Modeling and Simulation of a time series Forecasting Models and Analysis in a Manufacturing Industry

[1]Ezeliora Chukwuemeka Daniel
[1]Department of Industrial and Production Engineering, Nnamdi Azikiwe University Awka, Anambra State, Nigeria Mobile: 2348060480087, E-mail:cezeliora@gmail.com
[2]Willians S. Ebhora
[2] Manufacturing and Production Department, National Engineering Design Development Institute, Nnewi, Anambra State, Nigeria Mobile: 2348038010666, E-mail:willymoon2001@yahoo.com
[3] Fadeyi Johnson A.
[3] Department of Mechanical Engineering, Michael Okpara University of Agriculture Umudike, Abia State, Nigeria Mobile: 2348035292574
[4]Okenwa Ugochukwu
[4] Mechanical Engineering Department, Michael Okpara University of Agriculture Umudike, Abia State, Nigeria Mobile: 2348038010666, E-mail:willymoon2001@yahoo.com

ABSTRACT: This work was used to address the problem of predicting precisely the optimum production plastic yield on there monthly products in Finoplastika manufacturing industry. Data on production yield were collected from the industry covering a period of three years and were applied to precisely determine optimum production yield in the industry. The model was developed based on there historical data. The model was generated using a simulating programme and a tool known as Matlab tool. The model was therefore used to suggest optimum monthly production output for different product types investigated. This will prevent the incident of under producing or over producing as identified.

Key words: Forecasting, Time-series, Modeling, Matlab software and Simulation

Introduction

Scientific Modeling: Scientific modeling is the process of generating abstract, conceptual, graphical and/or mathematical models. Science offers a growing collection of methods, techniques and theory about all kinds of specialized scientific modeling. A scientific model can provide a way to read elements easily which have been broken down to a simpler form.

Modeling is an essential and inseparable part of all scientific activity, and many scientific disciplines have their own ideas about specific types of modeling. There is an increasing attention for scientific modeling [1] in fields such as of philosophy of science, systems theory, and knowledge visualization.

A scientific model seeks to represent empirical objects, phenomena, and physical processes in a logical and objective way. All models are *in simulacra*, that is, simplified reflections of reality, but, despite their inherent falsity, they are nevertheless extremely useful.[2] Building and disputing models is fundamental to the scientific enterprise. Complete and true representation may be impossible (see non-representational theory), but scientific debate often concerns which is the better model for a given task, e.g., which is the more accurate climate model for seasonal forecasting.[3]

Attempts to formalize the principles of the empirical sciences, use an interpretation to model reality, in the same way logicians axiomatize the principles of logic. The aim of these attempts is to construct a formal system that will not produce theoretical consequences that are contrary to what is found in reality. Predictions or other statements drawn from such a formal system mirror or map the real world only insofar as these scientific models are true.[4]

For the scientist, a model is also a way in which the human thought processes can be amplified.[5] For instance, models that are rendered in software allow scientists to leverage computational power to simulate, visualize, manipulate and gain intuition about the entity, phenomenon, or process being represented. Such computer models are *in silico*. Other types of scientific model are *in vivo* (living models, such as laboratory rats) and *in vitro* (in glassware, such as tissue culture).[6]

Scientific modeling basics: Models are typically used when it is either impossible or impractical to create experimental conditions in which scientists can directly measure outcomes. Direct measurement of outcomes under controlled conditions (see Scientific Method) will always be more reliable than modeled estimates of outcomes.

Simulation of a Model: A simulation is the implementation of a model. A steady state simulation provides information about the system at a specific instant in time (usually at equilibrium, if such a state exists). A dynamic simulation provides information over time. A simulation brings a model to life and shows how a particular object or phenomenon will behave. Such a simulation can be useful for testing, analysis or training in those cases where real-world systems or concepts can be represented by models.[7]

Structure of a Model: Structure is a fundamental and sometimes intangible notion covering the recognition, observation, nature, and stability of patterns and relationships of entities. From a child's verbal description of a snowflake, to the detailed scientific analysis of the properties of magnetic fields, the concept of structure is an essential foundation of nearly every mode of inquiry and discovery in science philosophy, and art.[8]

Systems Modeling: A system is a set of interacting or interdependent entities, real or abstract, forming an integrated whole. In general, a system is a construct or collection of different elements that together can produce results not obtainable by the elements alone.[9] The concept of an 'integrated whole' can also be stated in terms of a system embodying a set of relationships which are differentiated from relationships of the set to other elements, and from relationships between an element of the set and elements not a part of the relational regime. There are two types of system models: 1) discrete in which the variables change instantaneously at separate points in time and, 2) continuous where the state variables change continuously with respect to time.[10]

The process of generating a model: Modeling refers to the process of generating a model as a conceptual representation of some phenomenon. Typically a model will refer only to some aspects of the phenomenon in question, and two models of the same phenomenon may be essentially different, that is to say that the difference or differences between them is more than just a simple renaming of components.

Such differences may be due to differing requirements of the model's end users, or to conceptual or aesthetic differences among the modelers and to contingent decisions made during the modeling process. Aesthetic considerations that may influence the structure of a model might be the modeler’s preference for a reduced ontology, preferences regarding probabilistic models vis-a-vis deterministic ones, discrete vs. continuous time, etc. For this reason, users of a model need to understand the model's original purpose and the assumptions made that are pertinent to its validity.

The process of evaluating a model: A model is evaluated first and foremost by its consistency to empirical data; any model inconsistent with reproducible observations must be modified or rejected. One way to modify the model is by restricting the domain over which it is credited with having high validity. A case in point is Newtonian physics, which is highly useful except for the very small, the very fast, and the very massive phenomena of the universe. However, a fit to empirical data alone is not sufficient for a model to be accepted as valid. Other factors important in evaluating a model include.

- Ability to explain past observations
- Ability to predict future observations
- Cost of use, especially in combination with other models
- Refutability, enabling estimation of the degree of confidence in the model
- Simplicity, or even aesthetic appeal

People may attempt to quantify the evaluation of a model using a utility function.

Visualization of a Technique: Visualization is any technique for creating images, diagrams, or animations to communicate a message. Visualization through visual imagery has been an effective way to communicate both abstract and concrete ideas since the dawn of man. Examples from history include cave paintings, Egyptian hieroglyphs, Greek geometry, and Leonardo da Vinci's revolutionary methods of technical drawing for engineering and scientific purposes.

Applications of Modeling and Simulation: One application of scientific modeling is the field of "Modeling and Simulation", generally referred to as "M&S".[11] M&S has a spectrum of applications which range from concept development and analysis, through experimentation, measurement and verification, to disposal analysis. Projects and programs may use hundreds of different simulations, simulators and model analysis tools.

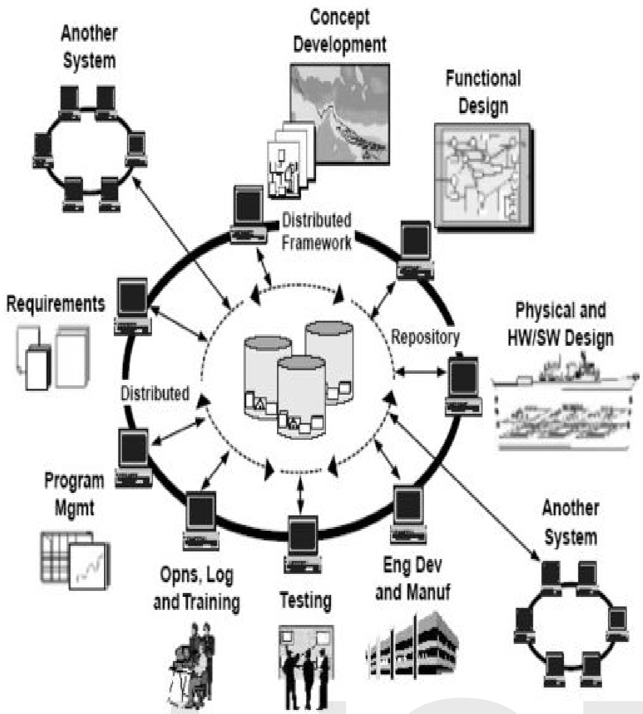

Figure 1: Modeling and Simulation in Defense life cycle management

Examples of the integrated use of Modeling and Simulation in Defense life cycle management. The modeling and simulation in this image is represented in the center of the image with the three containers.[12]

The figure shows how Modeling and Simulation is used as a central part of an integrated program in a Defense capability development process.[12]

General linear model: The *general linear model* (GLM) is a statistical linear model. It may be written as [13]

$$\mathbf{Y} = \mathbf{X}\mathbf{B} + \mathbf{U}, \quad (1)$$

Where **Y** is a matrix with series of multivariate measurements, **X** is a matrix that might be a design matrix, **B** is a matrix containing parameters that are usually to be estimated and **U** is a matrix containing errors or noise. The errors are usually assumed to follow a multivariate normal distribution. If the errors do not follow a multivariate normal distribution, generalized linear models may be used to relax assumptions about **Y** and **U** [13].

Predictive modeling: Predictive modeling is the process by which a model is created or chosen to try to best predict the probability of an outcome.[14] In many cases the model is chosen on the basis of detection theory to try to guess the probability of an outcome given a set amount of input data, for example given an email determining how likely that it is spam.

Models can use one or more classifiers in trying to determine the probability of a set of data belonging to another set, say spam or 'ham'.

Research Method Used: The research method used in this work is a quantitative research approach. The data gathered were the daily record of plastic pipes production over the month for three years. The method used was time series technique to model for the quantity of pipes (sizes and shapes) to be produced in the industry using predictive tool namely Matlab tool for the development of the model and the forecasting of the results.

This model developed was used to predict the actual quantity of the plastic pipe products, the case study industry is supposed to be producing every month. The essence is to make it easier to use and to produce results using simulation technique.

Simulation of the Model

```
t=0:36;
Yt=58282.8-(566.889*t); % eqn 1
plot(t,Yt,'lineWidth',2)
xlabel('time in months')
ylabel('yield')
title('Trend Analysis of Product, PT')
figure

Yt=21405.50-(238.595*t); % eqn2
plot(t,Yt,'lineWidth',2)
xlabel('time in months')
ylabel('yield')
title('Trend Analysis of Product, P1')

figure

Yt=8724.51-(130.143*t); % eqn3
plot(t,Yt,'lineWidth',2)
```

```
xlabel('time in months')
ylabel('yield')
title('Trend Analysis of Product, P2')

figure

Yt=11766.8-(96.5404*t); % eqn4
plot(t,Yt,'lineWidth',2)
xlabel('time in months')
ylabel('yield')
title('Trend Analysis of Product, P3')

figure

Yt=6821.76-(27.2436*t); % eqn5
plot(t,Yt,'lineWidth',2)
xlabel('time in months')
ylabel('yield')
title('Trend Analysis of Product, P4')

figure

Yt=-27.0397+(11.4466*t); % eqn6
plot(t,Yt,'lineWidth',2)
xlabel('time in months')
ylabel('yield')
title('Trend Analysis of Product, P5')

figure

Yt=6223.24-(39.8192*t); % eqn7
plot(t,Yt,'lineWidth',2)
xlabel('time in months')
ylabel('yield')
title('Trend Analysis of Product, P6')

figure

Yt=2866.82+(4.58919*t); % eqn8
plot(t,Yt,'lineWidth',2)
xlabel('time in months')
ylabel('yield')
title('Trend Analysis of Product, P7')

figure

Yt=-1.73016+(4.89833*t); % eqn9
plot(t,Yt,'lineWidth',2)
xlabel('time in months')
ylabel('yield')
title('Trend Analysis of Product, P8')
```

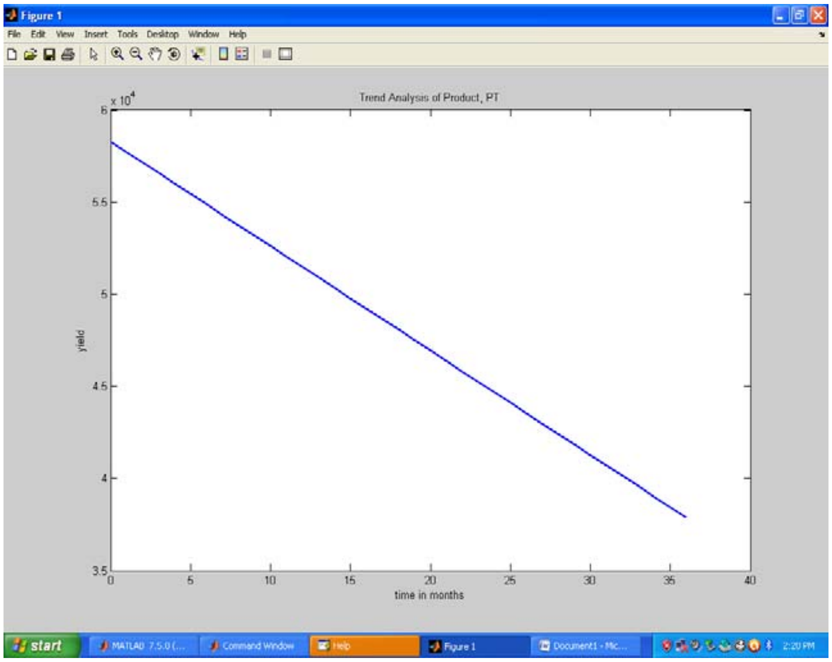

Figure 2: Trend Analysis of PT

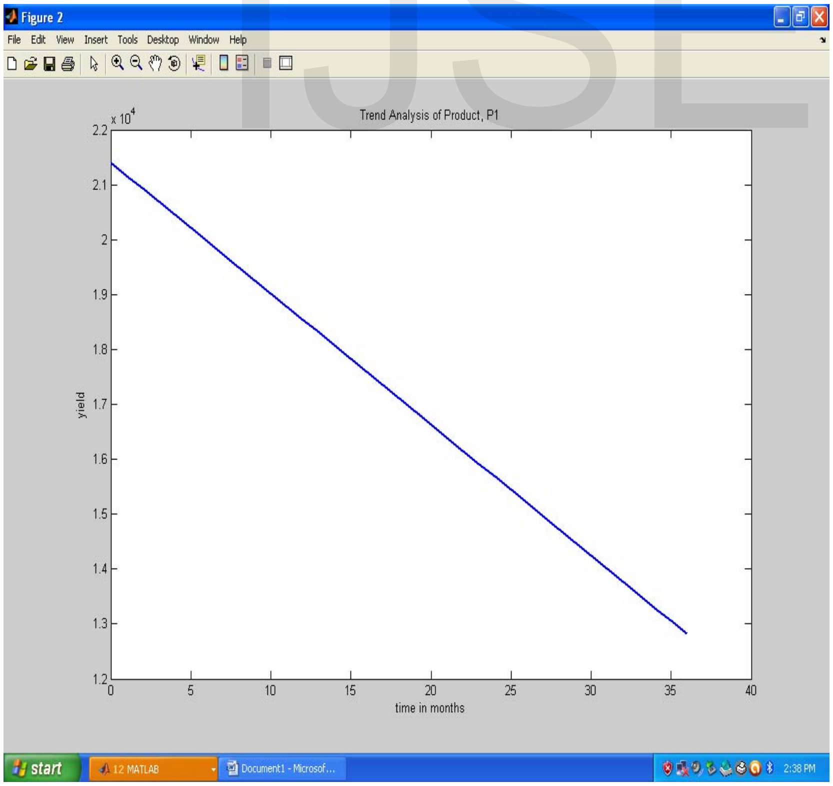

Figure 3: Trend Analysis of P1

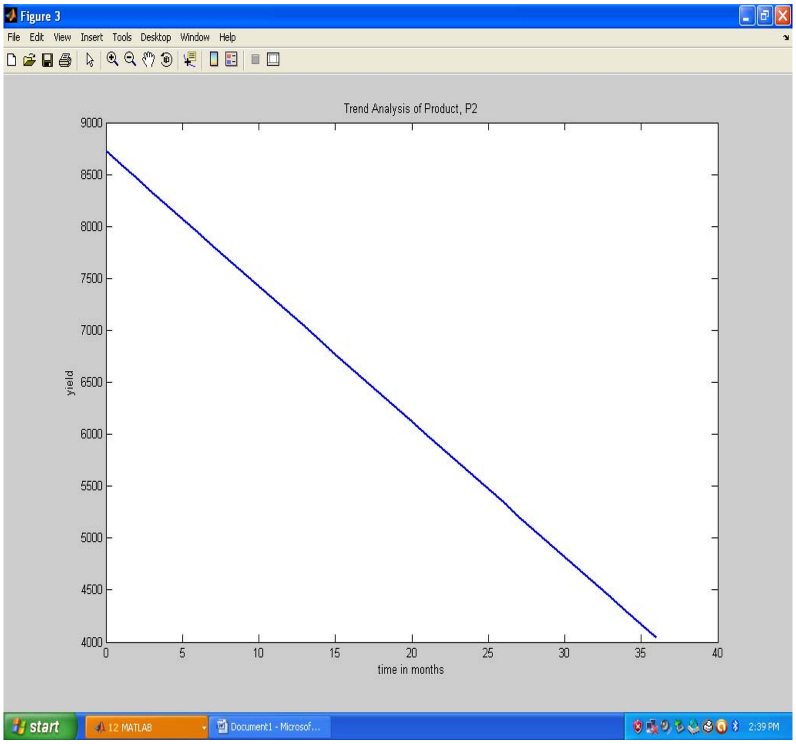

Figure 4: Trend Analysis of P2

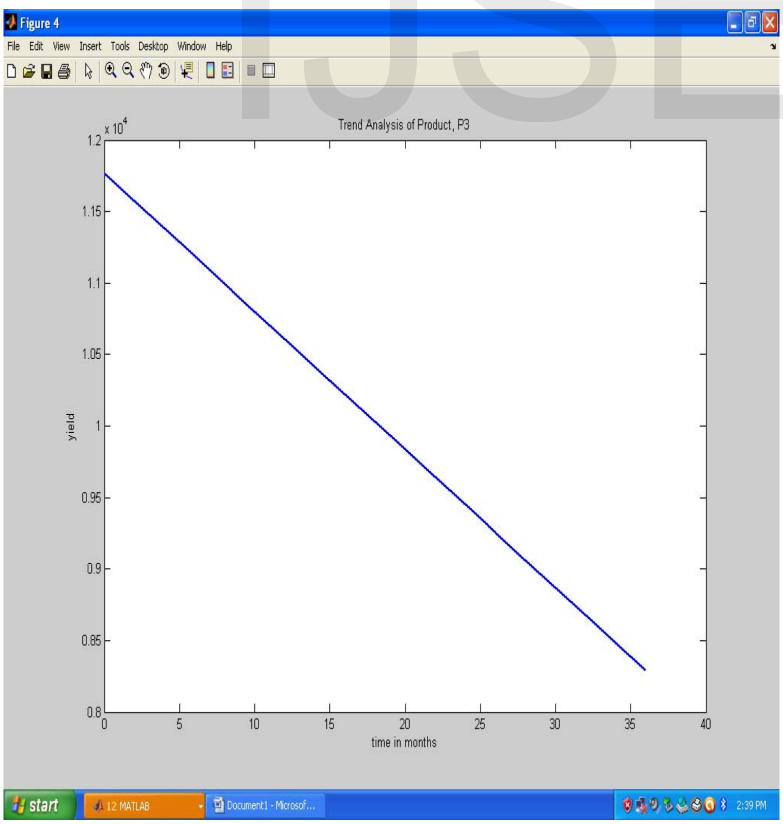

Figure 5: Trend Analysis of P3

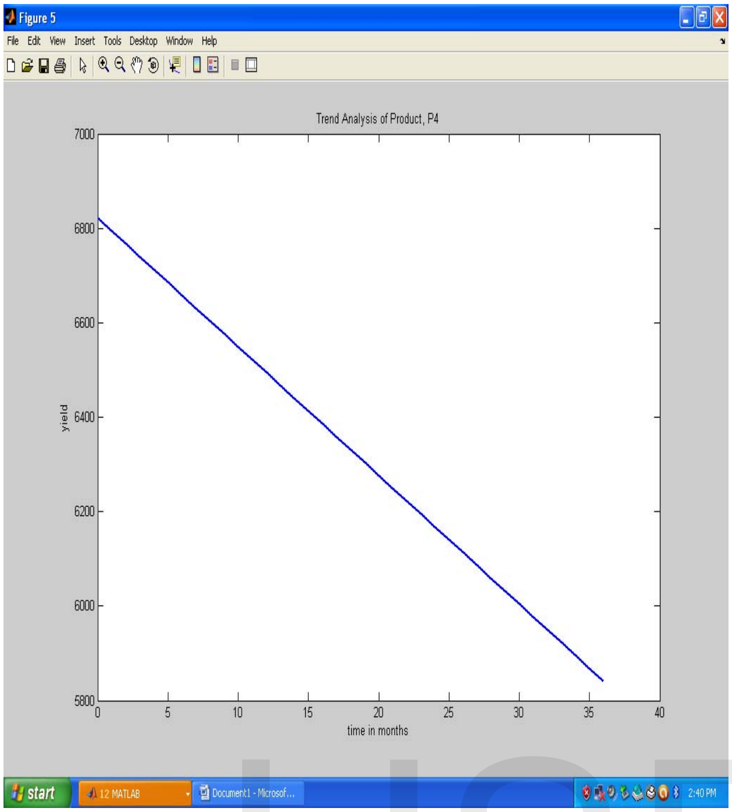

Figure 6: Trend Analysis of P4

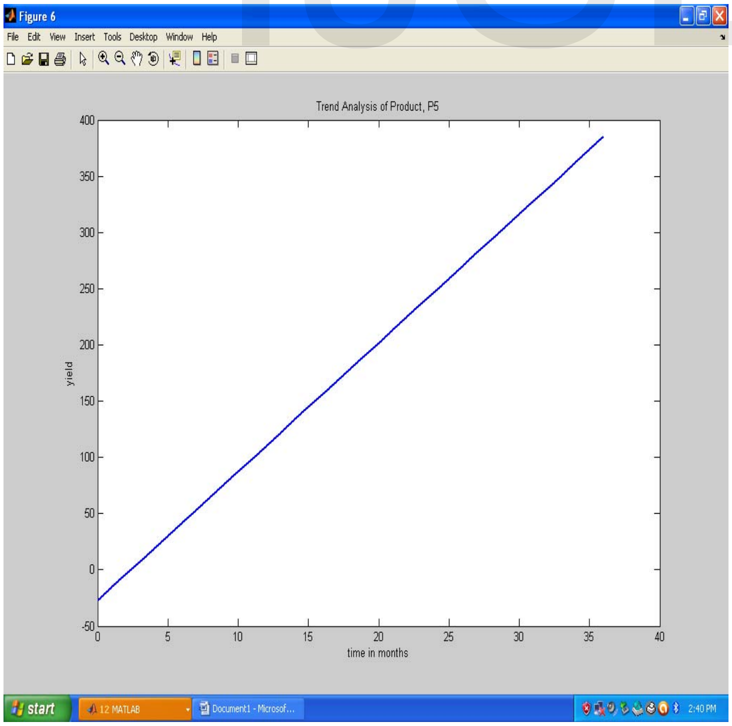

Figure 7: Trend Analysis of P5

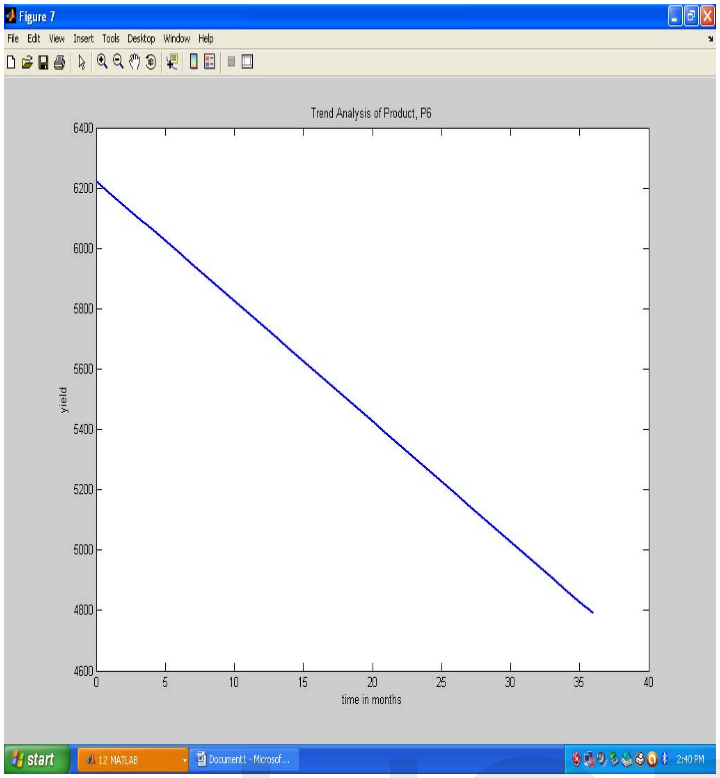

Figure 8: Trend Analysis of P6

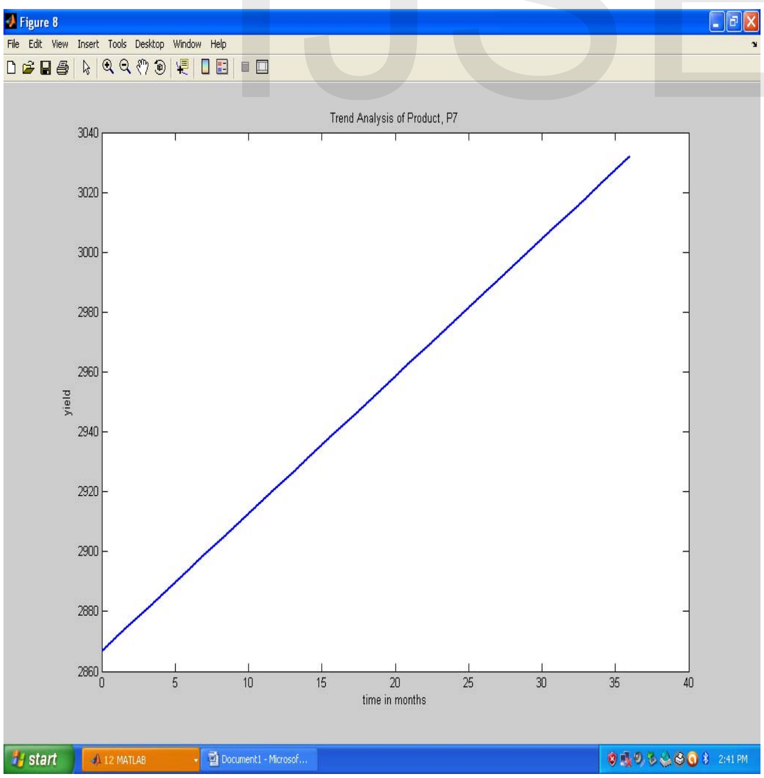

Figure 9: Trend Analysis of P7

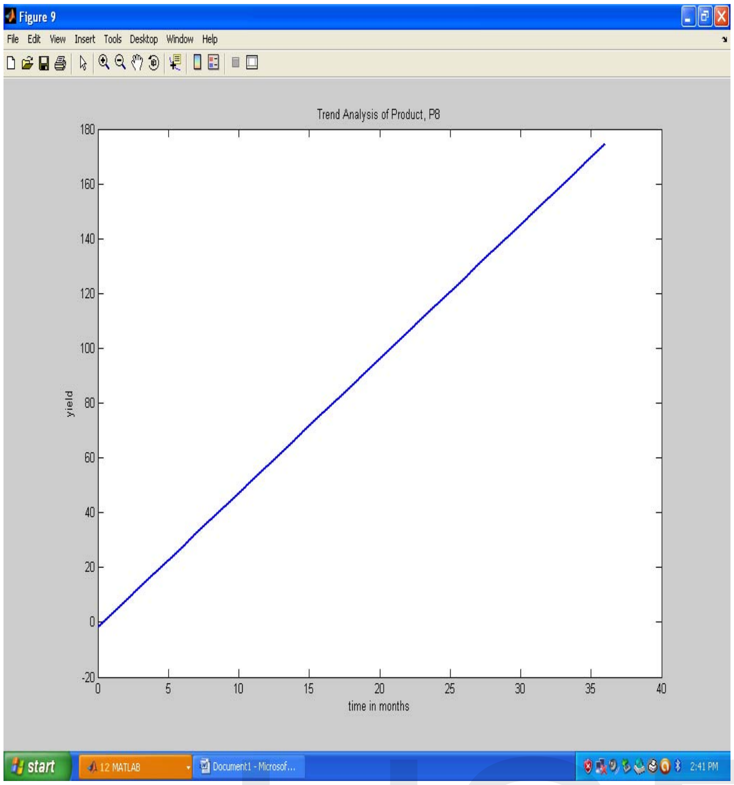

Figure 10: Trend Analysis of P8

Discussion of Results

The discussions of results were based on the charts and the simulated forecasting models developed by using Matlab. The forecasting models are simple regression models. The eight products models simulated can be used for the prediction of their future production outputs. The essence of simulating the model is to make very easier for other products and any other company that wants to use simple regression model in forecasting of their products. The simulation was performed by using Matlab tool. Furthermore, the charts developed show that out of the eight products, five (5) of the products (i.e. P1, P2, P3, P4 and P6 products) show a downward trend. This shows that the five products will decrease in the future production output. However the next three (3) products (i.e. P5, P7 and P8 products) show an upward trend. This shows that the three products will increase in the future production output when applied their models. These charts were also developed using Matlab software.

Conclusion

In conclusion, a forecasting model for predicting monthly product requirement has been developed. The model was simulated using a matlab programme. The model was tested using historical data collected from the case study company. The testing of the model reveals that the company at present was under producing with respect to customers' orders and requirements. This implies that greater percentages of the customers are not served as and when due leading to queues and waiting before customers are served. The tool developed can help the company to remedy this situation.

References

1. *Frigg and Hartmann (2009) state: "Philosophers are acknowledging the importance of models with increasing attention and are probing the assorted roles that models play in scientific practice". Source: Frigg, Roman and Hartmann, Stephan, "Models in Science", The Stanford Encyclopedia of Philosophy (Summer 2009 Edition), Edward N. Zalta (ed.), (source)*
2. *Box, George E.P. & Draper, N.R. (1987). [Empirical Model-Building and Response Surfaces.] Wiley. p. 424*
3. *Hagedorn, R. et al. (2005) http://www.ecmwf.int/staff/paco_doblas/abstr/tellus05_1.pdf Tellus 57A:219-233*
4. *Leo Apostel (1961). "Formal study of models". In: The Concept and the Role of the Model in Mathematics and Natural and Social. Edited by Hans Freudenthal. Springer. p. 8-9 (Source)],*
5. *C. West Churchman, The Systems Approach, New York: Dell publishing, 1968, p.61*
6. *Griffiths, E. C. (2010) What is a model?*
7. *Systems Engineering Fundamentals. Defense Acquisition University Press, 2003.*
8. *Pullan, Wendy (2000). Structure. Cambridge: Cambridge University Press. ISBN 0521782589.*
9. *Fishwick PA. (1995). Simulation Model Design and Execution: Building Digital Worlds. Upper Saddle River, NJ: Prentice Hall.*
10. *Sokolowski, J.A.,Banks, C.M.(2009). Principles of Modeling and Simulation. Hoboken, NJ: John Wiley and Sons.*
11. *Because "Modeling and Simulation" is frequently taught in male dominated undergraduate environments, this field of application is deliberately named "Modeling and Simulation", rather than "Simulation and Modeling", to avoid distractions which may arise due to any possible association with the negative connotations of S&M.*
12. *Christensen, Ronald (2002). Plane Answers to Complex Questions: The Theory of Linear Models (Third ed.). New York: Springer. ISBN 0-387-95361-2.*

13. *Wichura, Michael J. (2006). The coordinate-free approach to linear models. Cambridge Series in Statistical and Probabilistic Mathematics. Cambridge: Cambridge University Press. pp. xiv+199. ISBN 978-0-521-86842-6, ISBN 0-521-86842-4. MR2283455.*

14. *Geisser, Seymour (1993). Predictive Inference: An Introduction. New York: Chapman & Hall. p. [page needed]. ISBN 0-412-03471-9.*

Authors Biography

Corresponding Author's Biography

I am Ezeliora Chukwuemeka Daniel by name, from Amesi Town in Aguata Local Government Area, Anambra State, Nigeria. An Alumina of Holy Child Primary School Isuofia, Igwebuike Grammar School Awka and Saint Charles Special Science School Onitsha. I have my Bachelors of Engineering in Mechanical and Production Engineering from Nnamdi Azikiwe University Awka, in 2008. Currently, I am a Masters student in Industrial and Production Engineering from the same University above, with my thesis titled "Application of Selected Forecasting Techniques in Modeling and Analysis of Historical Data Related to Plastic Pipe Products". I am a member of Nigeria Society of Engineers (NSE) and Institute of Mechanical Engineers (I MechE). And I am also a full member of Human right Organization and International Association of Engineers (IAENG). Currently, I have developed about twelve international Journals on Mechanical and Production Engineering areas and I am the corresponding author in majority of them. Some of the Journals titles are: "Comparing Chatter Stability of End-Milling Processes of Different Number of Teeth", "Time Series and Statistical Analysis of Plastic Yield", "Moving Average Analysis of Plastic Production Yield in a Manufacturing Industry", etc. In my life, I love been a researcher, and I am still researching for more works, although some are still pending due to its facilities are not yet available. In terms of research, I love more of the areas in Production Engineering and above all I love been good to friends.