Work System Design
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Lecture – 05
Productivity Measurement Models

Namaskar friends, welcome to session 5 in our course on work system design, as you all know that in the first 2 weeks, the target of our discussion is the word productivity and we have already completed 4 sessions in which we have try to understand that what is the basic concept of productivity, how it is defined, how it is different from the word performance, how it is different from the word efficiency.

So, all these things we have try to understand in our initial discussion on productivity just to take you one session back, if we go to the previous session that is session number 4 in week one, we have discussed the different productivity measures, we have seen the partial productivity measures, we have seen the total productivity measures, total factor productivity measures and finally the last one, we have seen was the multifactor productivity measures.

So, what is the need of having all these types of productivity measures, this question was coming to my mind also. When the basic definition of productivity says that it is the relationship between the outputs to the input, so why we need to have so many productivity measures that is question 1, then the question 2 is that when we have to ensure that we have to convert our raw materials, our inputs quite efficiently and effectively into the output.

Then why to make mathematically cumbersome relations in order to relate the inputs and outputs, why not the things can be very, very simple that is output divided by the input, so this is a very simple question. So, today our target is productivity measurement models, last session we had 4 different productivity measures, so all these are important from the point of view of the difference in the type of organisations.

There are different factors that motivate us that guide us that give us a direction that we must have specific productivity measurement models for specific situations for specific type of

organisations because each and every organisation is different, we can classify the working of different organisations into maybe 4 or 5 different classes but still each class may require a different type of productivity measurement technique or productivity measurement model.

Now, depending upon the factors that influence productivity, we have tried to bring together in this presentation 3 important models. There are other models too but our target is to understand that there is a variety of models which are available, which we can use as per our requirement. So, in today's session, we will have a brief introduction or 3 different types of models which are used in industry for calculating the productivity of the organisation.

Now, before going into the intricacies of the models, let us first try to understand that these depends upon different models, so the different factors sorry; so we have may be different factors which will influence the productivity measurement models. Now, what are these factors, quickly we will try to outline them, we will try to list them and we will try to understand them.

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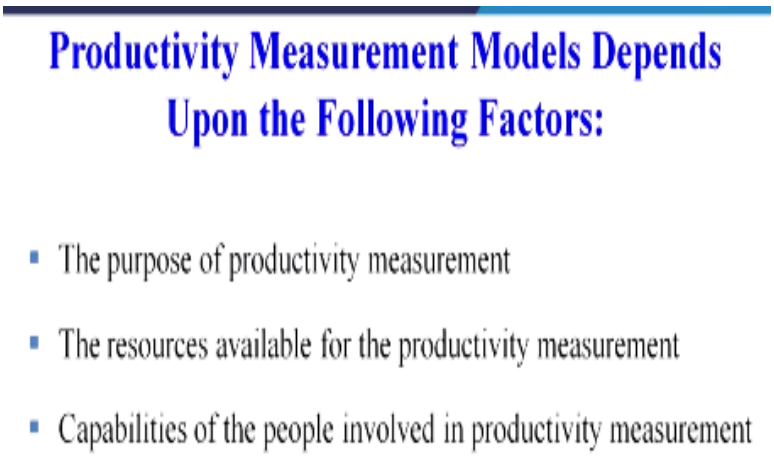

So, the first one is what is the purpose of productivity measurement and for this answer, you have to go back to the previous sessions which we have already discussed, which in which we have seen what are the objectives of productivity measurement, why do we need to measure the productivity of an organisation, why do we need to measure the productivity of our workforce, why do we need to weather the productivity of the energy that we are giving as a input.

So, we need to understand the objectives of productivity measurements, so these models that which model we are going to select will depend upon that what is our target, what is our purpose, what is our goal, what is our objective of the productivity measurement. Next, the resources available for productivity measurement because mathematically, we are trying to relate the input to the output, so we must be able to quantify all the parameters or quantities that we are using for productivity measurements.

So, we may not be able to have many of the terms, which can be quantified in terms of rupees or in terms of dollars. So that is a one challenge which we will come to in today's session, later on we will see that this is one of the major challenge for the productivity measurement models. So, sometimes data may not be available that is the summary of second point, then capabilities of the people involved in productivity measurement.

So, many times the expertise may not be available with the managers or the engineers involved in productivity measurements, so that is also one factor that influences that the choice of the productivity measurement model.

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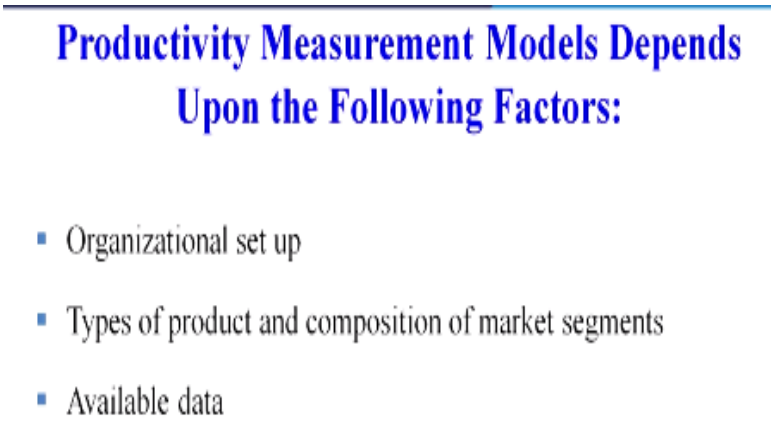

Then, the organisational setup; we have different types of organisational setups like functional type of organisation, line type of organisation, matrix type of organisation, now depending upon

the organisational setup also, the productivity measurement model may vary, then the types of product and composition of the market segments also influence the selection or choice of the productivity measurement model.

As well as, we have already this is some kind of duplication in first case, we have focused on the general resources, here it is very, very specific that many times the data may not be available for undertaking a particular model, we will see 3 different models and 3 different types of data is required to calculate the productivity for a particular model. So, for a particular model we want to use a particular model but we do not have the data which is required for doing the productivity measurement.

So, we will not use that model, so what is the next stage? We will have a different model which requires may be significantly less data but is giving us a fairly accurate measure of the productivity we will use a model which is relevant to our specific data. So, these are the factors which influence or which guide us in the development of different types of productivity measurement models.

So, these factors will influence our choice of the particular productivity measurement model, all of you know that today we are going to discuss 3 but there is other variety of models which are available. Last time, we have seen that what are the mathematical measures which can be used for productivity measurement. Today, we will focus on specific models developed by researchers and scientists for measuring the productivity of an organisation.

So, last time was just the mathematical tools which can be used for productivity measurement, if you remember again I will revise 4 types we have seen; the first one was a partial productivity, the second one was a total productivity, then total factor productivity and the last one was the multifactor productivity measures, so these are the measures which are used. Today, our focus is specific models, which can; which may be using the similar concept only of the productivity measures.

But are named for specific purposes or are named in the name of the researchers who have developed these models, so let us quickly now move to what models we are going to discuss today, I think the concept of productivity is now clear to all the learners, so what we are going to discuss today are the productivity measurement models.

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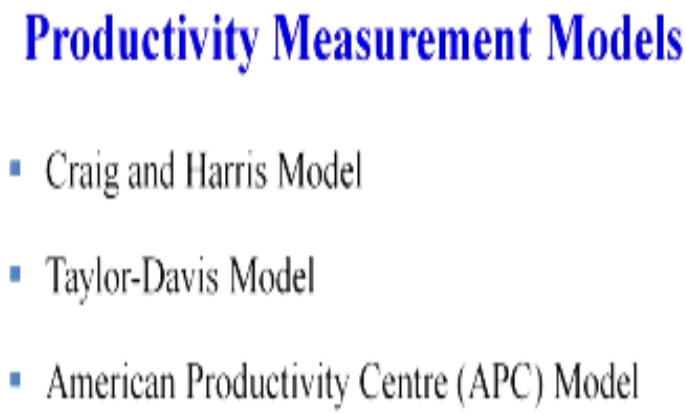

On your screen you can see the Craig and Harris model, then Taylor Davis model and then finally the American productivity Centre model, so 3 different models we are trying to understand today, which are used for measuring the productivity of an organisation. So, each one of these will use the different terms, different quantities and we will see that they have their specific application areas also.

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Craig and Harris Model

- This model points out inadequacy of partial productivity measure.
- It is also called "service flow model" because physical inputs are converted into currency, for example Rupees, that are payments for services provided by inputs.

Let us first try to understand the Craig and Harris model, this model points out inadequacy of the partial productivity measures, which we have seen in the last sessions, so this is in continuation to what we have discussed in the last session that is a partial productivity measure was one of the productivity measure in which the output was divided by an individual input the individual, input can be labour, it can be capital, it can be energy.

So, it; this particular model points out as the inadequacy, so wherever we have a partial productivity model is not relevant there, we can go and do our calculations using the Craig and Harris model. It is also called service flow model, so it has been highlighted the service flow model.

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Craig and Harris Model

Total productivity is expressed as $P = \frac{O}{L+C+R+Q}$ — (4)

Where, P= Total productivity

L= Labour input factor

R= Raw material and purchase part

C= Capital input factor

Q= Other misc., goods and services

So, what do we mean by service flow model that we will try to understand, so may be again, I will go to the previous slide, what do we mean by the service flow model? So, if you see, it is service flow model is the key function here, here all the physical inputs are converted into the currency or the currency for example, can be dollars or it can be rupees that are payments for the services provided by the input.

So, basically, the inputs; whatever inputs are used for calculating the productivity model, we will try to convert it into the currency and then do our calculations accordingly, so that is one of the important points and another point you can see here is that we are talking about the inputs and we are not talking about a single input or an individual input and therefore, this model takes care of the inadequacies of the partial productivity model.

Because there we focus only on the individual input, so friends, as per the Craig and Harris model, we will see, the total productivity is expressed as P in which we have O, that is the output, now what are these 4 inputs you can see, we have L, which is labour, we have C, which is capital input, we have R, which is raw material and we have Q, which is other miscellaneous goods and services.

So, we see that here we are using 4 input quantities, in case a partial productivity all of you know in partial productivity measure, we have only 1 input but here we are having 4 inputs, so labour

is taken care, raw material is taken care, capital is taken care and the other miscellaneous goods and services are also taken care, so it overcomes the inadequacy of the partial productivity models.

So, wherever required we can use the Craig and Harris model, it will give out a total productivity which will relate our overall output with the 4 types of input and if you remember in the last session, we have taken multifactor productivity and total factor productivity in which specific inputs were use, some of the inputs were excluded only few inputs were used for calculating the productivity.

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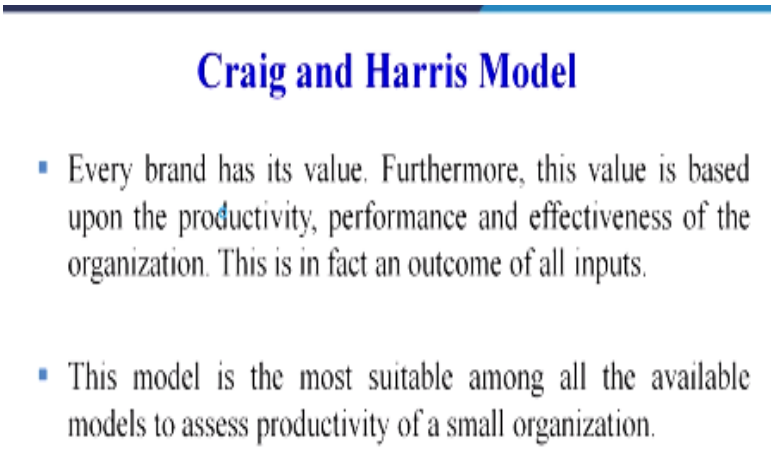

But here we are using 4 different types of input which are related to the output and the total productivity is being calculated. Now, let us quickly see the finer points of Craig and Harris model; Craig and Harris model is particularly useful for medium size organisations, you can see the utility is for medium size organisations, so this is an application area on which we can focus on where we can apply the Craig and Harris model.

There are some deficiencies in this model like it does not consider any technological change or change in the human resource skill, so this is maybe many times I have told that sometimes it is difficult to quantify in currency or in rupees each and every factor, so that is one big challenge

and in many times there are factors which we are not able to include in our mathematical calculations, so that is one challenge.

So, here also we can see technological change and change in the skill of the workers that sometimes become it can be included but sometimes become difficult to quantify in terms of money. Similarly, there are some intangible gains also same, which we cannot quantify easily, so there are some intangible gains for every organisation and surprisingly no model considers the intangible factors, so that is one thing.

Then, every brand has its value, furthermore this value is based upon the productivity, performance and effectiveness of the organisation, this is in fact an outcome of all the inputs, now whatever inputs we are giving, we are producing some output; output is usually in terms of the numbers that we are producing or sometimes we correlated with money that what is the total money that is; that we are generating with these inputs.

So, basically all that money that is generated is taken in the numerator and whatever inputs are going in terms of money are taken in the denominator but these inputs may be generating some brand value for the product, so that brand value sometimes is not included or is intangible benefit of all these inputs, which may lead to the productivity or profitability of an organisation which sometimes or many times I must say is not included in the calculations.

So, this model is from the application point of view is most suitable among the available models to assess the productivity of a small to medium size of organisation, so this is one model we have seen output is related to 4 different types of input.

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Taylor-Davis Model

- In this model, **raw material** was not considered as input on the basis that raw material is the result of some other labour and effort.
- Contrary to Craig and Harris total productivity model, they defined a **Total Factor Productivity** (TFP) model

Let us see the Taylor and Davis model; in this model, raw material was not considered as input on the basis that raw material is the result of some other labour and effort. Now, one thing that we can include here is the example of a fruit, now in the case of a fruit, some other person has worked, he has planted a tree, now the fruit has come, so labour has been done by one person, he has given effort for producing this fruit.

So, this fruit suppose we are using in some Agro based industry and we are producing fruit juice, so this food is an output of a somebody's else effort and labours, so this may not be included as an input in the case of our model, so it is; maybe it is considered at both as output as a input and it is nullified as we can see in the models, so the effect of this output of other persons labour and effort is nullified in this model.

So, raw material is not considered as an input, contrary to Craig and Harris total productivity model, they define the total factor productivity model, so if you remember in the previous session, we have covered the different measures, so here their focus; Taylor and Davies focus on the total factor productivity, whereas the previous one was based on the total productivity model; previous one means the Craig and Harris model.

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Taylor-Davis Model

$$TFP = \frac{S+C+MP-E}{(W+B)+[(KW+KF)Fb*df]}$$

Where,

S = Net sales adjusted (i.e deflated to base year)

C = Inventory change (Raw materials, finished good and WIP)

MP = Manufacturing plant (Unsaleable products like jigs and fixture, SPM)

This is Taylor Davis is based on total factor productivity, now the equation is given here we can see the total factor productivity can be calculated as S + C + MP – E, so the equation is given here and the abbreviated forms are also given, S = net sales adjusted that is deflected to the base year, the C is the inventory change; raw materials, finished goods and work in process, WIP here means the work in process.

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Taylor-Davis Model

E = Exclusions (Materials and services purchased from outside + depreciation of buildings+ plant + equipment + renters)

W = Wages and salary

B = Benefits

KW = Working capital

KF = Fixed capital

Fb = Investors contribution

df = Price deflator

MP is the manufacturing plant that is unsaleable products like jigs and fixtures, so that is basically MP and then it has -E which is exclusions like materials and services purchased from outside, so we are not bringing them into our consideration, we are subtracting it as an output, so if you see in the denominator also, we will see and numerator also, here we are excluding that so,

materials and services purchased from outside + the depreciation of buildings + plant + equipment + renters, all this is; these are the exclusions, then they are in the numerator.

In the denominator, what we have? we will have; we will take all the inputs that are going into the system, so we have wages and salary which is an important input, we have the benefits as an important input, capital; all of you know is an input, so working capital, fixed capital is an input, investors contribution is an input, price deflator is also an input. So, we have different inputs, again I will go back to the slide.

And we can see that here we have in the numerator, net sales inventory change and the manufacturing plant - the exclusion and in the denominator, we have; if you see in the denominator we have wages, salaries, benefits, working capital, fixed capital, investors contribution and price deflator. So, if you see that 2, 3 different parameters are there in the denominator and in the numerator also the sales and the output is represented.

So, this is a different way of representing the inputs and the output and then the total factor productivity if you see we are calculating here the total factor productivity, so the total factor productivity measure is used in with by the Taylor and Davis model.

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American Productivity Centre (APC) Model

- This model distinguishes among profitability, price recovery and productivity.
- It can be utilised to measure productivity changes in labour, material, energy and capital.
- APC model is based on the premise that profitability is a function of productivity and price recovery.
- Productivity relates to quantities of output and quantities of inputs while price recovery relates to price of output and cost of inputs.

So, the last model that we have to discuss today is the American productivity Centre model or normally called as the APC model. So, this model distinguishes among profitability, price recovery and productivity, so these are 3 words that we need to understand; profitability, price recovery and productivity. So, I must understand now that productivity is known to everybody, we have seen different productivity measures.

We are now trying to understand different productivity measurement models, what do we mean by productivity? We have been discussing all through this week today is the last session for week 1, so productivity word I believe is known to everybody. Now, let us try to understand the word profitability and price recovery because these 3 words are used by the APC model for productivity measurement.

So, let us see, it can be utilised to measure productivity changes in labour, material, energy and capital. Now, if you see all these 4, whatever we see that is labour 1, material 2, energy 3 and capital 4, all these are 4 are our inputs, so it can; our this APC model can be utilised to measure the productivity change because when we change this 4 inputs, suppose we change labour input or we change the material input or we change the energy input, with the change in the input our output is definitely going to change.

And the output to input ratio will give us productivity, so this model can help us to measure the productivity change in context of the labour, energy, capital and material, so the APC model is based on the premise that profitability is a function of productivity and price recovery, so profitability we can say is a function of productivity and price recovery, how they are related that we need to understand and we will see in the subsequent slides.

So, we will see that how profitability; what do we mean by profitability and how it is related to productivity and price recovery? Now, productivity relates to quantities of output as we have seen earlier that we say that more and more products we produced with the same input level, we say we are more productive because with the same input we are producing more output, so the productivity is normally related to the number of parts or the quantity of parts or we can say volume of parts that will produce a volume of products that we produce.

A productivity relates to quantities of output and quantities of input while price recovery relates to price of output and cost of input. Now, price recovery basically whenever we are making some product for example, we are making a pen, so it has different types of input, so we will say that for the refill, we are spending this much money for making the cap, this much money is going for making the barrel or maybe for making the body of the pen, this much cost is going.

So, we add up all these cost, cost of painting, cost of printing all this cost will add up to the cost of inputs and then we are selling it with some profit to the consumer, so we say that is related to the price of the output. So, price recovery relates the price of output that whatever pen we have produced what is the selling price of that output and what is the cost of the inputs, so price recovery is related to the selling price and the cost of the input.

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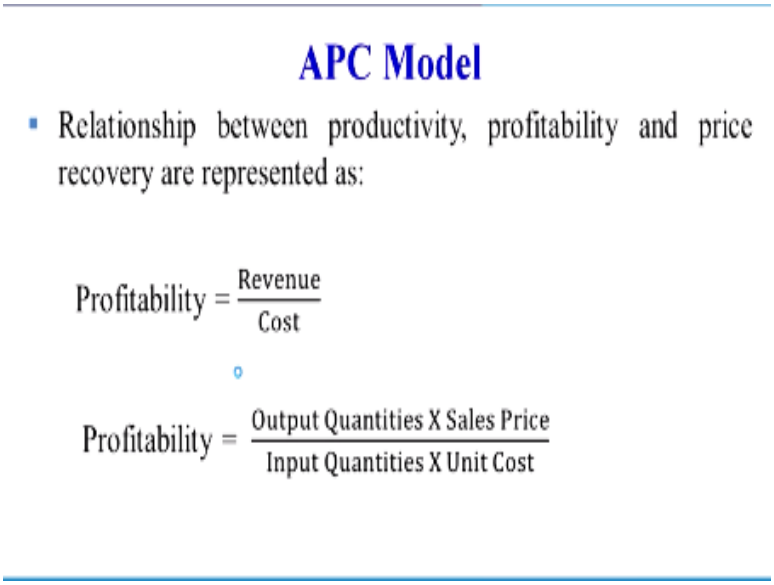

And our productivity is related to the; is related to the quantities of output produced to the quantities of input that we are giving in to the system, so relationship between productivity, profitability and price recovery is represented as; now, profitability is what? Revenue divided by cost, so if we say the revenue that we have generated is more than the cost incurred in producing the product.

We will say that we have made some profit but if it is the ratio is less than 1, which means that revenue that is generated is < the cost that we have spent in producing the product, then we will say the profitability is less, now profitability can be then calculated as output. What is revenue basically? Now, revenue is suppose, I have sold 100 pens that I have produced at the rate of Rupees 10 per pen.

So, we will say what is the revenue generated 100 multiplied by 10, so output quantity 100 multiplied by sales price is Rupees 10, so 100 multiplied by 10 become my revenue and the cost that is the money spent will depend input quantities, now how many pens I have made; 100 multiplied by the unit cost, so suppose if the cost was 7 rupees per pen, so 100 multiplied by 7 is my cost and 100 multiplied by 10 that is sales price is my revenue.

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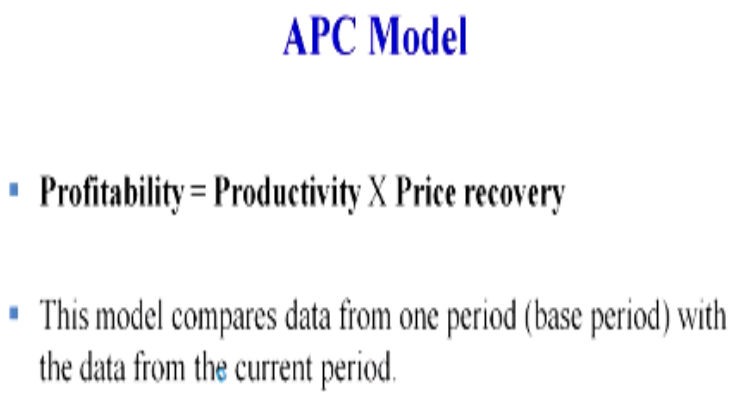

So, the revenue by cost will give me the profitability, now profitability is equal to productivity into price recovery, so this is a common relationship which establishes a relationship between profitability, productivity and price recovery. Now, price recovery if you know what is price recovery; it is a ratio of the selling price to the unit cost, so this model compares data from one period with the data from the current period.

So, here we are using productivity as one measure and then we are finally calculating the profitability, in some cases this measure profitability may be a better representation of finding

out or establishing or comparing the economic health of an organisation. So, productivity may be for some organisations are theoretical value but profitability may be a more practical way of representing the economic well-being of an organisation.

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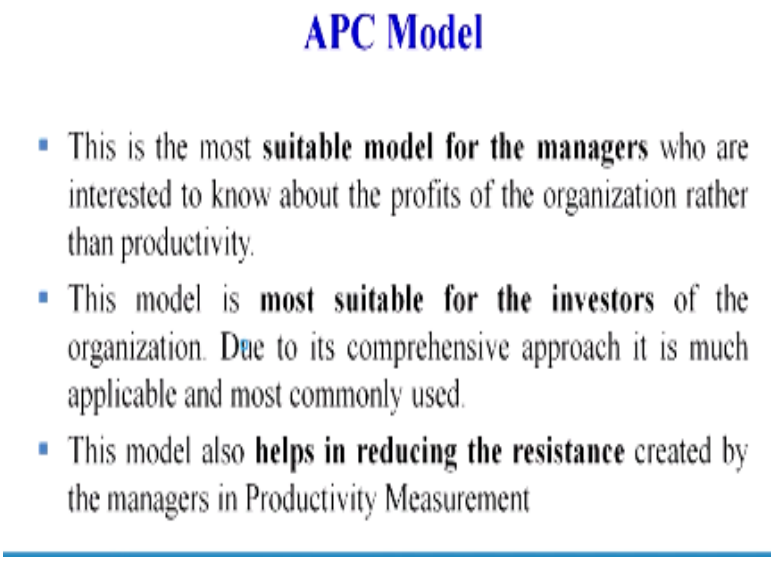

So, we will try to see that what benefits we can accrue, if we calculate this profitability instead of productivity, so quickly we will try to understand this, so this is the most suitable measure for managers who are interested to know about the profits of the organisation rather than productivity. So, for the managers who know; want to know about the profits, this profitability is a better measure as compared to productivity.

This model is most suitable for the investors of the organisation, so everybody will invest if they see that the organisation is profitable, so that is one thing. So, the most suitable for the investors of the organisation due to its comprehensive approach it is much applicable and most commonly used, so this APC model is may be a commonly used model for measuring the profitability of an organisation.

This model also helps in reducing the resistance created by the managers in productivity measurement, so in the last session also, if you remember we have seen that whenever we want to change always there is a resistance, so we need to learn the intricacies of change management. So, whenever we say that we want to increase the productivity of people who are working in our

organisation, we want to increase the productivity of the machines that we are using for converting our raw materials into the final product.

There is always going to be some resistance among the employees, among the managers, among the various stakeholders of the organisation, so all the stakeholders who are actually converting the raw material into the final product will have some resistance to change, if we talk about the productivity but if you tell them profitability that if we do or manage these changes properly, we will be able to be profitable.

So, we will get more profit by adopting these changes, there it is more acceptable term to the managers as well as to the workers, therefore APC model focus more on profitability in which is in turn related to the productivity of an organisation. If you see once again, I will go to the slide, the profitability is = productivity into the price recovery, so we are; in any case, we are calculating the productivity also.

We are calculating the price recovery as well as we are calculating based on the price recovery and the productivity, we are calculating the profitability which is a much practical point of view of representing the economic well-being of an organisation. So, with this we conclude the today's session as well as the discussion for this week in which we have just tried to understand the concept of productivity.

We have tried to see that mathematically what are the productivity measures we have tried to understand very briefly the different models of productivity measurement, in next session our target will be in next weeks, sorry our target will be to understand that what are the causes of low productivity, we will try to understand the different mathematical case studies we will try to solve and try to understand that how productivity measurement is helpful for the organisations.

So, maybe with this we conclude the discussion for week 1 and we will carry forward our discussion on the same topic of productivity in week 2. Thank you.