Developing a new method to measure partial productivity in terms of total productivity

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Abstract

Productivity is one of the measures used to evaluate performance of the production system. It represents the relationship between output (product/service) and input (resources used in providing output). This relationship indicates the contribution of one unit of input spent to create output. The paper aims to formulate a new method to measure the partial productivity of each element of the input (labor, materials, machines, capital, and other expenses) in terms of total productivity. These two equations use the same output value in their numerators, while the inputs in partial productivity are part of the gross inputs used in total productivity, therefore, the results for both must reflect the relationship between the whole and the part, i.e., the result of the partial productivity equation reflects the amount of its contribution to creating the output, and at the same time, it is a part of the total productivity.

Keywords: Total productivity, Partial productivity

Introduction

Productivity is defined as an indicator of the efficient use of available production resources, represented by input to create output (goods and services) during a set period.

Productivity as a measure reflects the relationship between output (Actual Capacity) and input (Available Capacity), with the aim of determining the amount of contribution of one unit spent from input to create output.

Measuring productivity is necessary as it determines the efficiency levels of a company in converting inputs to output. Productivity may be measured either on aggregate or on individual basis, which are called total and partial productivity. The traditional method used in measuring total productivity and partial productivity suffers from some problems, including the following (1):

1-Total productivity, which expresses the amount of contribution of the monetary unit (one dollar) spent from the total input to create the output (in cash or units), does not clarify the amount of contribution of the monetary unit spent for each element of the input (production resources) in the result of the equation.

2- Partial productivity indices, depending upon factors used, it measures the efficiency of individual factor of production resources. It shows the contribution of a unit spent from one of the input factors to create the output (in cash or units), but the problem is that the numerator of the equation (output) is the result of all inputs and not the result of just one element. This makes the contribution of the input unit greater than the contribution of the input unit in the case of total productivity, and this is contradict the logic in which the contribution of the part is greater than the contribution of the whole. The production process to create outputs is the result of the interaction of all input elements (labor, machine, materials, capital, and other expenses), and cannot be the result of one input element.

Equation to measure partial productivity in terms of total productivity

The equation to measure partial productivity in terms of total productivity is based on the following:

1- Calculating total productivity (output in cash or units) using the following equation:

Total productivity = (Output in cash or in units) ÷ (total input in cash)

2- Calculating the percentage of each element value of input to the total input in cash using following equation:

The percentage of each element value
= (Element value ÷ total input in cash) × 100

3-Partial productivity of the element
= The percentage of each element value × total productivity

Hypothetical example:

Data-monthly		
Output	Output in units	6000 unit
	Output in cash	$ 90,000
Input	Material cost	$ 15,000
	labour Cost	$ 9,000
	Other expenses	$ 6,000
	Total inputs	$ 30,000

First: Traditional methods of measuring productivity include the following

1- The simplified method for calculating total and partial productivity, as shown in Table (1) and in light of the following equations (1)::

- Total productivity = (Output in cash or in units) ÷ (the total input in cash)
- Partial productivity of the element = (Output in cash or in units) ÷ (element input in cash)

From the table(1) it is clear that the contribution of the monetary unit from the aggregate value of input in the total productivity equation (in the two cases of adopting output in cash or units), amounting to [(3 dollars/dollar), (0.2 units/dollar)], is less than the contribution of the monetary unit for each input element (materials, labor and other expenses) in the partial productivity equations, as it amounted to [(6 dollars/dollar), (0.4 units/dollar)] for materials, and [(10 dollars/dollar), (0.67 units/dollar)] for labor, and [(15 dollars/dollar, (1 unit/dollar)] for other expenses.

Table (1)

Calculating total and partial productivity according to the traditional method

Data-monthly		
Output	Output in units	6000 unit
	Output in cash	$ 90,000
Input	Material cost	$ 15,000
	labour Cost	$ 9,000
	Other expenses	$ 6,000
	Total inputs	$ 30,000
Total productivity	Output in cash	(90000 / 30000) = 3 $/$
	Output in units	(6000 / 30000) = 0.2 unit/$
Partial productivity of materials	Output in cash	(90000 / 15000) = 6 $/$
	Output in units	(6000 / 15000) = 0.4 unit/$
Partial productivity of labor	Output in cash	(90000 / 9000) = 10 $/$
	Output in units	(6000 / 9000) = 0.67 unit/$
Partial productivity of other expenses	Output in cash	(90000 / 6000) = 15 $/$
	Output in units	(6000 / 6000) = 1 unit/$

It is true from a mathematical standpoint that decreasing the value of the denominator in the equation while keeping the value of the numerator constant leads to an increase in the result. However, from a logical standpoint, the contribution of the part cannot be greater than the contribution of the whole, because the process to create output, whether in cash or units, is the result of the interaction of all the elements of production and not the product of a single element.

2-: Method of measuring total productivity in terms of partial productivity (2).

As shown in Table (2) and in light of the data of the hypothetical example, this method is based on measuring total productivity in terms of partial productivity using the following equations:

- Partial productivity of the element = (Output in cash or in units) ÷ (element input in cash)

The percentage of each element value = (Element value ÷ (total input in cash) × 100

Total productivity = The percentage of each element value × Partial productivity of the element

Table (2)
Method of measuring total productivity in terms of partial productivity

Data-monthly		
Output	Output in units	6000 unit
	Output in cash	$ 90,000
Input	Material cost	$ 15,000
	labour Cost	$ 9,000
	Other expenses	$ 6,000
	Total inputs	$ 30,000
Partial productivity of materials	Output in cash	(90000 / 15000) = 6 $/$
	Output in units	(6000 / 15000) = 0.4 unit/$
Partial productivity of labor	Output in cash	(90000 / 9000) = 10 $/$
	Output in units	(6000 / 9000) = 0.67 unit/$
Partial productivity of other expenses	Output in cash	(90000 / 6000) = 15 $/$
	Output in units	(6000 / 6000) = 1 unit/$
Ratio of material cost to total input value	(15000 / 30000)× 100 = 50%	
Ratio of labor cost to total input value	(9000 / 30000)× 100 = 30%	
Ratio of other expenses to total input value	(6000 / 30000)× 100 = 20%	
Total productivity	Output in cash	(90000 / 30000) = 3 $/$
	Output in units	(6000 / 30000) = 0.2 unit/$
Total productivity in terms of Material productivity	6 × 50%	3 $
	0.4 × 50%	0.2 unit/$
Total productivityin terms of labour productivity	10 × 30%	3 $
	0.67 × 30%	0.2 unit/$
Total productivityin terms of Other expenses productivity	15 × 20%	3 $
	1 × 20%	0.2 unit/$

From the table (2) it is clear that, this method correctly, measured the total productivity in terms of the partial productivity, but the amount of contribution of the unit spent from each of the input elements is still greater than total productivity.

Second: Method of measuring partial productivity in terms of total productivity

As shown in Table (3) and in light of the data of the hypothetical example and using the following equations:

- Total productivity = (Output in cash or in units) ÷ (total input in cash)

The percentage of each element value= (Element value ÷ (total input in cash) × 100

Partial productivity of the element =The percentage of each element value × total productivity

From the table (3) it is clear that the total productivity (output in cash) amounting to (3 dollars/dollar), i.e. the monetary unit (one dollar) spent from the total input in cash contributes to achieving (3) dollars of output ($90,000), and this result for the total productivity is distributed over the partial productivity of materials (1.5 dollars/dollar), labor (0.9 dollars/dollar), and other expenses (0.6 dollars/dollar). That is (1.5+0.9+0.6=3 dollars/dollar). Also, the total productivity (output in units) amounting to (0.2 units/dollar) i.e., the monetary unit (one dollar) spent from the total input in cash contributes to achieving (0.2 units) of Output (6000 units), and this result for the total productivity is distributed over the partial productivity of materials (0.1 units/dollar), labor (0.06 units/dollar), and other expenses (0.04 units/dollar). That is, (0.1 + 0.06 + 0.04 = (0.2 units / dollar). In this way, the value of partial productivity of each input element is less than the total productivity, and the sum of the value of partial productivity has become equal to the total productivity.

Table (3)
Method of measuring partial productivity in terms of total productivity

Data-monthly		
Output	Output in units	6000 unit
	Output in cash	$ 90,000
Input	Material cost	$ 15,000
	labour Cost	$ 9,000
	Other expenses	$ 6,000
	Total inputs	$ 30,000
Ratio of material cost to total input value	(15000 / 30000)× 100 = 50%	
Ratio of labor cost to total input value	(9000 / 30000)× 100 = 30%	
Ratio of other expenses to total input value	(6000 / 30000)× 100 = 20%	
Total productivity	Output in cash	(90000 / 30000) = 3 $/$
	Output in units	(6000 / 30000) = 0.2 unit/$
Partial productivity of materials	Output in cash	(3 × 50%) = 1.5 $/$
	Output in units	(0.2 × 50%) = 0.1 unit/$
Partial productivity of labor	Output in cash	(3 × 30%) = 0.9 $/$
	Output in units	(0.2 × 30%) = 0.06 unit/$
Partial productivity of other expenses	Output in cash	(3 × 20%) = 0.6 $/$
	Output in units	(0.2 × 20%) = 0.04 unit/$

Conclusions

1- The two equations (total and partial productivity) use the same output value in their numerators, while the inputs in partial productivity are part of the gross inputs used in total productivity, therefore, the results for both must reflect the relationship between the whole and the part, i.e., the result of the partial productivity equation reflects the amount of its contribution to creating the output, and at the same time, it is a part of the total productivity. Traditional methods have failed to solve this problem, so the amount of contribution of the unit spent from an element of the inputs to create the outputs was greater than total productivity.

2-The method of calculating partial productivity in terms of total productivity has provided solutions to the problems associated with traditional productivity measurement,

so that, the partial productivity is less than the total productivity, and the sum of the partial productivity values of all elements of input is equal to the total productivity.

3- The method of calculating partial productivity in terms of total productivity is only possible when the inputs in partial productivity are expressed in cash, because the unit measures of inputs are different (kg or unit for materials, hours of work for wages or number of workers, and money for other expenses), which makes it impossible to calculate the percentage of each input to the total input.

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