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Designing a Model for Measuring Manpower Productivity in the Project-based Service Organizations (Electricity Company as Case Study)

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Abstract

Manpower productivity index is one of the most important productivity measures. This index is the ratio of added-value to number of the employees (or the employee's salaries). Regarding this fact that manpower cost, annual depreciation, and annual profit is almost fixed and isn't indicative of the organizations actual performance, therefore measuring added-value in the common methods is fixed and unrealistic and is not function of the organizational performance. Therefore, with respect to the project-based nature of such organizations, a large amount of their budget is spent for the projects in progress and hence measuring the added-value through the common formula and without considering projects means that large amount of the organizations capital and manpower, which are involved in the project implementation, are not considered in measuring added-value. Therefore, in order to measure the actual performance of the organization, the added-value that is gained from the projects future exploitation should be added to its added-value.

In the designed model, added-value is calculated so that all of the organizations outputs include current activities and also the investments that will be exploited in the future. As a

result, the calculated value is overall reflects of the organizations performance and also manpower productivity is calculated actually.

In order to measure the productivity in this method, the actual added-value that is achieved from offering the services should be extracted from financial statements. In order to measure the added-value of the projects in progress, the future incomes from their exploitation are simulated during the projects lifetime and then take from maintenance costs and inputs; its present value is calculated for the base year through engineering economics formula.

Since, manpower productivity is the ratio of added-value to the organizations manpower, it is possible to measure every units and employee's productivity through determining every their role by organizational excellence models in creating the added-value and then determining their role in the units added-value.

The designed model is implemented in an organization with the mission of supplying and distributing the electricity energy and then every units productivity in this organization is calculated through this method.

Keywords: Productivity Measurement, the Potential added-value, the Actual added-value, and Project-based organization

Introduction

Hoisin introduced the productivity for the first time in 1776. After about a century in 1833, Liter defined productivity as the power and ability of producing [4]. Nowadays, the organizations are forced to achieve the best outputs regarding their limited resources. The productivity is an index for evaluating systems performance and determining the extent of their success or failure in achieving the goals regarding the appropriate consumption [7].

Increase the productivity at the national level leads to improve in citizen's life quality, decrease in the inflation, and create competitiveness potentiality in this level. This is strived from increasing productivity of the organizations, businesses, and economic institutes. Therefore, this can be considered as an index for evaluating progress and development of a country in comparison to other ones.

Productivity is the main core of competition at the organizational level in combining the production factors for creating more value. Therefore, the productivity measurement can be used in terms of two dimensions that the first is change in the productivity measurements trend during the time periods that help the organization to analyze the reasons of increase or decrease in the productivity in different areas and the second is comparing the productivity with the other organizations and institutes for determining relative position that can be used as the beneficial instrument in the future planning about products, services, process, market, and other factors in a competitive environment.

Manpower productivity is one of the most important productivity measures. This is the ratio of the added-value to the employees or their salaries. In this study, a model was designed as the main factor of determining the manpower productivity index with respect to the

characteristics and conditions of project-based public service organizations. With respect to the purpose of this study that is to measure the manpower productivity in each of the organizational main departments, a mechanism was developed for determining the role of each unit in the total added-value and finally the manpower productivity was studied in the organization and also manpower productivity of each unit was measured.

Literature review

In addition to the inconsistent productivity measurement problem, another issue that contributes to the complexity of productivity estimating is the existence of numerous productivity-influencing actors, such as weather and labor skill. Productivity rates can fluctuate considerably due to the influence of these factors. Numerous studies have been conducted to examine the productivity influencing factors of various construction activities, such as concrete construction [1], masonry construction [2], pile construction [3], and bridge false work [4]. Therefore, a number of modeling techniques have been introduced to study the relationship between influencing factors and productivity for estimating purposes. These modeling techniques include statistical and regression models, expert systems, artificial intelligence, and simulation. For example, regression-based models were used to study earthmoving productivity [5] and masonry productivity [2,6]. An example of using expert systems for productivity modeling is the system developed by Hendrickson et al. _1987_ for masonry construction. Fayek and Oduba [7] applied fuzzy expert systems to predict productivity of pipe rigging and welding.

studies of Measuring and Modeling Labor Productivity Using Historical Data[8] presents an approach to measuring productivity, collecting historical data, and developing productivity models using historical data. The selection of productivity modeling techniques is primarily determined by the quantity and nature of influencing factors, the complexity of the mapping relationship, and the capability of a particular modeling method, as well as a researcher's preference. ANN and simulation were successfully applied in this research.

ANN is found to be effective in modeling individual activities that have complex detail operations and a complex mapping relationship between productivity and influencing factors. Simulation combined with ANN was successfully applied to model the productivity of a production system that consists of a number of related activities. The proposed methodology and the industrial case study standardized the measurement of productivity in steel drafting and fabrication projects and improved the collection and utilization of productivity data by standardizing its structure and enhancing its interpretation and analysis.

To measure the productivity of a government production unit, we need to measure the prices and quantities of the outputs produced and inputs used by that unit or establishment for two periods of time. Then productivity growth can be defined as a quantity index of outputs produced divided by a quantity index of inputs used by the establishment.[9,10] It is usually possible to measure the price and quantity of inputs in a fairly satisfactory manner[11] but there are problems in measuring the prices and quantities of government nonmarket outputs.

The paper of measuring productivity in the public sector [12] analyzes three possible general methods to measure the price and quantity of nonmarket government outputs. If quantity

information on nonmarket outputs is available, then the first two methods of price valuation rely on either purchaser based valuations or on cost based valuations. If little or no information on the quantity of nonmarket outputs produced is available, then the method recommended in the System of National Accounts 1993 must be used, where aggregate output growth is set equal to aggregate input growth.

Despite the existence of well-developed frameworks within academic economics for thinking about productivity, there appears to be no consensus amongst industry researchers about how to investigate productivity performance in construction. The seminal report on The Social and Economic Value of Construction [13] cites estimates [14] for labor and total factor productivity (TFP) which suggest that the UK construction industry's international record on average labor productivity (ALP) is not as good as its record on TFP.

Woudhuysen [15] states that these figures are inconsistent and that 'output per hour worked should be regarded as the bottom line of productivity'. A common view is that: productivity measures do not deal adequately with the impact of technological change, nor with factor substitution, where capital and equipment may be substituted for labor [16] and that productivity measures are limited because they do not take always take into account factors adding value such as: The effectiveness of management . . . The quality level reached . . . Innovations .. . [16]

The paper of Measuring productivity in the construction industry [17] provides an overview of methods used to measure productivity in the construction industry. The paper has presented a framework that can explain the alleged inconsistencies in the productivity estimates presented in Pearce (2003), and it points to solutions for problems identified in the construction literature. The authors prefer an approach that involves formally modeling the entire production process. Whilst it is accepted that data requirements are a major constraint to such an approach, it is suggested that by establishing a robust measurement framework, data deficiencies can be defined more easily. Guidance on areas where improvements are needed is provided and it is considered that the focus of future research should be in creating new and improving existing datasets.

Necessity of the study

The characteristics and conditions of the project-based service organizations in the developing countries

In the project-based service organizations, it is necessary to design and implement the development and construction projects for their future exploitation in order to sustaining service capabilities for the customers and always large amount of the their capital is spent for development investments so that the they are able to supply more services for their customers and users.
These organizations have especial conditions and characteristics that the productivity measurement models facing problem in them. Some of these characteristics and conditions include the following items.

- Lack of transparency and actuality in the financial statements.

-Investing large amount of organizational budget in the new development and investment section for sustaining service capabilities.
-Using the given financial resources means that governmental budget is allocated for the organization based on the given quantity and then the budget amount and its increase and ---decrease has not direct relationship with the organizational performance.
-Delivering services for the public section.
The fixed cost of these organizations is increasingly almost fixed trend depends on their budget growth.
-The current costs based on the projects implementation are influenced by how to manage the projects and also the quality of the organizations performance.
-The actual incomes are gained from service delivery and are countable.
-The potential incomes of the future exploitation from the projects in progress are predicable that usually is not considered.
-The profit and loss of such organizations are affected by wide spread changes with respect to the governmental macro policies.

The importance and necessity of proposing a new model

Since, manpower costs, annual depreciation, and annual profit is almost fixed in the public service organizations and is not indicative of their actual performance, so the added-value and the productivity are almost fixed and are not a function of the organizational performance and also because of project-based nature of such organizations, always a large amount of their budget is spent in the projects in progress, hence measuring the added-value through the common formula and without considering projects means that a large amount of their capitals and manpower that are involved in the project implementation do not considered in measuring added-value. In order to measure the organizational performance, therefore, the added-value of the future projects exploitation should be added to the organizations added-value. Since the gained added-value from the presented methods in this study includes all of the company's outputs such as current activities and future investments, so the gained value is an overall reflect of the company's performance and their manpower productivities are measured actually.

Describing the proposed model for measuring manpower productivity

In this method for measuring the productivity, the actual added-value that gained from delivering services should is extracted from the financial statements and then is added to the potential added-value that is gained from the future exploitations of the projects in progress. In order to measure the added-value of the projects in progress, the future incomes of their exploitation during the project life should be stimulated and then after subtracting maintenance costs and outcomes from them, their present value should be calculated for base year through engineering economics formulas.

Since manpower productivity is the ratio of the added-value to the organizations manpower, it is possible to determine each units and every employee's productivity through determining the role of every unit in the added-value and then determining role of every employee in the unit's added-value.

Calculating the total added-value in the project-based public service organizations

In a project-based service organization that a large amount of its annual budget is spent in the development section investment, its total added-value is the sum of added-values that are gained from delivering services for the customers (the actual added-value) and estimate of the added-values that are gained from future exploitation from the present investments for the development and the construction projects in progress (the potential added-value). In other words, the total added-value is calculated through the following formula:

Total added-value= (the potential added-value that is gained from future exploitation of the projects in progress) + (the actual added-value that is gained from services delivery)

Calculating the potential added-value that is gained from future exploitation from the projects in progress by production or subtract methods

In the project-based services organizations that always a large amount of their resources are spent in the development investment so that the they are able to supply more services for its customers with respect to the increase in demand, measuring the added-value through the common formula and without considering the projects in progress means that a large amount of the organizations capital and manpower that are involved in the project implementation in every time period do not considered in the added-value calculation. In order to calculate the actual performance, therefore, the gained added-value from future projects exploitation should also be calculated.

With respect to the formula of total added-value:

The potential added-value that gained from the future exploitation of the projects in progress= output (or outcome – input)

Outputs or outcomes

All of the financial benefits that are gained from future exploitation from the projects in progress can be considered as organizational outcomes or outputs in a year.

In order to estimate the projects outcome, it is necessary to calculate three factors including estimate of the projects nominal capacity during a year after its construction, estimate of the project performance efficiency in time of its construction, and estimate of the projects lifetime. Therefore, the project output is the result of the multiplication of these factors.

Project output= (nominal capacity * performance efficiency * lifetime)

Project nominal capacity: this refers to annual income of the project exploitation that is calculated based on the standard rates.

Project performance efficiency: every projects performance is subject to comprising the performed work to the predicted work. The performance efficiency is calculation of the planned time and cost variances with the projects actual performance.

This index is the result of the multiplication of the CPI by SPI.

The Cost Performance Index (CPI) in indicative of the project cost performance and is the result of the ratio of the Budgeted Cost of Work Performed (BCWP) to the Actual Cost of Work Performed (ACWP). If this index is more than 1, indicates that the project will be performed cheaper than its primary estimate and if this is less than 1, indicates that the project will be performed with more cost than its primary estimate and finally if the CPI is 1, the project will be performed accordingly to its primary estimates. Schedule Performance Index (SPI) is the ratio of the Budgeted Cost of Work Planed to the Budgeted Cost of Work Scheduled. If this index is more than 1, indicates that the project will be finished sooner the primary schedule and if it is less than 1, the project will be finished later than the primary estimate. Finally if the SPI=1, then the project will be finished according to the primary schedule.

Estimation of the project lifetime: this refers to the estimation of the time period that the project can respond the nominal capacity and is exploitable.

Data

The data is all of the project construction costs (construction costs) and the predication of the projects exploitation costs during its lifetime.

Calculating the actual added-value that is gained from delivering services through sum and distribution methods

According to the sum or distribution methods, the added-value is gained from sum of the manpower costs, net profit, the paid taxes, and the depreciation. In other words:
Added-value that is gained from delivering services = manpower costs + net tax + depreciation + distributed costs

Manpower cost: the manpower cost or salaries of the employee are known as work compensation. This includes the sum of the gross cash and future payments such as salaries, compensation, and overtime that is paid by the employers for their part-time and full-time employees continuously or non-continuously in a time period [3].

Depreciation: the depreciation or the fixed capital expenditures is the costs that are spent for the organizations constructions, machines, computers, vehicles, mercantile capitals and tangible products and then they are recorded in the financial statements [3].

Operational profit: this is gained from the difference between the total value of inputs and the total value of output of the organizations data during a financial year [3].

Tax: that is paid for the government in the end of the financial year.

Distributed costs: this is gained from difference between organizational total costs and the costs of intermediate consumptions, tax, depreciation, operational profit (loss), and manpower costs that usually is known as general costs or administrative costs [3].

Calculating the role of every unit in the organizations exploitation and determining manpower productivity

Since different units in every organization have different effects on the extent of the organizations total added-value, so it is possible to calculate the extent of the work importance (or the amount of every sections effect on organizations total added-value). For this purpose, the EFQM model and also brainstorming method can be used so that every unit's role and effect is determined in creating organizations added-value.

The "J" refers to the nine components of the EFQM model, the "i" refers to the different departments of an organization, and also "Sij" refers to the score of every department with respect to the every measure, then we have:
J=1,2,…,9
I=1,2,…,m

So, percentage of every department's role of the nine factors of EFQM for every "i" is from 1 to m.

$$S_i = \frac{\sum_{j-1}^{9} Sij}{1000} * 100$$

After calculating every department's participation role or its effect extent on the total added-value, the extent of the added-value should be multiplied by every role percent so that every unit's added-value is calculated. Now, the ratio of the added-value of every unit to the number of its employees should be measured so that manpower productivity index is obtained.

Manpower productivity= $\frac{added-value}{number\ of\ the\ employees}$

Implementing the proposed model

Introducing the electricity company

The electricity company has the mission of supplying the safe and suitable electricity power for its users and customers through developing and exploiting its infrastructures. With respect to this company's job mission in terms of producing and transmitting the energy, this company is considered as a public service organization (selling the energy) and also is a project-based organization (constructing and developing projects). In other words, it can be considered as a project-based public service organization.

Characteristics and conditions of the Yazd electricity company

It is necessary to design and implement the development and construction projects for exploiting in the future in the electricity company as a project-based company for sustaining its service capability to the customers. Therefore, a large amount of its resources are spent

for investing in the development section so that the company is able to satisfy its customer's needs and wants in term of the energy.

Some of this company's characteristics and conditions were indicated in the following section.

- Using the budget-based funds that are allocated for it based on its determined extent by the governmental budget.
- The Yazd Electricity Company (selling the energy) and supply the suitable and safe electricity power services for the society.
- The Yazd Electricity Company should implement the operational projects and also exploit them for sustaining its service capability.
- A large amount of The Yazd Electricity Company budgets are spent for constructing and implementing the projects.
- The company's fixed coast is changeable based on its budget growth.
- The budgets implementation costs are affected by the method of project management and also this company's quality.
- The actual incomes are gained from energy selling and are countable.
- The potential incomes of the company are gained from exploiting the projects in progress and do not calculated to now but are predictable based on the knowledge.

Measuring the manpower productivity in the electricity company

Calculating the potential added-value that are gained from future exploiting of the projects in progress through production and subtraction methods

The projects Outputs

Every project's output is the result of its nominal income (during projects lifetime that in this study is supposed 30 years) that multiplied by performance efficiency.

Predicting the nominal income that is gained from future exploiting of the projects in progress:

Generally, the purpose of the Line and Post Projects is to decrease the grids losses and also decrease blackouts or the not distributed power to the customers. In other words, a projects nominal income is the sum of the decreased losses and also the not distributed energy (the decreased blackouts) during the projects lifetime.

It is necessary to implement the feasibility studies before the project is implemented in the electricity companies and also their technical and economic effects are predicted. Implementing every new project leads to decrease the girds losses that its extent is calculated based on the megawatt for 30 years (30 years is its useful life) in the feasibility studies.

Decreased losses (during project lifetime): the extent of decreased losses (based on the kilowatt) * the price of per kilowatt hour of energy

In the reliable studies, the effects of every project in increasing the grids reliability and finally decreasing undeclared blackout are calculated through the DIGSILENT software that this calculates the effect of every project on the extent of blackouts in the kilo watt hour for a year. Since every undeclared blackout leads to damage the customers, so the coefficient of damage for industrial and personal customers that is defined as the multiplication of damage coefficient by the extent of not distributed energy (i.e. the extent of decrease in the blackout) for a year.

The extent of the not distributed energy in megawatt * coefficient of every damage

The monetary value of the not distributed energy in a year – time

Projects performance efficiency

Every projects performance depends on comprising the performed work with the predicted work in the given time and then performance efficiency is the planed time and cost variance with the projects actual performance. Indeed, manpower performance is measured in the time and cost areas during its implementation in terms of CR index and then the future incomes from project is affected by possible delays in its construction or its surplus cost and also negatively and also affected by its early exploitation or saving costs positively. Involving time and cost performance in every project means that the costs of improper performance that leads to delay in its exploitation or surplus costs and also the benefits of proper human resource performance are considered in terms of measuring added-value.

Table1: measuring the project output

Output of every project is the result of multiplication of project nominal income (during projects lifetime) by its performance efficiency (based on the following table).

Project / Factor	Post A	Post B	Post C	Post D	Post and line E	Post F	Post G	Post H	Post I	Post K	Post J	Post L
Predicting the project income during its lifetime	92198	276163	40473	73254	18696	101145	73572	18393	73560	18390	60319	91993
The Project performance efficiency	64.8%	105.7%	112.7%	76.9%	4.5%	102.6%	117.1%	99.1%	112.8%	96.6%	121.9%	90.7%
Project output regards performance efficiency	59746	291930	45622	56400	848	103771	86187	18236	82985	17764	73583	83473

Project data

Every project data includes all of the projects construction costs and the predicted exploitation costs during its lifetime (30 years).

The construction cost is predicted in the beginning of every project and its information is extracted from project the control plan.

Exploitation costs include manpower costs and annual maintenance costs that are based on the definition of manpower added-value definition; these costs do not include exploiter manpower and maintenance costs and only include parts and consumables. In order to predict materials and parts costs in time of project exploitation, every exploitation Line, Post, or Line and Post project have been stimulated.

Table2: predicting the projects construction and exploitation costs

Projects	Post A	Post B	Post C	Post D	Post and line E	Post F	Post G	Post H	Post I	Post K	Post J	Post

The predicted costs of project construction	250000	140000	330000	30000	10000	32628	74898	37000	43000	220	50000	3400
The parts and consumable costs (for 30 years)	1350	750	1780	1620	50	170	400	20	230	15	270	180
Total cost	1,330,451											

The potential added-value of the projects in progress

According to the formula of added-value for every project, this is the projects outputs regarding performance percentage that subtracted from the project costs that are measured for every Line and Post projects as the following table.

Table3: measuring the projects added-value

Factors / Projects	The extent of projects outputs regarding performance percentage	The extent of costs during projects lifetime	Total added-value during project lifetime (30 years)	The projects annual added-value
The total projects	920,550,935,387	1330451000000	-409900064612	-13663335487

Calculating the actual added-value that is gained from selling and transmitting energy through sum or distribution methods

According to sum or distribution methods, the added-value is the result of sum of manpower costs, net profit, paid tax, and depreciation. In other words:

The added-value from selling energy = depreciation + profit (loss) + net tax + manpower costs + the distributed costs

The measured items in the actual added-value from selling and transmitting the energy	
Compensation	130000
Depreciation	103/833
Other not distributed costs	24/349
Benefit (loss) from operations	-159/000
Net tax	0

Added-value= 103/833 – 159/000 + 130/000 + 24/349 = 99/182

Calculating total added-value of Electricity Company

Total added-value in the electricity company as a project-based organization is sum of the added-values that are gained from selling and transmitting energy (actual added-value) and predicting the added-value that is resulted from future exploitation of the Line and Post projects in progress (potential added-value). In other words, total added-value is calculated through the following formula:

Total added-value= actual added-value + potential added-value

Calculating added-value	
Potential added-value of exploiting	-13/436
Actual added-value of transmitting and selling	99/182
Total added-value	85/746

Calculating the units productivity and company's manpower

According to the later descriptions, the role of every department (unit) in achieving added-value is calculated based on the EFQM model as following formula.

Added-value by every unit= added-value * percentage of every unit role

Table4: different unit's role in the nine factors and every unit's added-value

Measures / Units	Leadership	Policy and strategy	Employees and their results	Companies and resources	Processes	Customers results	Key performance results	Society results	Every unit scores
Area	100								100
Assistance		40			70	100			210
Assistance		40		40	70				150
Assistance			180						180

Assistance				50			100		150
Assistance						100	50		150
Other								60	60

Now that every department (unit) added-value has been calculated, it is possible to calculate manpower productivity that is the ratio of every department added-value to the number of employees that are working in that department. For example, this ratio if for human resource assistance with 16 employees is:

Human resource assistance employees productivity = $\frac{unita\,dded-value}{number\ of\ the\ employees} = \frac{15/434}{16}$

Conclusion

Regarding the fact that manpower costs, annual depreciation, and annual profit is almost fixed in the public service organizations and this isn't indicative of the organizations actual performance, therefore measuring added-value in the common methods is fixed and unrealistic and is not function of the organizations performance. With respect to the project-based nature of the organization, therefore, a large part of the budget is spent for the projects in progress and so measuring the added-value through the common formula, and without considering projects means that large part of the organization's capital and manpower, which are involved in the project implementation, are not considered in measuring the added-value. Therefore, in order to measure organizational actual performance, the added-value that is gained from projects future exploitation should be added to its added-value.

In this study a model was presented for measuring manpower productivity in the project-based service organizations that resolve the problems of the common methods of manpower measurement methods and this model was implemented in the organization that its mission is to supply and distribute electricity energy among its customers.

Since the calculated added-value that is gained from this model in our study includes all of the organizational outputs such as future exploitation from the projects in progress, so the calculated value is reflective of the organizational performance and also performance efficiency of such organizations is calculated actually. The characteristics of the designed model that make it effective and efficient include the following items:

- Calculating actual manpower productivity and considering all of the performed activities in the company in service delivery section and project implementation regarding the fact that a large amount of the budget, manpower, and organizational facilities are spent in the project implementation.
- Creating a mechanism for determining the extent of employee's efforts and rewards based on the productivity outputs.
- Creating an indirect mechanism for measuring project efficiency in the organization
- Identifying balance between costs and incomes and possibility of examining this balance by the organizations
- Identifying the extent of productivity trend based on the projects performance trends and disregarding fixed productivity trend

- Encouraging employees to participate in the projects and support them and organizations for attending the efficient project management and promoting employee's efforts in the non-routine affairs

What is valuable in this model is conversion of the services value and projects future value to financial value that in this conversion should be considered as a rational, acceptable, and reliable by the organization and its stakeholders. On the other hands, since the organizational excellence model was used for determining every unit's role in creating added-value and finally calculating manpower productivity, it is necessary use a rational approach, organizational consensus on the role of every unit in creating added-value.

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