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Demand forecasting, Economic Order Quantity and inventory costs calculation of a company producing solar panels

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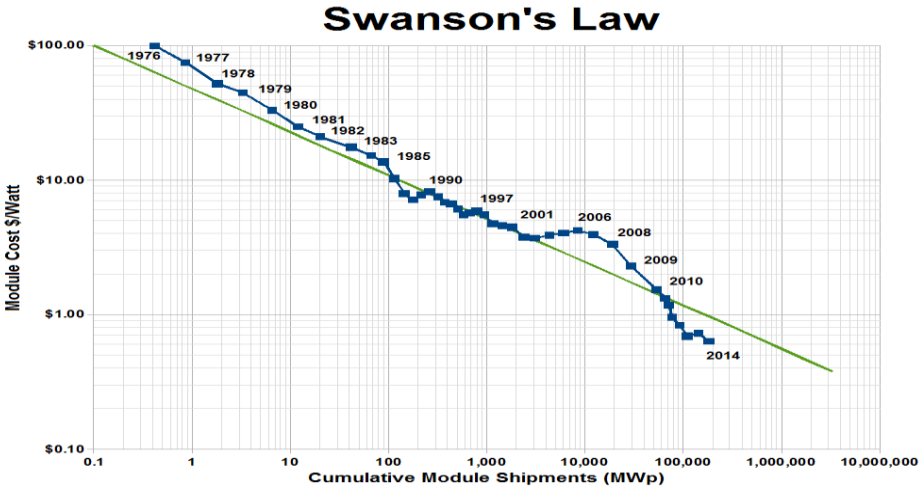
***Abstract**: Forecasting accuracy drives the performance of inventory management. This study involves forecasting the sales of PV modules of a solar panel manufacturing company by demand forecasting methods including regression and exponential smoothing models. Demand forecasted is used to control inventory, minimize cost of ordering and holding inventory. The model should propose a viable economic order quantity which reduces the total cost of the plan.*

I. Introduction

ORRECT forecasting has become a need for survival in today's business world. Not only for production unit but correct forecasting is required at every stage of product development. It is a foundation upon which the all company plan and objectives are built in terms of market and revenue. Correct forecasting helps save wastage in materials, man hours, machine idle time etc which leads to increased efficiency and productivity. Exponential smoothening and regression models have been potently used as they are the most cost effective statistical tools.

With the advent of rapid industrialization, increased locomotives and energy needs, there is a need to shift to renewable forms of energy to fulfill our energy needs. Thus, the dataset selected is that of Solar Panel which under general consensus states the rising demand of solar panels signifies the rising acceptance of using solar energy as a viable alternative energy source. Solar Panel refers to a panel designed to absorb the sun's rays which is an ultimate source of energy for generating electricity or heat. The factor that has hampered the production of solar panels is the high installation and starting cost but as the acceptance of solar panels rises the cost of setting up solar panels has been seen to be decreasing. From the past demand curves, as stated by Swanson's law which states that with every doubling of production of panels, there has been a 20 percent reduction in the cost of panels, which holds true within the limit of error.



The demand forecasts form a key input to the economic appraisal. As such any errors present within the demand forecasts will undermine the reliability of the economic appraisal. Moreover, incorrect forecasts could create several problems such as over or under production, wastage etc, in the organization as forecasting forms a key input to the planning function. The study aims to efficiently forecast demand for solar panels for a

solar panel manufacturing company and develop an adequate inventory control model along with determining the optimum order quantity for regulating the storage of silicon, which is a key raw material in manufacturing of solar panels.

II. Methodology

Two methods used in this study were Exponential Smoothing and Non Linear (Polynomial) Regression: Exponential Smoothing: It calculates the smoothed series as a damping coefficient times the actual series plus 1 minus the damping coefficient times the lagged value of the smoothed series. The extrapolated smoothed series is a constant, equal to the last value of the smoothed series during the period when actual data on the underlying series are available. While the simple Moving Average method is a special case of the ES, the ES is more parsimonious in its data usage.

Where:

$$F_t+1 = \alpha D_t + (1 - \alpha) F_t$$

- D_t is the actual value
- F_t is the forecasted value
- α is the weighting factor, ranging from 0 - 1
- t is the current time period.

Notice that the smoothed value becomes the forecast for period t + 1.

Non Linear Regression:

In statistics, nonlinear regression is a form of regression analysis in which observational data are modeled by a function which is a nonlinear combination of the model parameters and depends on one or more independent variables. The data are fitted by a method of successive approximations. We have used the polynomial regression by fitting and extrapolating our data in an equation of the form of

$y=Ax^2+Bx+C$

Where y is the dependant variable and x is the independent variable.

III. Research Elaborations

The material balance suggests that 5 grams of polysilicon is required per watt of c-Si PV Module.

The wattage of PV Module is 250. Hence raw material (polysilicon) required per module = 250*5= 1250g = 1.25 kg

Forecasting of demand by Exponential Smoothing:

Demand forecasted by Exponential Smoothing is given in Table 1.

Total demand of PV Modules for the financial year 2015 = 11463985 units

Raw material (polysilicon) required = 1.25*11463985 = 14329981.25kg = 14329.981 tons

Holding Cost/ton/Year (C) = 1840

Fixed Cost per Order (F) = 1230645

EOQ of polysilicon = 4378 tons

No of reorders per year = 3.27

Inventory costs of polysilicon

Ordering costs = Rs 4028127

Holding costs = Rs4027760

Total inventory costs = Rs 8055880

Forecasting of demand by regression:

Demand forecasted by Polynomial Regression is given in Table 2.

Total demand of PV Modules for the financial year 2015 = 14846575 units

Raw material (polysilicon) required = 1.25* 14846575.13 = 18558219kg = 18558.219 tons

Holding Cost/ton/Year (C) = Rs 1840

Fixed Cost per Order (F) = Rs 1230645

EOQ of polysilicon = 4982 tons

No of reorders per year = 3.725

Inventory costs of polysilicon

Ordering costs = Rs 4584140

Holding costs = Rs 4583440

Total inventory costs = 9166880

IV. Results

In this work demand of PV modules is forecasted by Exponential smoothing and regression methods. EOQ and no of orders of polysilicon is calculated with the help of forecasted demand. Inventory costs, raw

material holding costs and ordering costs of polysilicon for the financial year 2015 is obtained. Total inventory costs of the demand forecasted by exponential smoothing is 13.8% less than the total inventory costs of the demand forecasted by regression.

V. Conclusion

The world is moving towards renewable resources and solar energy is a very important dimension in it. In order to help the company, producing solar panels, reduce their stock outs, a forecasting model was provided along with an economic order quantity. Finally, the economic order quantity is, optimized the order quantity for each product when an order is placed, reducing the company's product stock out issue. By providing and recommending the inventory control model, the results have shown improvements in forecasting as well as in cost reduction. The error associated with the model by exponential smoothing is 18%, and the error associated with the regression model is 11%. Thus the regression model is a more accurate representation of the increasing trend in the solar panel demand. The total inventory cost is however more in the regression model, this also leads to a safety in spikes and randomness which may arise due to unregulated demand for the future. Thus the regression model benefits in both the aspects. The recommended analysis showed that simple, yet complex techniques are the key for retail success which could give them the competitive edge.

Table 1: Actual Demand

Quarter	DEMAND (MW)	DEMAND - UNITS OF MODULES
3Q12	245.5242967	982097
4Q12	251.6624041	1006650
1Q13	251.6624041	1006650
2Q13	257.8005115	1031202
3Q13	306.9053708	1227621
4Q13	365.2173913	1460870
1Q14	389.769821	1559079
2Q14	448.0818414	1792327
3Q14	693.6061381	2774425
4Q14	880.8184143	3523274
1Q15	586.1892583	2344757
2Q15	721.2276215	2884910
3Q15	1077.237852	4308951

Table 3: Forecast using Polynomial Regression

Quarter	Forecast	Absolute Error	% Absolute Error
3Q12	917608	64490	0.065665096
4Q12	953900	52749	0.052400888
1Q13	1029155	22505	0.022356429
2Q13	1143371	112169	0.108774909
3Q13	1296549	68928	0.056147226
4Q13	1488689	27819	0.019043009
1Q14	1719791	160711	0.103080933
2Q14	1989854	197527	0.110206878
3Q14	2298880	475545	0.171403119
4Q14	2646867	876407	0.248747906
1Q15	3033816	689059	0.293872105
2Q15	3459727	574816	0.199249184
3Q15	3924599	384352	0.089198548
4Q15	4428434		**11.8472787**

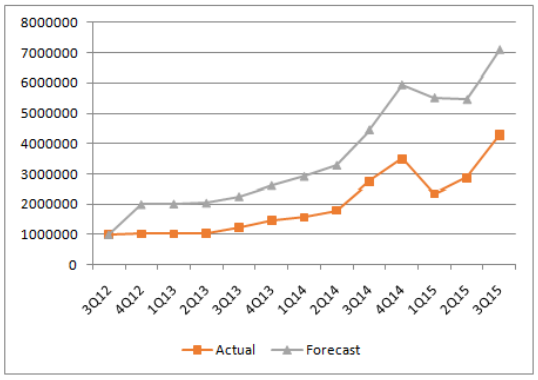
Table 2: Forecast Using Exponential Smoothing

Quarter	Forecast ($\alpha = 0.7$)	Absolute Error	% Absolute Error
3Q12			
4Q12	982097	24552	0.024390244
1Q13	999284	7366	0.007317073
2Q13	1004440	26762	0.025952381
3Q13	1023173	204448	0.16654
4Q13	1166287	294583	0.201648739
1Q14	1372495	186584	0.119676063
2Q14	1503104	289223	0.161367521
3Q14	1705560	1068864	0.385256183
4Q14	2453765	1069508	0.303555293
1Q15	3202421	857664	0.365779525
2Q15	2602056	282854	0.098046099
3Q15	2800054	1508897	0.35017735
4Q15	2859454		**18.4142206**

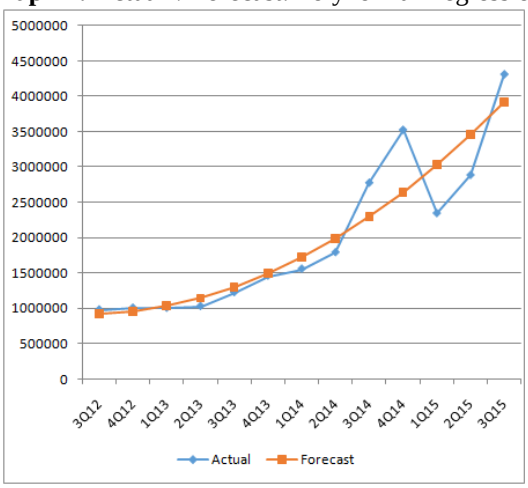
Table 4: Values of coefficients in the equation Ax^2+Bx+C: Polynomial Regression

A	19480.91
B	-22150.1
C	920276.9

Graph 1: Actual v Forecast: Exponential Smoothing



Graph 2: Actual v Forecast: Polynomial Regression



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