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A study of components of P^3 system-forecasting for business decisions

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Abstract
This epitomic work in this paper targets at identifying different methods to forecast (1) demand and (2) sale pattern; both of these are random variables. It is known that there are three important components of P^3 systems Viz. (1) Planning, (2) Production, and (3) Procurement; these are inter-related and non-separable constituents of the said system. There is one external factor- Demand, which is a gross of many parameters- some of them are known and some have remained unknown, which forces it to be a random variable. Our effort, using different statistical tools, focuses on forecasting 'demand' in some next cycles which in turn, possibly, prove a criterion for production phase and also procurement phase also. The content of this paper, on comparing different criteria of forecasting using 'U' test justifies our approach.

Keywords: P3 system, Forecasting, Operations, Supply Chain,Mann- Whitney U test, Production, Planning

1. Introduction
We have already studied perfectly designed P^3 System and justified sound results of the different companies who have in practice adopted the system as a whole. It is justifiably claimed that the system takes care of the total operation cycles right from procurement stage to all intermediate steps till the procurement phase of the successive cycles.
As studied and implemented by various agencies and corporations, we truly believe that P^3 system is a systematically designed set up running through entire supply chain right from procurement to far end when the products reaches the customers. In our case, the production being afflicted to life-saving drugs, each phase has to be sound in its performance. There are, till now not revealed as they were parts of core policy matter of the designers of the P^3 system, stringent norms and check-up criterions which on thorough verification will allow pass from one phase to the next one.

2. About demand and sale Pattern
Demand and actual sales both of these patterns have remained prime focus to any manufacturing unit. These are random variables and in the most cases they have remained unpredictable entities. Production is directly proportional to demand and demand is closely or primarily dependent on current sales amount and some additional factors like brand name, advertisement, marketing strategies, consumers' long term satisfaction and many more attributes. All these factors with variable proportion constitute a gross which we call demand. Though the above mentioned components mentioned above do never provide exhaustive list but stretches more towards it.

1. **The ideology of P^3 System and its realistic working pattern:** Customers or buyers to not find gaps between to what the ideals P^3 system are and the ways actual operations are carried out. In real life situations there is little gap in what have been underlying doctrines convey and how they are being implemented in the concerned group or the companies following the P^3 system. This helps the concerned parties to derive their own performance measure instead the executions of the company shades their decisions criteria in critical cases.

2. **Quality of the product:** It has always remained, being the Pharma products dealing with emergency medical treatment, company's policy that each unit that leaves the gateway must be perfect to its capacities and utmost to its performance to its capabilities.
   Most of the drugs are complemented with properly formulated with additional contents that can supplement and compensate the effect of some ingredients which have basic

nature of degradation and decelerate on timely effectiveness. This varies policy decision principally accepted by the management and implemented for each of its production batches has truly helped to develop the confidence and reliability of the customers. This is one of the secrets of developing brand name of the product. These are, in fact, some major reasons for achieving higher sales goal then what the actual demands estimated for the production.

In most of the cases, total sales figures arrived at have always remained higher than the lot demand estimated before running the production run the company has, in principles, adopted a policy of 20% additional units of production in accordance with the surplus amount of units left/unsold at its inventory. This additional production, in turn, compensate with the notion of despatching and maintaining safety stock, emergency stock, and lightening stock the last one that is directly in possession of the company.

3. Relative Impacts

As we have seen that demand and sale both are random variables which have a poor correlation but at the same time there are certain assignable causes for their upheavals. There are some of the causes we have identified which are to some extent responsible for sharp movements, either upwards or downwards, of demand and sale.

3.1 Sudden rise in the demand

There are certain qualifying factors responsible in steady or sharp but gradual rise in the demand. This may be accounted to many prevailing situations in the market.

(a) National Emergency: In the case of national emergency government authorities look for companies which can supply, maintaining standard specification and consistent quality, required amount within stipulated time slot.

(b) Export Inquiry: There have occurred some cases that some countries float tenders or in alignment with official government agencies approach the directors of the companies that manufacturing emergency medicines that they need, In such cases the concerned company has to either slowly restrict their current flow after fulfilling committed contract or if long term contracts are agreed upon then the governing body can plan enhancing its production capacities.

(c) Sudden Closure of some manufacturing unit: There are many reasons which may force operations and management of some companies to shut down or to switch over or to discontinue production of certain type of medicine which has remained till now a strong one in business competition. In such cases the consumers try to seek the best alternatives and such situation is liable to probably increase the demand of specific medicine.

3.2 Sudden fall in the demand

(a) Price Rise: This might be due to rise in the cost of API (Active Pharmaceutical Ingredients), Packing materials or some excipients. This may lead to rise in the price of finished product in the market.

(b) Market complaints: This may be due to quality of the product.

3.3 Sudden rise in sale

(a) Cyclic effect: Many ailments are cyclic in nature. For example, viral infection is seen to be active in the winters. Demand for anti-viral and anti-invectives see a surge in winters.

(b) High Demand: This may be due to shift of preference of prescribers or patients. For example recently there has been a higher demand for oral gliptins though they are expensive as compared to insulin injection in the treatment of diabetes. This shift in preference has led to high demand of oral gliptins in the market.

3.4 Sudden fall in sale

(a) Shortages: This may be due to shortage of some components which is highly essential or a key component for the production of a particular type of medicine which remains at a high demand level or some regulatory issues with vendor of some component. This adversely affects the availability of raw material in the market, resulting into shortage of the finished product. For example, a large manufacturer of Losartan was recently asked to stop production by US FDA, leading to shortage and sudden fall in the sale of Losartan based medicines used for cardiac treatment.

4. Line of Action

In this section we show phases of our line of action to possibly meet our objectives of this paper. These are as follows:

(a) We have selected, at random, a company which is pursuing P3 system and has organized planning for each component of P3 system.

(b) Primary records of cycles, including demand and actual sale has been taken into consideration. As we have mentioned earlier production amount is proportional to demand higher by about 20%. This is to meet with pre-designed supply and maintenance and supply of additional stocks to meet with shortages if any.

(c) From the record of demands of eight cycles shown in the record, we use Monte Carlo simulation to generate demand for next eight cycles to follow in sequence.

(d) In this part we use techniques of regression analysis for time cycles (1 to 8) as independent variable x and demand as dependent variable y and fit quadratic curve which gives better results on the demand records of first eight cycles. We use the quadratic equation for estimating demand () for the next eight cycles.

In this way, we have data for eight more cycles to likely occur in coming operations.

(e) Mann-Whitney U test

At this point of time we have two [(1) Obtained by Simulation technique and (2) by Regression analysis] records obtained as estimation of next eight cycles to follow.

As they are obtained from two different sources we, in order to test, whether there is a significant numerical difference between each pair of estimations corresponding to each one of eight cycles, we apply U test.

(f) The above steps through (b) up to (e) we execute on the actual sales figures of first eight cycles.

5. Statistical Applications

As said above we work systematically on the demand and sales figure of data of first eight cycles.

We draw corresponding graphs and interpret our views in comments.

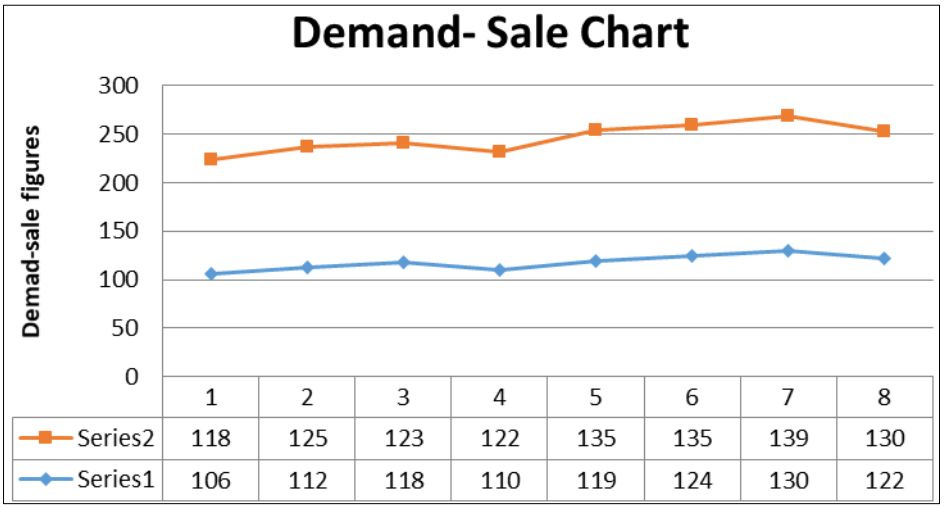
Table 1: Records of eight cycles

Cycle No.	Demand (Units)	Estimated Production*	Previous stock	Actual Production	Stock on Hand	Actual Sale (Units)	Surplus	Shortage
1	106	128	-------	128	128	118	10	--
2	112	135	10	125	135	125	10	--
3	118	142	10	132	142	123	19	
4	110	132	19	113	132	122	10	
5	119	144	10	134	144	135	9	---
6	124	149	9	140	149	135	14	--
7	130	156	14	142	156	139	17	--
8	122	147	17	130	147	130	17	----

Comments

- We have, at a particular production unit, maintained the records of demand and corresponding production. As we have adopted P^3 system shortages are occasional and that too have narrow gap. Just to be on probabilistic format it is one in eight (1/8 = 0.125) which implies slim chances of its reoccurrence if proper attention is paid to justified analysis.

*Production units = 120% of the demand $\mp$ previous Stock



Graph 1: Quadratic Correlation between Demand units (x) and Sale units (y)

Comments

- Both 'demand' and 'sale' are non- correlated variables as it can be seen from the graph.
- Correlation co-efficient between these two variables, say x and y

I.e. correlation co efficient γ= 0.113241

- This suggests very low correlation and it shows their independence. [γ = Correlation Coefficient close to $\pm$ 1 shows perfect correlation in either direction or 'γ' value closer to '0' shows no such relation]

5.1 Simulation and Estimation

In this section we apply Monte- Carlo Simulation and derive simulated demand figures and sale figures for the next eight cycles.

Fitting a regression curve (line, quadratic, cubic, etc…) is one of the most reliable and scientific method. At this point of time we use quadratic curve fitting to explore estimated demand and sale for the next eight cycles.

(a) Simulation of demand

Monte- Carlo Simulation was conducted using the random number fitting model.

The random numbers are taken as follows

(1) 0.7836 (2) 0.5550 (3) 0.9197 (4) 0.3294 (5) 0.2345 (6) 0.4597 (7) 0.8960 (8) 0.3267

The corresponding eight values of demands have been shown in the internal brackets of demand and their frequencies have been noted.

Table 2: Simulated Demand

Cycle No.	Original Demand (Units)	Cycle No.	Simulated Demand	
			Average Demand (Units)	Maximum Demand (Units)
1	106	9	120	124
2	112	10	120	124
3	118	11	130	134
4	110	12	110	114
5	119	13	110	114
6	124	14	120	124
7	130	15	130	134
8	122	16	110	114

(b) Estimation of demand using Regression

At this point of time we use quadratic curve fitting to explore estimated demand for the next eight cycles.

The equation of the curve that suits most close to a given data and which can be extended for the remaining eight cycles is as follows.

$Y = -0.196\ x^2 + 4.4494\ x + 102.494$

We put x= time cycle= 9, 10,…, 16 and obtain y= demand, which is shown in the next table.

Table 3: Regression of demand

Cycle No.	Original Demand (Units)	Cycle No.	Regression Demand (Units)
1	106	9	122
2	112	10	128
3	118	11	128
4	110	12	128
5	119	13	128
6	124	14	127
7	130	15	126
8	122	16	124

(c) Simulation of sale

Monte- Carlo Simulation was conducted using the random number fitting model.

The random numbers are taken as follows

(1) 0.4846 (2) 0.6564 (3) 0.8712 (4) 0.4320 (5) 0.8894 (6) 0.9239 (7) 0.2867 (8) 0.7521

The corresponding eight values of sales have been shown in the internal brackets of sales and their frequencies have been noted.

Table 4: Simulated Sale

Cycle No.	Original (units) Sale	Cycle No.	Simulated Sale (Units)	
			Average Sale (Units)	Maximum Sale (Units)
1	118	9	122	126
2	125	10	132	136
3	123	11	132	136
4	122	12	122	126
5	135	13	142	146
6	135	14	142	146
7	139	15	122	126
8	130	16	132	136

(d) Estimation of sale using Regression

Fitting a regression curve (line, quadratic, cubic, etc…) is one of the most reliable ad scientific method. At this point of time we use quadratic curve fitting to explore estimated sales for the next eight cycles.

The equation of the curve that suits most close to a given data and which can be extended for the remaining eight cycles is as follows.

$Y= -0.351 x^2 + 5.55 x +112.232$

We put x= time cycle= 9, 10,…, 16 and obtain y= sale, which is shown in the next table.

Table 5: Regression of Sale

Cycle No.	Original Sale	Cycle No.	Regression Sale (Units)
1	118	9	134
2	125	10	133
3	123	11	131
4	122	12	128
5	135	13	125
6	135	14	121
7	139	15	117
8	130	16	111

5.2 Applying Mann-Whitney U test

(e) Demand

At this stage we are equipped with eight values of demand forecasts:

1) Demand values using Simulation
2) Demand values using Regression

These are tabulated in the next table.

Table 6: Demand forecasts

x	Simulated Values (Units)	Regression Values (Units)
9	124	122
10	124	128
11	134	128
12	114	128
13	114	128
14	124	127
15	134	126
16	114	124

H_0: That there is no significant difference between the statistical estimations of demand figures obtained by simulation process and Regression process.

H_1: There is a difference.

α: 0.05- Level of Significance (Maximum value of making Type-I error)

Results of test statistics:

- Mean of Simulated demand: 122.75
- Mean of Regression demand: 126.375
- $n_1= 8$ & $n_2= 8$
- S.D. of Simulated demand: 8.345
- S.D. of Simulated demand: 2.269
- Z= -1.188

Conclusion: That there is no significant difference between the statistical estimations of demand figures obtained by simulation process and Regression process and Z value obtained from two tailed test falls in A.R. [-1.96, 1.96] so H_0 is accepted.

(f) Sale

At this stage we are equipped with eight values of sale forecasts:

1) Sale values using Simulation
2) Sale values using Regression

These are tabulated in the next table.

Table 7: Sale forecasts

X	Simulated Values	Regression Values
9	126	134
10	136	133
11	136	131
12	126	128
13	146	125
14	146	121
15	126	117
16	136	111

H_0: That there is no significant difference between the statistical estimations of sale figures obtained by simulation process and Regression process.

H_1: There is a difference.
α: 0.05- Level of Significance (Maximum value of making Type-I error)

Results of test statistics:
- Mean of Simulated Sale: 130.75
- Mean of Regression Sale: 125
- n_1= 8 & n_2= 8
- S.D. of Simulated demand: 8.345
- S.D. of Simulated demand: 8.159
- Z= 1.0833

Conclusion: That there is no significant difference between the statistical estimations of sale figures obtained by simulation process and Regression process and Z value obtained from two tailed test falls in A.R. [-1.96, 1.96] so H_0 is accepted.

6. Conclusions
Though known to all striving in the business environment that two crucial factors demand and actual sale and hence associated profit factor are mutually independent and closely dependent factors have always remained an arm away but our efforts to intercept them using more refined tools have mostly remained responding resplendently and supported by application of 'U' test. Still the question needs small gaps to fill in but our efforts persistently continues.

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