PMWorldToday

Published in *PM World Today* – October 2009 (Vol XI, Issue X)

PM WORLD TODAY – FEATURED PAPER – OCTOBER 2009

Mathematical Theory of Human Work (Methodological Problems and Static Mathematical Models of Human Work)

*By **Pavel Barseghyan**, PhD*

Abstract

Over the past few decades there have been made many attempts to develop statistical methods for project estimations based on historical data.

Despite the huge amount of wasted effort, by far, statistical methods in project management cannot be considered satisfactory because of their unacceptably large estimation errors.

The most dangerous situation during the processing of data is their interpretation without a top-down conceptual model, guided only by their external attributes, as their accumulation and the orientation of data in the project space.

Because of unreliability of statistical data mining methods, solutions of many problems of quantitative project management simply have to be started from scratch.

This state of affairs requires extensive research to address high priority problems of fundamental nature in the theory of project management.

Therefore, at present the primary challenge for quantitative project management is not how to find solutions for the managing of complex projects in the difficult and unpredictable environments (though this is a very important problem too), but how to manage the most ordinary and simple projects in easy and predictable environments. Unfortunately even for these simple cases, modern quantitative project management doesn't have correct solutions.

Without knowing solutions of the problems for simple cases it is simply impossible to find correct solutions for highly complicated cases. From here the high failure rate for complex projects exist.

To improve the overall situation in the field of quantitative project management and its exit from the current crisis it is required to conduct systematic studies in mathematical modeling of human labor and the creation of a common theoretical framework for analysis and synthesis of projects.

This paper consists of two parts dedicated to the discussion of the methodological problems of quantitative project management and development of the static mathematical models of human labor.

Introduction: Methodological problems of project estimation

Quantitative and qualitative methods are working in parallel in project management for a long time complementing each other. The purpose of these methods is to achieve the objectives of the project by correct planning and monitoring during the course of its implementation.

Traditionally the role of qualitative methods in project management is higher than the role of quantitative methods in it, but the accumulation of detailed quantitative data on the projects in the past few decades and attempts to analyze those opens new opportunities and allow for the new approaches to the problems of quantitative descriptions of projects.

Many attempts are made to construct statistical models of project estimation using project historical data. Attempts to predict the parameters of the projects in the conditions of increased uncertainty and risk are made too. All these attempts have so far had a dubious success, since the errors of estimates and predictions of projects are unallowably high.

Therefore the problem of paramount importance for the project management community is not the building of a global theory of project estimation in a dynamically changing environment with increased risks, but the building of the relatively simple methods of project estimation with acceptable accuracy.

The true content of the project estimation problems which is necessary and meaningful today is incomparably simple, than it is possible to think. The discussion deals about the fact that currently even in the easy predictable environments with low risk levels we do not have reliable methods of estimation and prediction of the parameters of projects.

For the explanation of the aforesaid let us examine a simple example of the conversion of a project [1].

In this work the complex behavior of projects is described by the following state equation:

$$N_{av} * T = \frac{S * D}{P} \tag{1}$$

Here N_{av} - is the average team size, T - is the project duration, P - is the team productivity, S - is the project size, D - is the project difficulty.

We can add the level of project reuse R then the new size of project will be $S - R$ and the corresponding state equation of project will have the following form

$$N_{av} * T = \frac{(S - R) * D}{P} \qquad (2).$$

Each specific set of parameters of the project characterizes its state in the project space. A change in the value in one of the parameters leads to the specific changes in the remaining parameters, and as a result project moves to a new equilibrium state in the project space.

In spite of their relatively simple form, these equations reflect an extremely complex behavior of interdependencies between parameters of the project.

These equations can be used for various project analysis purposes including the change analysis of the parameters of projects.

The transition from one state in the project space to another state occurs along the specific trajectories. These trajectories are the reflections of the fundamental functional relationships between parameters of the project. Describing well the balance of project's total effort at each point of project space, equations (1) and (2) cannot describe transition trajectories between the different points of this space. Therefore the equations of state of projects cannot be directly used for the analysis of project changes. Let's illustrate this using an example from [1].

Example: Assume instead of the old project size S in expression (1) we have a new size $S + \Delta S$, where ΔS is the change of project size. The question is that what consequences can have this change for the whole project. It is clear that changing project size we need to change project duration on some value ΔT and project average staffing on another value ΔN_{av}. In its turn the change of project average staffing ΔN_{av} will result a new value of team productivity $P + \Delta P$ because of the changed interaction between the people. This will cause a serious uncertainty because the change ΔS will generate three new changes ΔT, ΔN_{av} and ΔP. This will result a transition of the project from one state to a new state in project space with a new balance equation

$$(N_{av} + \Delta N) * (T + \Delta T) = \frac{(S + \Delta S) * D}{P + \Delta P} \qquad (3)$$

To be able to manage the project work with ΔS change we need to know the values of changes ΔT, ΔN_{av} and ΔP.

The solution of this problem is beyond of the capabilities of the contemporary quantitative project management because from a formal mathematical point of view we have one equation (3) and three ΔT, ΔN_{av} and ΔP unknowns. In fact in accordance with the equation (3) takes place a division of the increment of project size ΔS between three increments ΔT, ΔN_{av} and ΔP. To solve this problem we need two more equations or some assumptions about the character of change trajectories in the project space.

So, now, modern quantitative project management does not have a precise scientific answer to this question. As for the pseudo-scientific methods in this field, we have to say that so far there are many of them.

Meanwhile, the change problem in the course of projects is a basic one and without having appropriate quantitative methods of dealing with different sort of project changes the whole modern quantitative project management is simply meaningless.

The solution of this problem can be based on the statement that there exist fundamental relationships between project parameters and we are able to find out those relationships by adding some new principles to the basic state equation (1) of projects.

The above example illustrates a comparatively modest deterministic problem of the project change analysis, namely, what will happen with the planned project, if we change one of its parameters. In this example we deal with a static conversion of the project, which has nothing to do with the dynamics of its parameters over time.

Crisis in quantitative project management

Thus, it can be stated that to date there is no unified quantitative approach to the problems project management. Specifying the problems, we can say that at present the quantitative methods to determine the functional relationships between the parameters of an arbitrary project are simply not available.

Existing methods, in most cases are not correct, or at best have a marginal role with respect to the dominant qualitative methods in this area.

Therefore, at present the primary challenge for the quantitative project management is not how to find solutions for the managing complex projects in difficult and unpredictable environments (though this is a very important problem too), but how to manage the most ordinary and simple projects in easy and predictable environments.

Suffice it to say that all modern quantitative project management is based on the statistical functional relationships between the parameters of the project. In turn, these functional relationships are derived from the project data using methods of regression analysis. But the fact is that the techniques of regression analysis cannot be applied to this data directly, because they are not the results of the experiment in the classical sense of the theory of experiment, but are the results of often indiscriminate collection of project data.

The results of this wrong methodological approach to the project data mining are the big project estimation errors. Therefore, because of the unreliability of the statistical data mining methods, solutions of many problems of quantitative project management simply have to be started from the scratch.

Difficulties of project data mining

Data mining in any field of knowledge can be considered successful if as a guide for the entire mining process serves a top-down conceptual interpretation of the phenomenon or process under investigation in the form of a mathematical model or in the best case in the form of a full-blown mathematical theory. Otherwise, the same data can have a variety of interpretations, which may be in conflict with each other.

A similar situation may arise when different parts of the data are interpreted by different modeling approaches. In this case, the probability that the outcome of such interpretations of the data will simply conflict with each other is very high.

But the most dangerous situation during the processing of data is their interpretation without a top-down conceptual model, guided only by their external attributes, as their accumulation and the orientation of data in the project space.

Unfortunately, currently all these shortcomings are characteristic for the data mining and interpretation in project management.

The role of top-down approach for data mining and knowledge discovery from data

In order to avoid the data analysis errors connected with misinterpretations of the project data and baseless/arbitrary conclusions it should be realized that top-down modeling of the same phenomenon or process under study has a paramount importance. If in the ideal case some model (or in the best case a fundamental theory) has a capability to explain and interpret qualitatively some phenomenon or process correctly then the role of data mining and analysis reduces to the correct interpretation of the coefficients of the mathematical model only.

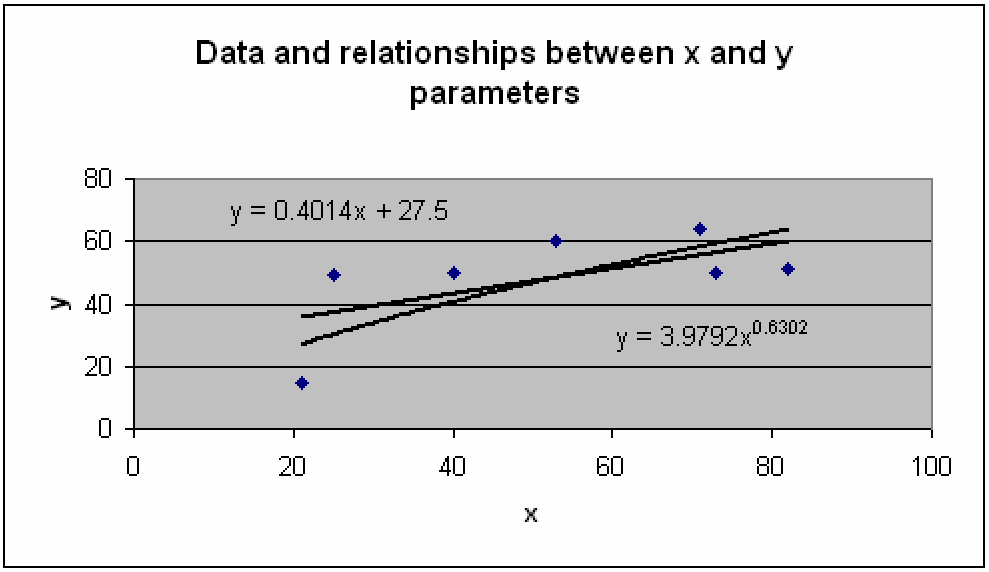


Fig.1. Options of a bottom-up interpretation of a specific data set

Let's illustrate the above statement by one trivial example. Assume there is a passive data about the relationship between unknown x and y parameters of a process or phenomenon, shown in Fig.1. Any data analysis mechanism that ignores the fact that the data is a result of a passive experimentation will try to approximate the data using the external attributes of the specific data set. The results can be the linear and power approximations shown in the picture.

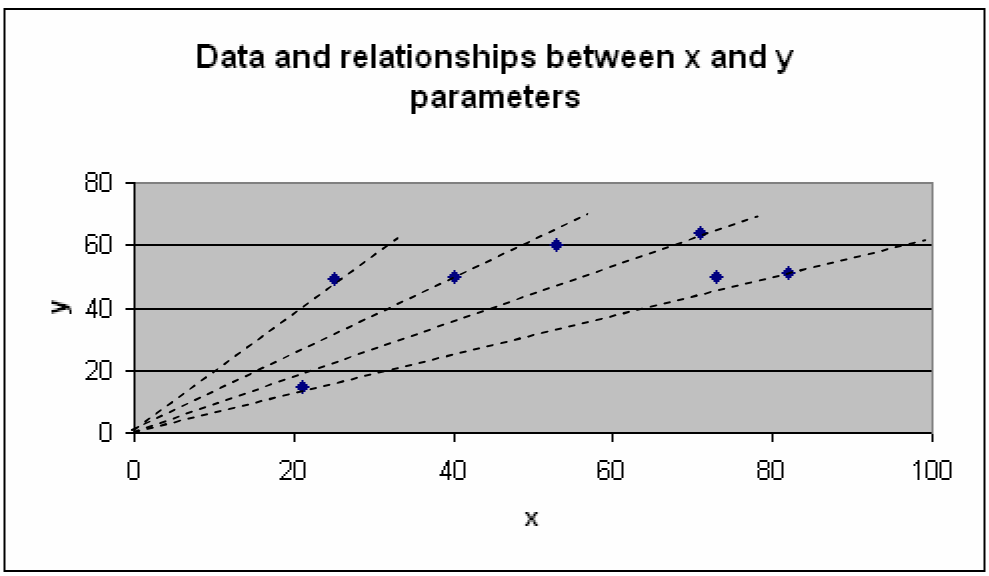


Fig.2. Interpretation of the data with the aid of Ohm's law

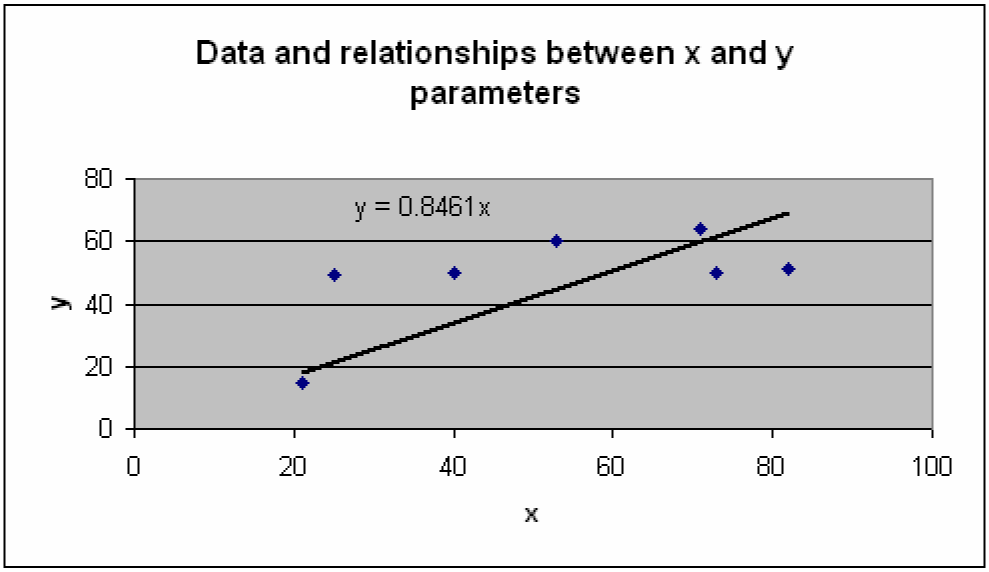


Fig.3. Averaged interpretation of the data with the aid of Ohm's law

Now assume that it is known that the object under study is a linear electrical circuit and parameter y is the voltage and parameter x is the current. This information will dramatically change the attitude to the data analysis process, because it is clear that the correct interpretation of the data is to connect each data point with the point [0, 0] (Fig.2.).

If this particular data set needs to have an averaged interpretation then the correct result has to be a linear function that passes through the origin of the coordinates. It is presented in Fig.3.

In this trivial and simple example the Ohm's law is a top-down guide for data interpretation. In this case that top-down guidance simply means that any approximation of the data has to be linear and it must pass through the origin of the coordinates.

The comparison of two results of data interpretation (with and without a top-down guidance) indicates that how it is dangerous to interpret the data by bottom-up approach using as a guiding rule the external attributes of data, namely concentrations of data points and their orientation in the given system of coordinates.

Moreover, this approach is highly unreliable and can be correct by a happy chance only. In the specific case when the data is very sparse this bottom-up data dependent approach to the data interpretation is a nightmare that can lead to the quite baseless and meaningless results.

Static and dynamic models of human labor

According to [2] human work can be **static** and **dynamic**. If the characteristic parameters of human work are not dependent on time, then such work is called **static**. Otherwise it is called **dynamic.**

It is convenient to link the definition of the static human work with the state equation (1). For instance, if the average staffing level of a working human group is constant, equal to N_{av1} then the state equation (1) is a static model of human labor.

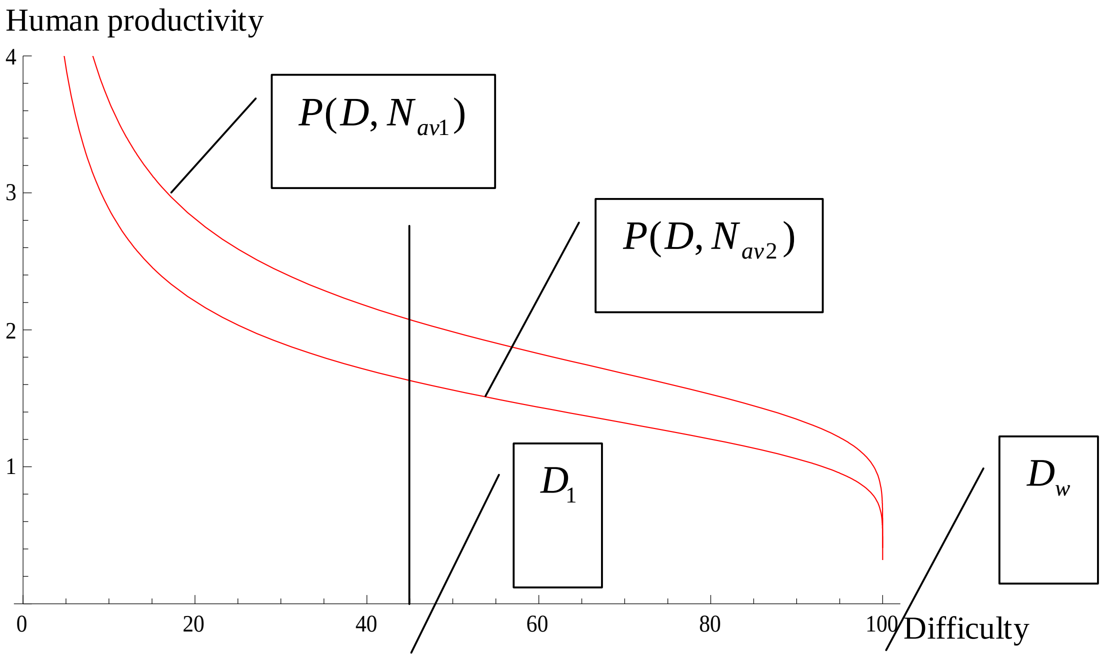


Fig.4 Differences between two productivities for the same difficulty of work D_1 due to two numbers of working people N_{av1} and N_{av2}

If the work has a size S and difficulty D then the state equation (1) will have the form

$$T_1 N_{av1} P_1 = S * D \qquad (4)$$

Here T_1 and P_1 are the corresponding values of the work duration and team productivity for the average staffing N_{av1}.

Any change in staffing level doesn't influence the difficulty of human labor. Therefore any change of the staffing level from N_{av1} to N_{av2} will change only the values of the work duration and the team productivity. So for the new staffing level N_{av2} we will have a new duration T_2 and new team productivity P_2 with the new state equation

$$T_2 N_{av2} P_2 = S * D \qquad (5)$$

In this case of change of the average staffing level doesn't change the work difficulty although the functional relationship between productivity and difficulty remains in force. As we know from [2] this functional relationship obeys the equation

$$\frac{dP}{dD} = -\frac{AP^2}{P_{Ind}(N_{av})D^{\alpha}(D_w - D)^{\beta}} \qquad (6)$$

In this equation P_{Ind} - is the individual productivity index, which is a relative measure of the human work productivity. This parameter is a function of the average staffing level N_{av} (Fig.4). A – is a parameter which is a function of the work structure and management style (meetings, communication, etc.), α and β - are the form factors that cover the individual diversity of the human's capacity to overcome the difficulties.

D_w - is the work difficulty limit.

Fig.4 indicates the differences between two productivities for the same difficulty of work D_1 due to two numbers of working people N_{av1} and N_{av2}.

Constancy of the work difficulty D allows establishing a relationship between the two static states of the same project. For that we need to equalize expressions (4) and (5). It will result the following condition for the transformation of the same project from one static state to another static state.

$$T_1 N_{av1} P_1 = T_2 N_{av2} P_2 \qquad (7)$$

In fact expression (7) reflects the relation between two states of equilibrium of an arbitrary project.

If the number of people working on the project is a function of time, the equation of state of the project in the form of (1) does not apply directly for the analysis of the project. In this case, the dynamics of the number of people can be described by differential equations. Related issues will be addressed in a special paper.

Consequences of the state equation of projects, presented in general form

Analysis of human labor shows that in the state of equilibrium there is a functional relationship between its parameters. In particular, such relationship exists between the parameters of the arbitrary project. This functional dependence in a general form can be expressed by the equation

$$f(W, P, T, N_{av}) = 0 \qquad (8)$$

Here W - is the amount of work.

Taking into account that the amount of work is the product of the size S of labor and its difficulty D [1], equation (8) can be expressed as

$$f(S, D, P, T, N_{av}) = 0 \qquad (9)$$

We can also add the reuse R and the state equation will have this form

$$f(S, R, D, P, T, N_{av}) = 0 \qquad (10)$$

View of this function is different for different works and, in particular, projects, but in all cases, it describes the state of human work. Therefore, equation (8) and (9) can be described as the state equations of human work.

For so-called ideal projects, this equation has a specific form, which is given in [1].

$$N_{av} * T = \frac{(S - R) * D}{P} \qquad (11)$$

Given the equation of state, changes of project parameters in the equilibrium bound by certain relations (for the sake of brevity, let us call all kinds of human work projects).

If these changes of the project state are small, said relationships between project parameters can be established without the knowledge of a specific type of functions (8), (9) and (10).

Project change analysis

In order to establish functional relationships between project parameters without knowing the specific form of the equation (8), let's resolve it on one of the variables, for example productivity P, that is, represent productivity P as a function of the remaining three variables W, T, and N_{av}.

$$P = P(W, T, N_{av}) \qquad (12)$$

Let's conduct the change analysis for a project with constant average number of people N_{av1}.

$$P = P(W, T, N_{av1}) \qquad (13)$$

If you maintain a constant the complexity of the project W and change the duration of the project T by a small number dT, the productivity will also receive a small increment, determined by the expression

$$d_1 P = \left(\frac{\partial P}{\partial T}\right)_W dT \qquad (14)$$

Sign of the derivative W indicates that in the differentiation of productivity P with respect to project duration T complexity of the project should remain constant. Thus, (14) is the partial derivative of productivity with respect to project duration, holding complexity W constant.

Now let the duration of the project be a constant, but the complexity of the project receives a small increment dW. Then, the corresponding increment of the productivity P would be the expression

$$d_2 P = \left(\frac{\partial P}{\partial W}\right)_T dW \quad . \qquad (15)$$

If we change both complexity of the project and its duration, the increment of productivity would be the sum

$$dP = d_1P + d_2P \quad . \tag{16}$$

Substituting d_1P and d_2P from (14) and (15) we can have

$$dP = \left(\frac{\partial P}{\partial T}\right)_W dT + \left(\frac{\partial P}{\partial W}\right)_T dW \quad . \tag{17}$$

This expression is true for the arbitrary small increments dT and dW therefore they can be considered as independent variables.

But the expression (17) remains in force also in the case when restrictions are imposed on the changes of the dT and dW in the form of a functional relationship between them. Then the increments dT, and dW will no longer be independent. For example, in the case of constancy of productivity P its increment $dP = 0$ and expression (17) transforms into

$$\left(\frac{\partial P}{\partial T}\right)_W dT + \left(\frac{\partial P}{\partial W}\right)_T dW = 0 \tag{18}$$

Solving this equation with respect to $\frac{dT}{dW}$ the value obtained in this way will give partial derivative $\left(\frac{\partial T}{\partial W}\right)_P$ because dT and dW mean increments of duration and complexity with constant productivity.

Thus

$$\left(\frac{\partial T}{\partial W}\right)_P = -\frac{\left(\frac{\partial P}{\partial W}\right)_T}{\left(\frac{\partial P}{\partial T}\right)_W} \tag{19}$$

Since there is an obvious relationship

$$\left(\frac{\partial P}{\partial T}\right)_W = \frac{1}{\left(\frac{\partial T}{\partial P}\right)_W} \quad , \tag{20}$$

expression (19) can be presented in the following form

$$\left(\frac{\partial T}{\partial W}\right)_P = -\left(\frac{\partial P}{\partial W}\right)_T \left(\frac{\partial T}{\partial P}\right)_W \qquad (21)$$

This expression can be transformed into the form

$$\left(\frac{\partial W}{\partial T}\right)_P \left(\frac{\partial P}{\partial W}\right)_T \left(\frac{\partial T}{\partial P}\right)_W = -1. \qquad (22)$$

This and many other similar relationships between project parameters allow enhancing the capacity of data mining methods sharply, using for that purpose not only the values of project parameters, but also the values of their partial derivatives.

Human work complexity definition problems

The main requirement to the methods of quantitative description of the complexity of human work is their invariant behavior with respect on the people's productivity. In other words the complexity of work should be independent and objective measure of the amount of work spent (no effort, namely a measure of work) required for its completion. People with different characteristics, including productivity of their labor, may spend different amount of effort to perform the same work.

If this requirement is not met, the resulting complexity, obtained by such quantitative definitions of work, which include the productivity of people, cannot be used for the objective comparison of different estimations of human work.

A good example in this regard could be the use of Function Points to determine the complexity of software projects [3].

Let us illustrate the meaning of the human invariant approach to determining the complexity of human work on a simple example of grass cutting in the field that has an area S.

It is obvious that in order to determine the complexity of the work the area of the field is a critical parameter, but on the other hand, it is insufficient to have a complete quantitative definition of the complexity of such work. The reason for that is the variation of the density d and height h of the grass from point to point of the field. That is, from point to point the difficulty of work varies, which also affects the overall complexity of work.

Quantitatively the difficulty D of this work is a function of the density d of grass and its height h. In their turn the density of grass d and its height h are the functions of coordinates x and y. This means that the complexity of this work can be expressed as

$$W = S * D = S * D[d(x, y), h(x, y)] \qquad (23)$$

It is clear that the skills of people and characteristics of grass cutting tools should also influence the overall process. But they should not have any relation to the definition of complexity. Characteristics of individuals and characteristics of grass cutting tools and machines are directly related only to the total amount of effort E spent on the completion of work W.

Any attempt to include the characteristics of people and characteristics of instruments in the definition of the complexity of work is fraught with very undesirable consequences. For example, if the definition of complexity is composed of only the characteristics of fields and grass, it helps to easily compare the complexity of different fields. But if the definition of complexity in addition to the physical parameters of field and grass includes characteristic of people and tools also, then it is not clear what we are comparing, the complexity of work, or the characteristics of working people and their tools.

Another point is that there should be a correspondence between the difficulty of work and productivity of individuals. Fig.5 and Fig.6 represent the duration of work and productivity of three people with different timing and productivity characteristics.

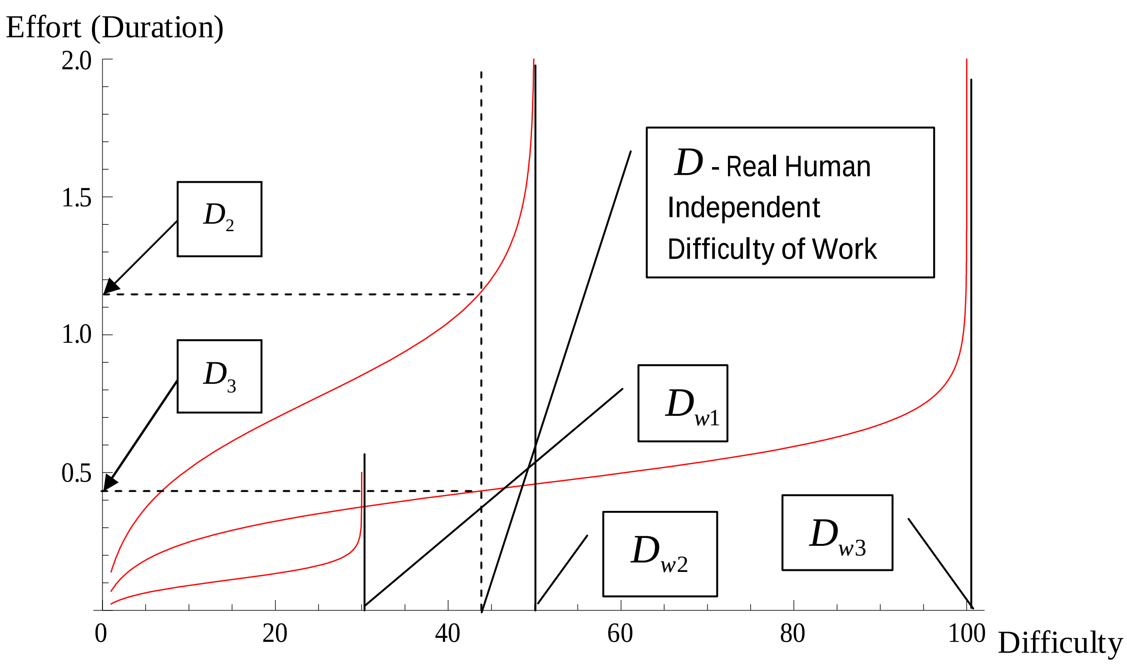


Fig.5 Three individuals with different abilities to overcome the real difficulty of work D

If the main reason for quantifying the complexity of human work is the estimation of expected effort and cost, the analysis of Fig.5 and Fig.6 indicates that any involvement of human productivity in the definition of work complexity introduces subjectivity and therefore it is unacceptable.

In Fig.5 and Fig.6 are shown the real difficulty D which is human invariant and human dependent characteristics of three individuals. Each of individuals has its own maximum difficulty limit, correspondingly D_{w1}, D_{w2} and D_{w3}.

For the assigned difficulty D the productivity of the first individual is equal to zero, and the productivities of the second and third individuals are equal respectively P_2 and P_3. Differ also efforts and durations for overcoming the difficulty D. Thus, the first individual work will carry out in infinite time, i.e., he will not carry out the work. Efforts or durations of the work of the second and third individuals are equal respectively D_2 and D_3.

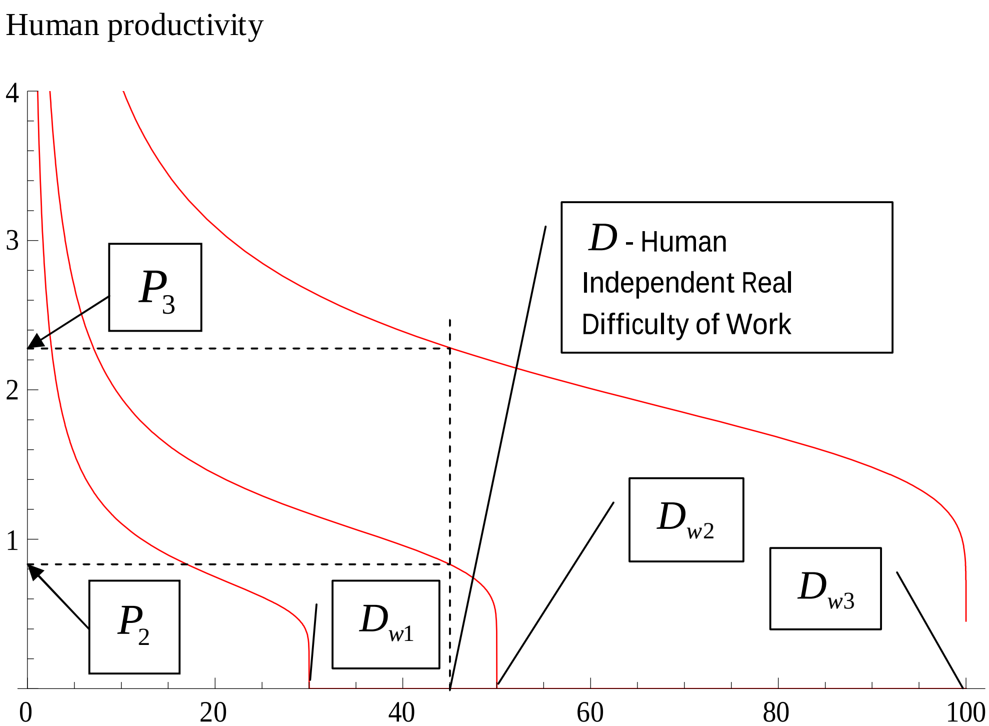


Fig.6 Productivities of three individuals with different abilities to overcome the real difficulty of work D

Thus, the correct definition of the complexity of work may only include the real difficulties of work, which is independent of the characteristics of working people.

Let's illustrate the above statements using state equation of projects from [1]

$$E = \frac{W}{P} = \frac{(S-R)*D}{P} \tag{24}$$

In this expression the numerator $(S-R)*D$ does not depend on the human factor directly, so it can be a measure of the project complexity. As for the denominator P, which is the human productivity, it cannot be a part of the definition of the project complexity in principle.

Complexity and effort of multi-component projects

Analysis of complexity and the total effort of multi-component projects are based on two fundamental principles.

1. Additive property of total effort of the project and its components,
2. The equation of state which is applicable for any part of the project.

This means that total effort can be presented as a sum where E_i is the effort of the work component "i".

$$E = \sum_{i=1}^{n} E_i \tag{25}$$

In its turn E_i can be presented in the form

$$E_i = \frac{(S_i - R_i)*D_i}{P_i} \tag{26}$$

where S_i, R_i, D_i, and P_i correspondingly are the size, reuse, difficulty and productivity for the part "i" of the project.

Substituting expression (26) into the (25) the overall project effort can be presented in this form

$$E = \sum_{i=1}^{n} \frac{(S_i - R_i)*D_i}{P_i} \tag{27}$$

Static mathematical model of work with random difficulty

Let's now assume that the difficulty of the grass cutting work in the field has a random character. Let's denote by $f(\delta)$ the difficulty density function of the grass cutting for the area S. It is clear that for the difficulty interval [$\delta, \delta + d\delta$] the area dS can be defined as

$$dS = Sf(\delta)d\delta\,. \qquad (28)$$

It is also clear that the amount of work per unit area is a function of difficulty δ. Let's denote this amount of work by $W_u(\delta)$. From here one can state that the amount of work dW for the arbitrary small area dS can be defined by the expression

$$dW = W_u(\delta)dS \qquad (29)$$

Substituting the value of dS from (28) into the expression (29) one can obtain

$$dW = SW_u(\delta)f(\delta)d\delta \qquad (30)$$

Integrating this expression in the interval $[0, \infty]$ one can find the total amount of work needed for the treatment of the area S.

$$W(S) = S\int_0^{\infty} W_u(\delta)f(\delta)d\delta \qquad (31)$$

Using this expression it is possible to calculate the total effort E needed for the treatment of the area S. If the average productivity of the treatment of the area S is P then the total effort can be calculated as

$$E(S) = \frac{W(S)}{P} = \frac{S\int_0^{\infty} W_u(\delta)f(\delta)d\delta}{P} \qquad (32)$$

In the more general case when productivity P is a function of difficulty δ, the total effort for the interval $[\delta, \delta + d\delta]$ can be defined as

$$dE = \frac{dW}{P(\delta)} = S\frac{W_u(\delta)f(\delta)d\delta}{P(\delta)} \qquad (33)$$

After integration of (33) we can have

$$E(S) = S\int_0^{\infty} \frac{W_u(\delta)f(\delta)}{P(\delta)}d\delta \qquad (34)$$

This expression can be generalized for the arbitrary number of people N. Also analysis can be continued by accounting for the functional relationship between productivity and difficulty from [2] in the form of the differential equation (6).

Static mathematical model of human labor with extremum principles

Equation of state represents all possible human labor related trajectories in project space. Each of these trajectories represents a realization of the human work process, but in terms of the objectives of the project, these trajectories differ from each other. Human labor is an extreme process, therefore in the process of work are realized those trajectories in project space which provide extremum value to the project objectives.

In addition, for each specific situation trajectories reflect the right trade-off between the objectives of the project. This means that such a trajectory in the project space can be found as a joint solution of the equation of state of the project (2) and the objectives and goals of the project.

The mathematical formulation of this problem would be as follows.

$$\left.\begin{array}{l} N_{av} * T = \dfrac{(S-R)*D}{P} \\ \text{Goal1} = \text{f1(Project parameters)} \\ \text{Goal2} = \text{f2(Project parameters)} \\ \text{-.-} \\ \text{Goaln} = \text{fn(Project parameters)} \end{array}\right\} \qquad (35)$$

This approach to the analysis of the trajectories in the project space implemented in [4] for the case of a single objective function in the form of the headcount gradient (gradient of the number of working people).

The direct consequence of this approach is the following system of differential equations [4]:

$$\frac{dW}{dP} = -\frac{P}{W} , \qquad (36)$$

$$\frac{dW}{dT} = -\frac{T}{W} , \qquad (37)$$

$$\frac{dP}{dT} = \frac{T}{P} . \qquad (38)$$

In [4] it is shown that without project data, relying only on the joint analysis of the equation of project state and the goals of projects it is possible to derive functional relationships between the parameters of the project in an analytical way.

These relationships can serve as a basis for project estimations as well as for the analysis of project data [5].

Conclusions

1. Over the past few decades have been made many attempts to develop statistical methods for project estimations based on historical data.

2. Despite of the huge amount of wasted effort, by far, statistical methods in project management cannot be considered satisfactory because of their unacceptably large estimation errors.

3. This state of affairs requires extensive research to address high priority problems of fundamental nature in the theory of project management.

4. Instead, there is a continued expansion of the scope of problems in the direction of increasing complexity of projects in environments with high level of risk.

5. At the same time for the analysis of these complex problems are used the same erroneous statistical methods of project estimation.

6. If this state of affairs can be considered acceptable for the companies engaged in business, it cannot be considered normal in academic science.

7. Such an approach erases the boundaries between academic science and business, because academic science ceases to be a leader in the development of the science of project management.

8. Therefore, at present the primary challenge for the quantitative project management is not how to find solutions for the managing complex projects in difficult and unpredictable environments (though this is a very important problem too), but how to manage the most ordinary and simple projects in easy and predictable environments.

9. Without knowing solutions of problems for simple cases it is simply impossible to find correct solutions for highly complicated cases. From here the high failure rate for complex projects.

10. The most dangerous situation during the processing of data is their interpretation without a top-down conceptual model, guided only by their external attributes, as their accumulations and the orientation of data in the project space.

11. Because of unreliability of the statistical data mining methods, solutions of many problems of quantitative project management simply have to be started from the scratch.

12. Pure mathematical analysis of the state equation of projects allows establishing functional relationships not only between the project parameters, but also between their derivatives.

13. Availability of functional relationships between the derivatives of project parameters opens new opportunities for project data mining.

References

1. Pavel Barseghyan. (2009). Principles of Top-Down Quantitative Analysis of Projects. Part1: State Equation of Projects and Project Change Analysis. PM World Today – May 2009 (Vol XI, Issue **V**).

2. (Pavel Barseghyan. (2009). Task Assignment as a Crucial Factor for Project Success (Probabilistic Analysis of Task Assignment). PM World Today – April 2009 (Vol XI, Issue **IV**).

3. Estimating Software Costs: Bringing Realism to Estimating, by Capers Jones. 2007.

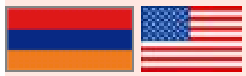
4. Pavel Barseghyan (2009) Principles of Top-Down Quantitative Analysis of Projects: Part 2 Analytical Derivation of Functional Relationships between Project Parameters without Project Data. PM World Today – June 2009 (Vol XI, Issue VI).

5. Pavel Barseghyan (2009) “Problems of the Mathematical Theory of Human Work (Principles of mathematical modeling in project management)”. *PM World Today* – August 2009 (Vol XI, Issue VIII).

About the Author

Pavel Barseghyan, PhD

Author



Dr. Pavel Barseghyan is the Vice President of Research for Numetrics Management Systems, has over 40 years experience in academia, the electronics industry, the EDA industry and Project Management Research. Also he is the founder of Systemic PM, LLC, a project management company. Prior to joining Numetrics, Dr. Barseghyan worked as an R&D manager at Infinite Technology Corp. in Texas. He was also a founder and the president of an EDA start-up company, DAN Technologies, Ltd. that focused on high-level chip design planning and RTL structural floor planning technologies. Before joining ITC, Dr. Barseghyan was head of the Electronic Design and CAD department at the State Engineering University of Armenia, focusing on development of the Theory of Massively Interconnected Systems and its applications to electronic design. During the period of 1975-1990, he was also a member of the University Educational Policy Commission for Electronic Design and CAD Direction in the Higher Education Ministry of the former USSR. Earlier in his career he was a senior researcher in Yerevan Research and Development Institute of Mathematical Machines (Armenia). He is an author of nine monographs and textbooks and more than 100 scientific articles in the area of electronic design and EDA methodologies, and tools development. More than 10 Ph.D. degrees have been awarded under his supervision. Dr. Barseghyan holds an MS in Electrical Engineering (1967) and Ph.D. (1972) and Doctor of Technical Sciences (1990) in Computer Engineering from Yerevan Polytechnic Institute (Armenia). Pavel can be contacted at pavel@systemicpm.com.