Journal of Advances in Science and Technology

Vol. 10, Issue No. 21, February-2016, ISSN 2230-9659

REVIEW ARTICLE

MATHEMATICAL MODEL FOR PRODUCTIVITY IMPROVEMENT

AN INTERNATIONALLY INDEXED PEER REVIEWED & REFEREED JOURNAL

www.ignited.in

Journal of Advances in Science and Technology
Vol. 10, Issue No. 21, February-2016, ISSN 2230-9659

Mathematical Model for Productivity Improvement

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INTRODUCTION

"*Mathematical Modeling is defined as the process of applying Mathematics to the actual world problems in order to comprehend the real life situations and estimating future prediction".*

Models are representation of systems or phenomena we want to study, understand and control. Models can be classified as physical, hypothesized (imagined) and mathematical. Models provide justifiable answers. They make problem solving a creative and iterative process. They provide precision, better design, and control for applications. They also allow optimum utilization of computing capabilities.

Mathematical modeling technique aims to solve the real world problems through mathematical equations. It describes the different aspects of the real world, their interaction and dynamics through mathematical expressions. It is much easier to solve mathematical equations provided we know how to formulate them. In the era when students want to solve the problem without getting into the physical insight of the situational problems, mathematical model becomes an important tool.

SCOPE AND OBJECTIVE

This research explores various models to identify the most apt model for the parametric control of processes that govern quality in the IT industry. Benchmark serves as an essential standard as well as a tool to measure and analyze the processes in the organization. The objective here is to study the application of modeling technique to a common metric, say productivity, used in the IT industry that would help in quantitatively navigating it towards the defined benchmark. As productivity depends on many other factors, organizations need a precise and accurate method for its measurement. This study identifies a simple, practical, yet an effective model to measure productivity.

BENEFITS OF MATHEMATICAL MODELING

1. A model embodies a *hypothesis* about the target system/process, and lets you compare that hypothesis with data.

2. The model formulation process clarifies assumptions, variables and parameters.

3. Models help in forecasting, designing, managing and optimizing industrial, social and ecological processes.

4. Models allow simulation and multi-dimensional analysis of systems.

TYPES OF MODELS

1. LINEAR v/s NONLINEAR:

All the operators in this model exhibit linearity. Linear models, if properly implemented, provide a simple and convenient way of measuring various attributes.

2. STATIC v/s DYNAMIC

A dynamic model accounts for time-dependent changes in the state of the system.

3. EXPLICIT v/s IMPLICIT

If all of the input parameters of the overall model are known, the output parameters can be calculated by a finite series in an explicit model.

4. DISCRETE v/s CONTINUOUS

A discrete model treats objects as discrete, such as the particles in a molecular model or the states in a statistical model.

5. DETERMINISTIC v/s STOCHASTIC

A deterministic model is one in which every set of variable states is uniquely determined by parameters in the model and by sets of previous states of these variables. Conversely, in a stochastic model, randomness is present, and variable states are not described by unique values, but rather by probability distributions.

6. DEDUCTIVE, INDUCTIVE, OR FLOATING

A deductive model is a logical structure based on a theory. An inductive model arises from empirical findings and generalization from them. The floating model rests on neither theory nor observation, but is merely the invocation of expected structure.

Application of mathematics in social sciences outside of economics has been criticized for unfounded models. Application of catastrophe theory in science has been characterized as a floating model.

CHARACTERISTICS OF MODELS

Robustness, Precision, Consistency and Realistic nature form the primary attributes of models. Oversimplified model may not represent reality whereas overambitious models may introduce complications. Deterministic models yield expected quantifiable predictions; yet unexpected predictions lead to important breakthroughs, assumptions and new criteria. Models could be hierarchical depending on their area, level and extent of coverage. Feedback based models are most desired as they help in continuous improvement and regulation in control systems. Different variants of a model may be required for similar applications in various fields and new versions would be required with enhanced capabilities in systems and processes.

PRINCIPLES OF MODELING

a) Identify the need for the model

b) List the parameters / variables which are required for the model

c) Identify the available relevant data

d) Identify the circumstances that can be applied

e) Identify the governing physical principles Identify

  i. The equation that will be used

  ii. The calculations that will be made

  iii. The solution which will follow

f) Identify tests that can check the

  i. Consistency of the model

  ii. Utility of the model

g) Identify the parameter values that can improve the model

STEPS FOR MODELING

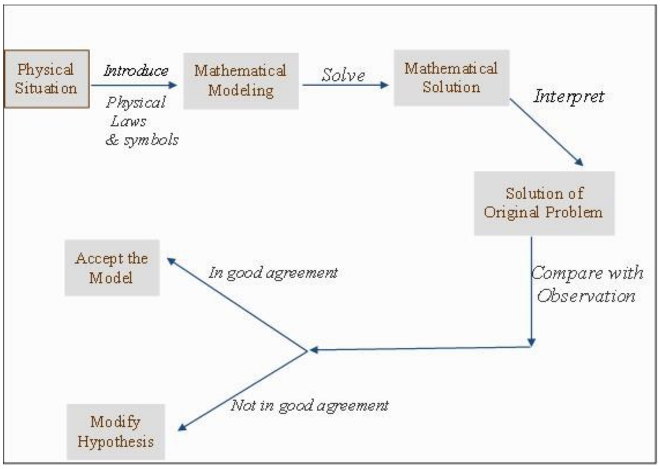
I. Identify the physical situation

II. Convert the physical situation into a mathematical model by introducing parameters / variables and using various known physical laws and symbols

III. Find the solution of the mathematical problem

IV. Interpret the result in terms of the original and compare the result with observations or experiments

V. If the result is in good agreement, then accept the model. Otherwise modify the hypothesis / assumptions according to the physical situation and go to step II.



BENCHMARKING

Software projects can be categorized into three groups, namely, development, maintenance and testing projects depending on where they occur in the project life cycle. In a survey of projects, it was found that out of the total number of projects, 37% of the projects were development projects. In terms of revenue, these development projects accounted for more than 43% of total revenue earned by the organization under consideration. Thus, benchmarking in development projects would have high impact to operating profits. This was a strong decisive factor to focus the study on productivity in development projects.

As mentioned earlier, benchmarking is an essential requirement to achieve higher goals and productivity. This process not only helps in achieving better results, but also in setting higher achievable standards. Benchmarking has been used quite effectively in all the industries. In manufacturing industries, it is easy to have quantifiable goals that can be used to benchmark the process. The nature of industry is such that the process of benchmarking can be drilled down to the last component level of tracking. For example, based on the overall benchmarking of annual productivity, the daily figure of production for each component or part for a month or even a week can be decided. This kind of benchmarking, however, will not be possible in service industry like IT. In IT industry, the job is more of a qualitative nature and the response to the requested service becomes a factor for benchmarking. Hence, the parameter for service industry benchmarking is different from manufacturing industry. IT industry is more of a service-oriented industry, where requests from customers are serviced by way of developing software. The software developed for a customer will definitely vary from the software developed for another customer as customization is done for each customer in most of the cases.

PRODUCTIVITY IN IT INDUSTRY

One of the key issues of software development projects is to reduce the time taken for developing software and thereby improve productivity while meeting quality criteria. It is important therefore to understand the factors which would influence productivity and quality.

Productivity in software development project is substantially different from productivity in manufacturing industries. In a manufacturing industry, productivity is the result of capital, technology, human resource, competence and skill of management. In software development, capital and equipment play a very nominal role. In software development, no raw material or bought-out component is used, whereas in manufacturing industry these two components form a very significant part and these determine, to a great extent, the productivity. Given this kind of difference, a study for productivity in manufacturing industry cannot be straightaway applied to software industry. If one takes a precise view of software industry, one observes that the key factor determining productivity in this industry is the human resource. Hence, measuring the software output in relation to manpower deployed is considered for measuring productivity.

High productivity implies that given the number of function points in a project, it has consumed less human efforts. However, it is possible that with less person-month being spent, the project may be completed in a hurry and it may result in high delivered defects which can affect product quality and cause customer dissatisfaction. It is therefore important that, while less effort is spent, no relaxation should be made on the final quality of the deliverable, or in other words, while a higher value of productivity is maintained, better quality software with less (within acceptable threshold limit) or no delivered defects should be guaranteed. Such guarantee can help in increasing efficiency and eventually result in higher profitability and higher return on investment. Similar dependencies on other crucial factors influence the productivity figures for an organization.

DEVELOPMENT OF HYPOTHESES

Through a prior understanding of cause and effect relationship, it is necessary to identify the variables that influence productivity. This would list the independent factors as variables. Then the degree of influence that each of these variables has on productivity needs to be evaluated. This would provide the proportionality coefficients. And finally the combined effect of the variables on productivity has to be calculated by summing the products of respective coefficients with the value of the variables.

Based on the premise discussed above, we may formulate the following hypotheses. Productivity would tend to:

H1- decrease with increase in application complexity

H2 - increase with increase in experience in technology

H3 - increase with increase in experience in domain.

H4 – increase with better client support

H5 - increase with availability of modules.

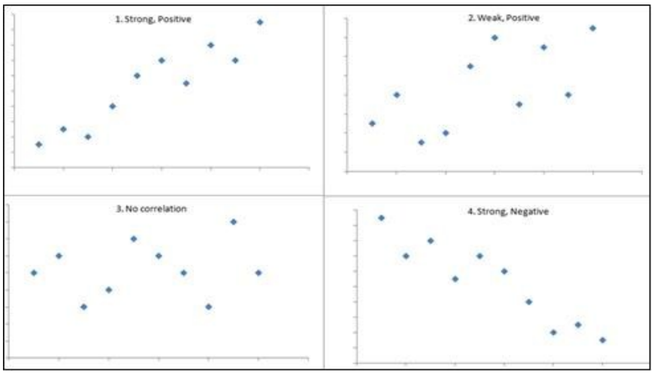
H6 - increase with higher automation

H7 – increase with availability of testing tools

H8 – increase with higher compliance to document management system

H9 - increase with increase in training effort

A graph could be plotted to correlate each hypothesis parameter value with the value of productivity. This would depict if the dependence is strong, weak or inverse. A sample correlation chart depicting 4 types of dependencies is shown below.



Using the above hypotheses, we may propose productivity as a mathematical function:

Productivity = ***f*** *(application complexity, experience in technology, experience in domain, training, client support, availability of modules, computation speed, testing tools availability and document management system)*

Similar to:

$$Y = c + a_1x_1 + a_2x_2 + a_3x_3 + a_4x_4 + a_5x_5 + a_6x_6 + a_7x_7 + a_8x_8 + a_9x_9 + u,$$

where Y was the dependent variable, productivity C was the intercept, or the result of other variables not considered n the equation, $a_1,\ldots,a_9$ were coefficients of the variables, $x_1,\ldots,x_9$, respectively,

x_1: represented application complexity,
x_2: represented experience in technology,
x_3: represented experience in domain,
x_4: represented training,
x_5: represented client support,
x_6: represented availability of modules,

x_7: represented computation speed,
x_8: represented testing tools,
x_9: represented document management system,
u: represented the error term.

Multiple Regression Analysis technique was decided as the mode for analysis for following reasons:

1) This technique would allow us to understand combined effect of all influencing factors (dependent variables) on independent variable.

2) The regression equation or model developed from this technique gives the best possible prediction of dependent variable with respect to independent variables.

3) For each independent variable, this technique indicates whether the variable is significant statistically. This can indicate whether we need to control this variable for achieving desired value in independent variable.

SUMMARY

The nature of software industry is such that there has not been any quantitative approach to benchmark the industry standards. The industry strives on customer-vendor relationship and this relationship revolves round the capability of vendor organization to service customer needs. The capability of vendor organization not only depends on the quality of the application being delivered, but also on the rate at which the service is provided to the customer. This capability of servicing the customer depends on productivity of the organization (vendor). It is thus imperative that organization (vendor) constantly improves its productivity level.

This necessitates the need to create high-quality software by measuring and controlling the influencing parameters using mathematical models. Mathematical models are represented by expressions. In absence of analytical solutions, the models are implemented on computing devices. The models are preferably simulated prior to implementation. This helps identify the shortcomings or wrong results.

In developing software, benchmarking helps in improving efficiency, quality and reducing cost. But there is a wide variation in the practice of benchmarking. Benchmarking types, such as external and internal, strategic and sectored, process and product are prevalent in software industry. The extent to which these different types are used is relatively less known. Similarly, for different types of projects, the choice of benchmarking type may depend on factors such as prior experience, technology, and several other factors. Thus, the complexities related to type of benchmarking calls for study in this area. Even after the factors are identified, the applicability to real life situation still remains as a question.

This paper aims at developing an appropriate mathematical model for measuring productivity in an IT organization. Prominent factors affecting productivity were identified. In a highly competitive market, IT organizations need to control these factors in such a way that high productivity is obtained while meeting quality specifications of the customers. It is also important to find the degree of influence that each factor has on productivity and quality. Once such degree of influence is known, to develop a mathematical model, which will help project members to control and monitor productivity value, becomes relatively easier.

Given the nature of problem, logarithmic form and nonlinear forms of regressions were considered inappropriate and rejected, and finally linear multiple regression was chosen. The regression coefficients from this technique represent the independent contributions of each independent variable in predicting the value of the dependent variable. This implies that, while keeping all other variables constant except one variable, the dependent variable will be influenced by this variable by an amount of its regression coefficient.

REFERENCES

[1] Sanjay Mohapatra, 2012, Information Theory and Best Practices in the IT Industry

[2] J. N. Kapur and Q.J.A Khan, 1979, Some Mathematical Models for Population Growth

[3] N.H Bingham, John M. Fry, 2010, Regression: Linear Models in Statistics

[4] Garrett M. Fitzmaurice, 2006, Estimation in regression models

[5] P. Chandramouli, 2009, Mathematical Modeling and Simulation