ECR are the major factors to take decisions related to handling residual stock. Either some buyers receive if they are, before arrival of the new lot of the next cycle, about to meet ' stock-out' condition and then surviving units left with the vendor become part of the new production lot just about to arrive. This completes one cycle on or before the new lot is on its way to the buyers on the new list.

(7) Gap Analysis, comparison, and suggestions:

Designers of any inventory management system do communicate decisions made by higher authorities that concern either directly or indirectly to Production and planning units, designers of marketing strategies, buyers' interaction, and customers (End users') response. The common goal of every planning and designing unit is to enhance profit on increasing sale by retaining quality of product, sustain efficient buyers by offering sales promotion schemes and finally watch for ' no shortage' complaints from the market. All of these factors are associated with market trend and future demand pattern. Any system will fade its colors if these factors are not partly within control limits.

VMI and CPFR strategies have also been applied to the inventory management and production planning in pharmaceutical industry as has been in other industries.

Glaxo Smithkline implemented VMI for its international operations covering several of its plants in Europe with its European supply chain network⁷

A statistical study based on figures and reports published on experiences of Glaxo and other similar corporations a few but significant gaps are observed on implementation of VMI and CPFR policies in pharmaceutical industry.⁷ some of them are as follows.

(a) Too Laborious:

* "In contrast to traditional VMI, in which the information exchange is dyadic and vertical, if VMI is to be used to optimize the whole supply network, it must be based on the exchange of information between several members of the supply network, using both vertical and horizontal forms of communication"⁷

"The success of a VMI system when extended to the supply network depends on the adoption of a central information system that allows suppliers/manufacturing plants to determine the quantities and scheduling of deliveries, taking account of all the necessary information concerning different supply network members, and supporting the production planning and order cycle processes in the upstream and downstream supply network"⁷

P³ system does not require a lot of integration on real time basis. The integration of the system is just based on simple information sent by the buyer that the safety stock use has been initiated. This serves as stimulus to mobilize the emergency stock, and then if required the lightening stock. Laborious real time integration and exchange information is not required in the P³ system. P³ system is, therefore, better in case of handling small and medium buyers that are aplenty in form of retailers, infirmaries, and small or mid-size hospitals that use life saving medicines. This relates more to the third world countries where all the prevailing facilities have not been a part of operating system on vendors or buyers side. They still use obsolete system and hence cannot remain or maintain on-line contacts.

(b) Limited Options:

"A vendor-managed inventory system can be bad for a business when it keeps the business from seeking better-suited or lower-cost options. Because VMI links the supply chain together so closely, it serves as a disincentive to make a change that necessitates changing the company's inventory management system. As a result, a business may find its inventory savings negated by settling for higher-priced or inferior goods"⁸

Since the P³ system doesn't require an intricate integration and closed system, the buyer has an ease of moving out the vendor and easily move to an alternative vendor. Thus P³ system is more customer-friendly. To add to this feature, P³ system has provisioned for supporting new or first time buyers that have on comparative study and market experience have initiated from their end,

P³ system equipped with "Residual Stock' has enough capacity to support fully or partly demand of new entrants and thus broadening its customer base by treating them proficiently.

Residual stock reserved and well maintained till the end of the first cycle is either diverted to

- (1) Buyers on current list (The topmost priority)
- (2) Distributors on the list (In case, if they have committed to some new buyers or the vendor has some behests.)
- (3) Permeable Stock—(Referential Stock) -A stock to be maintained and preserved for inspection purpose that can be enforced by competent authorities at any time and which stands as a proof of a production run during a given time interval.
- (4) All above these, if surplus, is diverted to as a part of new production lot and immediately forwarded to the distributor.

(c) Vendors that cannot deliver on time:

"When a business relies on vendor-managed inventory, it's placing a big bet on that company's ability to deliver. The vendor has to be able to determine when to send new stock, what specific products to send and in what quantities. This can be beyond the means of a supplier that doesn't have the software, infrastructure or expertise

in place to make that work. If just-in-time inventory turns into way-too-late shipments thanks to poor demand forecasts or a supply-chain breakdown, VMI isn't going to work.”⁹

Vendor plays a pivotal role in VMI as well as CPFR. A vendors dealing in production of life saving medicines has several challenges as against other commodities. Quality control and Quality assurance are of very high importance in medicines. Supplies may be delayed due to a small deviation or delay in any stage of manufacturing, in-process analysis, unplanned deviation, finished product analysis and review. The same delay can happen in the inputs of the raw materials. Delay in delivery is therefore quite a possibility when dealing in life saving medicines. The VMI/ CPFR etc may collapse when the vendor fails to deliver in time.

→ P³ system is unique in this aspect. It provides a multi-tier cushion, in terms of safety stock, emergency stock, lightening stock and residual stock. All these leverages the vendor to continue maintaining a seamless supply chain despite the possible delay in manufacture, testing or supply. This perhaps is the best advantage of P³ over VMI and CPFR, specifically in life saving medicines.

(d) Integration issues:

“Despite the aforementioned promises, CPFR is not without its obstacles. These obstacles may include: cultural and technical incompatibility among supply chain partners, lack of trust among supply chain partners, lack of scalability, lack of internal alignment, inadequate software and technology support, substantial start-up investment for building a communication infrastructure, antitrust laws, legacy systems, and difficulty in real-time coordination of information exchange (E.g. .,Mentzer et al., 2000; Barratt and Oliveira, 2001; McCarthy and Golicic, 2002; Seifert, 2003)”¹⁰

→ P³ system does not require a lot of integration and therefore suitable for small and medium scale companies, retailers and hospitals who have limited options on software and scalability.

(8) Conclusion:

The comparison of the P³ system alongside the other established systems like VMI and CPFR shows that the P³ system has distinct advantages in maintaining a seamless supply chain of essential life saving medicines. This model can therefore be of profound use to companies operating specifically in life saving medicines in third world, with a lot of small and medium retailers and hospitals. P³ models emulates the principles of established systems like VMI, CPFR etc but modifies them for specific use in products in which “out of stock” situations cannot be allowed, by providing a multi-tier supply chain system.

The introduction of a residual stock into the P³ system makes the system more robust to take care of meeting additional needs for new buyer introduction. This need was identified by some users of the system. This concept adds another level of cushion in the P³ system.

(9) Practical illustration:

We have past sales records and in connection with calculation and results derived from the previous papers on P³ system; here we perform calculations to find residual stock and carry out comparison of cycle time taken in application of both system.

We consider a factor, k_4 directly as a function of three factors safety index(= k_1), Emergency index (= k_2), and lightening index(= k_3) . Necessary formulae to calculate the factors k_1 , k_2 , and k_3 are as follows.

$$K_1 = \frac{\sum_{i=1}^{i=N} |q_i - q_{ib}|}{\sum_{i=1}^{i=N} q_{ib}} = \text{Safety Index}$$

$$K_2 = \frac{\sum_{i=1}^{i=N} |a_i - D|}{\sum_{i=1}^{i=N} a_i} = \text{Emergency Index}$$

$$K_3 = (K_1 + K_2) / 2 = \text{Lightening Index}$$

$$\text{and } D = \frac{N}{\sum_{i=1}^{i=N} (1/a_i)} = \text{Harmonic Mean}$$

As mentioned earlier, we take residual index $k_4 = (k_1 + k_2 + K_3)/3$

This helps find residual stock units to be produced as a fraction of total production

Sales Record of Last Six Months							H.M=D
	Buyer1	Buyer2	Buyer3	Buyer4	Buyer5	Total	
Month1	210	180	270	200	180		
Month2	220	190	260	200	170		
Month3	190	200	270	190	200		
Month4	250	200	280	200	200		
Month5	200	220	300	210	210		
Month6	230	190	250	210	200		
Sum Dem	1300	1180	1630	1210	1160	6480	
Ind. Ave.	217	197	272	202	193	1080	213
Deviation	4.01	15.99	59.01	10.99	19.32	109.32	
Demand	210	210	250	200	180	1050	
Nor. Dem	206	227	196	211	198	1038	
Abs Diff	3.89	17.07	54.30	10.90	17.99	104.15	
K1 = safety Index						0.0992	
K2 = Emergency Index						0.1012	
K3 = Lightening Index						0.1002	
K4 = Residual Index						0.1002	
K1qj	20.44	22.52	19.41	20.92	19.64	103	
K2 qj	20.86	22.99	19.81	21.35	20.04	105	
K3.qj	20.65	22.75	19.61	21.13	19.84	104	
Total Production in a given month =						1350	
Residual stock as a fraction of total production = K ₄ x Total Production						**135	
Supplied	268	295	255	274	258	1350	

**Comment:

Residual stock as mentioned earlier stands for different purposes and if in any case remains unutilized becomes a part of the next production and it is diverted on immediate basis either to the distributor or to the buyer.

Comparison by Parallel Operations:

Now, our next important task is to check whether implementation of P³ system establish its dominance over regular system and its operations. We consider the first buyer having the maximum sale of 1300 units in a six month period.

As per the record shown above;

Part1: Analysis and Conclusion in context to P³ system.

(1) Normalized Demand = 207 units against actual lot size 210 units.

[P³ is committed for economical operations on either side.]

(2) Safety Stock = 21 units

[Buyer receives 207 + 21 = 228 units in the first lot directly supplied by the vendor. As per the contract buyer gets stipulated discount on the invoice value of the safety stock and is allowed to make payment on or before the total lot , in this case 228, is about to finish.]

(3) Expected average sale per month = 212 units.(Approximately 7 units per day)

(4) Analysis:

Units left	units received	Stock – days	Total Units received
228—212 = 16	---	16/7 ≈ 2 days	207 + 21 = 228
-----	21 (Emergency Stock)	21/3 = 3 days	= 21
-----	21 (Lightning Stock)	21/3 = 3 days	= 21
Total = 16	42	= 7 days	= 270 units.

(5) Total Expected Annual Demand = 212 x 12 = 2544 units.

One Cycle supplies 270 units.

Vendor has 2544 / 270 ≈ 9.42 runs on maximum side. Hence there is a saving of 12-9.42 = 2.58 cycles per annum This helps derive claim of probable dominance of P³ system over competing others.

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