Production and Operation Management
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Lecture 11
Time Series Forecasting: Working Example of Exponential Smoothing 1

Welcome friends. So this is the eleventh session of this course, and we are entering into the third week of the course. In last few sessions, we started discussions on Forecasting and we started discussions particularly on Exponential Smoothing Methods in our last two sessions. We discussed the basic concept of exponential smoothing method that how it is an improvement of our weighted average moving method.

And at the same time, we also discussed different types of classification of these models, how we can incorporate trend, how can we in incorporate seasonality and different types of trends and different types of seasonality, whether it is linear or ratio, so all that we have already discussed in our last two sessions.

Now in this particular situation, we will see that how we can use these models in our calculations, how we can use these models to forecast and for that purpose we have some data with us and with the help of data, we will use our different types of forecasting models, particularly exponential smoothing model.

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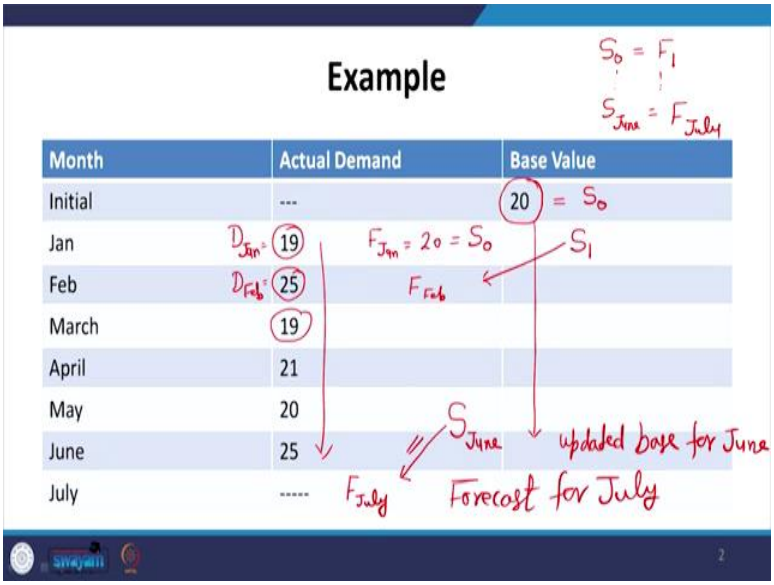

Now in this table we have the data of past six months from January of a month to June. Now we want forecast for July. So, you have actual demand data for these six months from January to June and with the help of this actual demand data we can forecast for July. We have already seen how can, we use simple moving average method and weighted moving average method where we will take, average of some most recent periods according to our choice of moving average according to our choice of moving average.

So, if my moving average period is let us say 3, so I will take the average of April, May, June's demand and that average will be the forecast for July. If I am going with weighted moving average method I will assign, let us say weight of 0.5 to the demand of June, 0.3 to the demand of May and 0.2 to the demand of April and then the product of weight and actual demand and the submission of that products will give me the demand of, will give me the forecast for the month of July.

So these two methods we have already discussed in our previous classes. Now in today's session we will discuss that how we can apply the exponential smoothing model for determining the forecast for the July. Now we know that in theory we have already discussed that the forecast is going to move and going to randomize around a base value. So, we assume a base value for initiating our process.

And now my job is to get the updated base value for the month of June and the updated base of June you can write it as, S June. This S June is going to be the forecast for July. This is forecast for the month of July. So, now in my simplest method of exponential smoothing, what I am going to do that I will do iterations to update the value of this initial base of 20 and you see, this initial base of 20 is actually the forecast for, January forecast is 20.

That is S naught, this initial base is nothing but S naught. Now the S1, which we will calculate that is the forecast for the month of February and this data D19 these are the demand of January. This is the demand of February. So, now the purpose of telling you is to familiarize with the conventions that what type of conventions we are going to follow, so that you understand what is the meaning of S, what is the meaning of D, what is the meaning of F.

Now it is clear that S naught is going to be the forecast for the period month, so similarly following this convention as I just wrote S June will be the forecast for July. So, my job is to

determine the value of S June. Now, for that purpose, if you remember in our last session we discussed that the base value have fluctuations because of variations in actual demand.

So, in this exponential smoothing method we are going to smoothen the fluctuation of this actual demand so that it comes closer to our base value. So, for that purpose, we need to use a smoothing constant.

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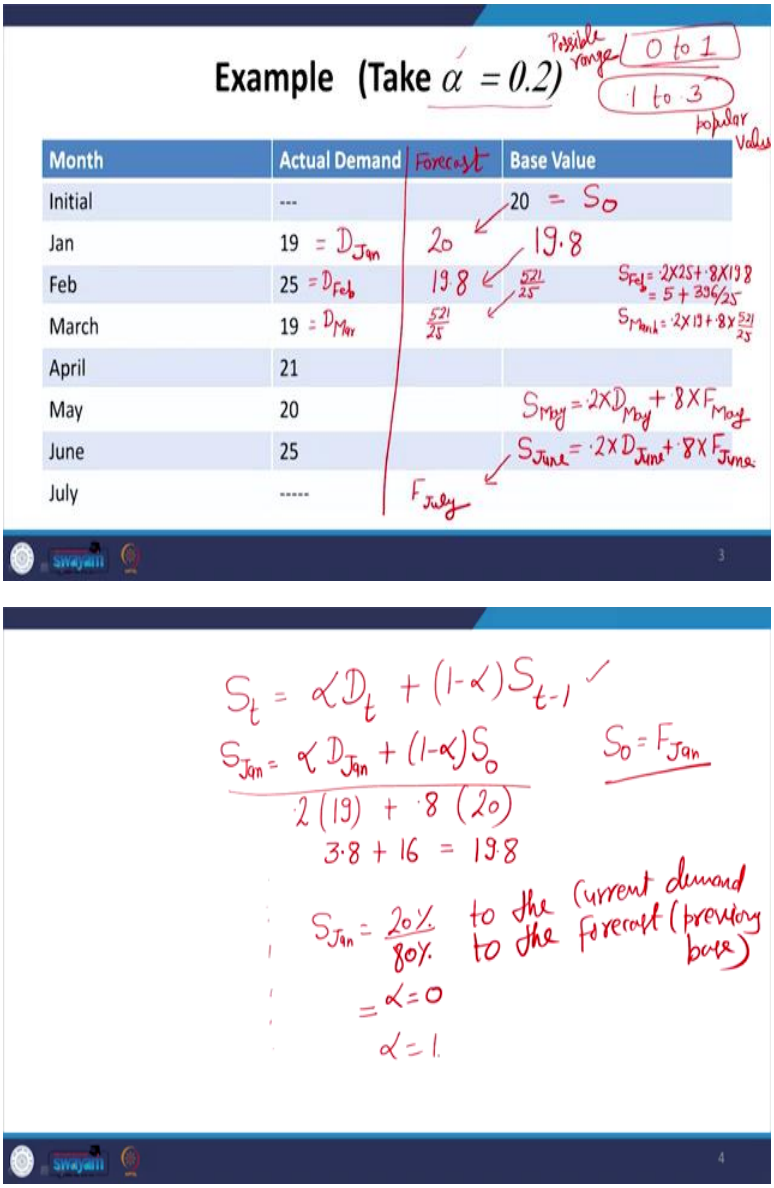

So, here we have only considered the fluctuations in the base value. So, we require only one type of smoothing constant. You can recall that we discuss that in a very, generalized condition there

may be a requirement of three smoothing constants. In our coming sessions we will do one case where all three smoothing constants are required.

But here this is a simple case. So, we are using only one smoothing constant that is alpha. You can also recall that the value of smoothing constants vary from 0 to 1. The values vary from 0 to 1 and we also discussed that the popular values of alpha vary from point 1 to point 3. These are popular values and this is the possible range. So, here randomly, we have taken a value alpha equals to 0.2. We have taken the value alpha equals to 0.2, and by taking this alpha equals to 0.2, we will update the value of base table

And therefore we will use this equation, if you recall that our St equals to alpha Dt plus 1 minus alpha St minus 1. This equation you may recall, which we have discussed in our previous sessions. So, now St is S January equals to alpha into D January plus 1 minus alpha S naught.

So, if you go with our available data, demand of January is 19, S naught is 20. So D Jan is 19 and S naught is 20. Value of alpha which we have taken is 0.2 and this becomes 0.8. So, here this becomes 3.8 and this becomes 16, so it becomes 19.8. So, this 19.8 will be the value of base which you can put here, or this is the base of January or it is a forecast for the month of February. Now using this 19.8, how did we do this calculation?

You can use this complete formula. Now we will do this calculation in this table itself so that you can understand that how this data is flowing and we can also add one more column of forecast. So, the forecast for the month of January was 20, now the forecast for the month of February is 19.8. So, you can understand that these values of previous periods are the forecast for the next period.

Now this D February is known to us. So, now my job is to determine the value of S February. Again, use the formula alpha Dt, so 0.2 in to Dt that is 25 plus 1 minus alpha that is 0.8 into St minus 1 that is 19.8. If I do this calculation, this becomes 5 plus 19.8 into this 0.8, I solved it. And we get 396 by 25. That becomes plus 5, so this becomes 521 by 25. So, that is the value of S February and this is going to be the forecast for the month of March.

Now again, in this iterative manner we can go forward. This is D of March, now D of March we will use to get the updated value of S of March which is 0.2 in to Dt that is 19 plus 0.8 in to this

St minus 1, that is 521 by 25. And in this fashion, you keep on doing the iteration and finally, you will find the value of S June and that will be the forecast of July. So, it is a very sequential way of calculation of the forecast.

Now the simpling of this whole project is that, if I have the value of let us say, this previous period that is S May which is 0.2 in to demand of May plus 0.8 into forecast of May. Now with this, if I am going ahead and I have the demand data of June. So, only by doing a slight change you can calculate the value of F July. So, the iterative nature of this calculation is so simple that whenever data gets developed, whenever new data is available, you will be able to update your forecast without much effort.

You need not to go back. You need to consider only the current equation and by putting your new values into that current equation, you can update your forecast. So, this is the forecast for July. So, in this case, we took the monthly data so the forecast are updated on the monthly basis. Similarly, you can do it on the weekly basis. You can do it on the quarterly, basis so you can choose a period of forecasting.

And depending upon the requirement of your organization, you can develop this kind of table. And nowadays it is very simple that even the simplest software like Excel can help you in doing this iteration automatically. You can put this formula like alpha Dt plus 1 minus alpha St minus 1, this formula you can put in the Excel and Excel this formula. This is the important formula. And by putting this formula, you can automatically get iteration step by step and your forecasting will be done.

So this is the simplest method of exponential smoothing. Now you can see that the weightage of our in this particular case, if you remember, here we took S January where we are giving 20 percent weightage, where we are giving 20 percent weightage to the demand of current period and 80 percent weightage we are giving to the forecast of January. This S naught is basically F January. Now you can recall it.

So here in this formula, you see 20 percent weight to the current demand and 80 percent to the forecast or previous base. Now you can recall we have already discussed again, I would like to reiterate that point. In case, this weightage is like that, alpha is equals 0. Now in this case, alpha

is equals to 0, you are giving 0 percent weightage to the current demand and 100 percent weightage to the previous case.

So, it means there are some fluctuations in the current period which are of extreme temporary nature. These are not going to be recurring, these are not going to affect your future demand. So, you want to discard those temporary changes you do not want to include that phenomena in your future calculations. So, in that case, you take alpha equals to 0 that is one extreme case. Alpha equals to 1, when you are considering that 100 percent changes need to be incorporated.

Here, your base has shifted to a new value and you do not want to continue with the previous base. In that case, you take alpha equals to 1. So these are the extreme conditions. It is important to remember these things again and again, and therefore you will also be able to appreciate the meaning of popular values of alpha that why the smaller values of alpha have more smoothing effect.

Larger values will give you a very impulsive kind of forecast, but smaller of alpha will give you a, more smooth values of forecast. So, we use more, smaller values so that your curve of forecast is more, smooth one? Now we go further in this discussion and here taking the same data you remember these old table.

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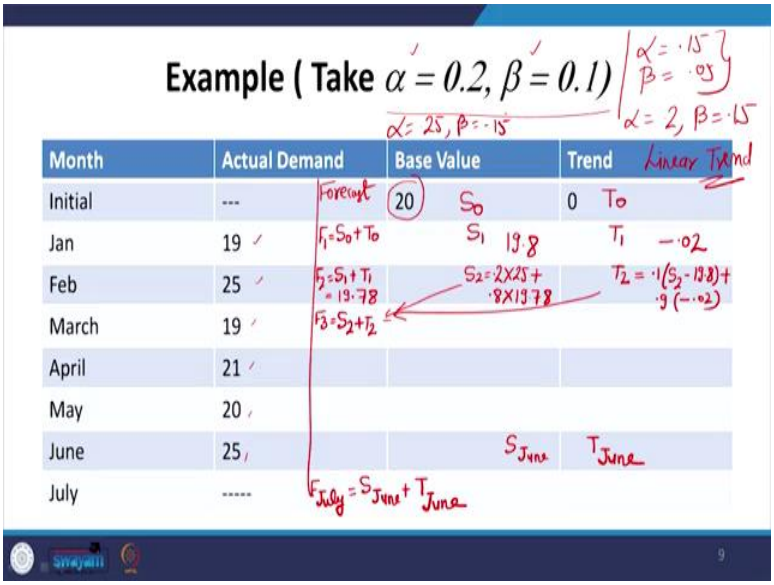
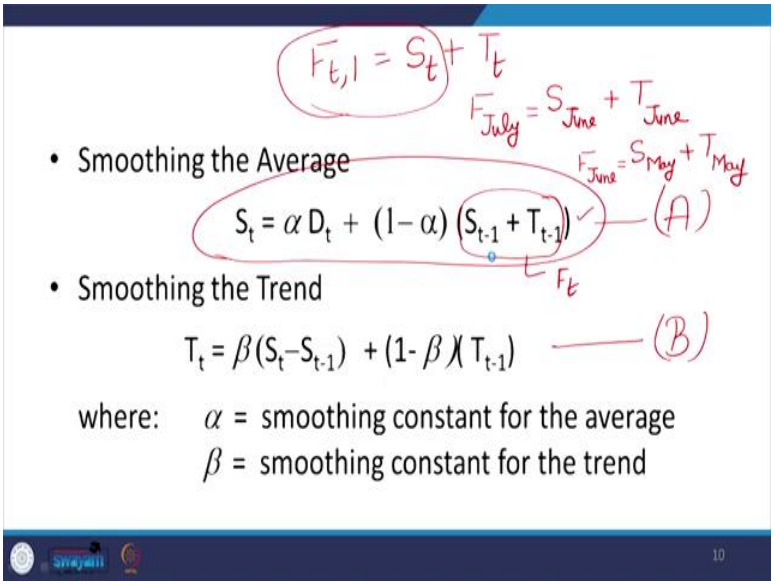
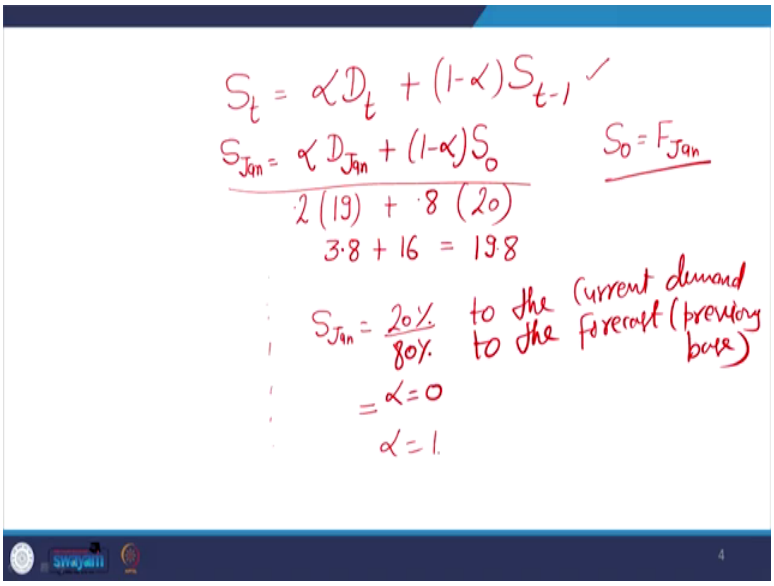


Month	Actual Demand	Base Value	Trend
Initial	---	20	0
Jan	19		
Feb	25		
March	19		
April	21		
May	20		
June	25		
July	-----		





The first was 19, 25, 19, 21, 20, 25. These were the demands of six period. So, the same data which we were discussing. Again we are going to use the same data. Now the base value again we have assumed 20. But now I feel that my data may have some more characteristics also and I am thinking that my data has linear trend. So, now I am going to use a smoothing model, which requires two smoothing constants, and therefore I have taken alpha and beta as my smoothing constants.

Alpha to smooth the fluctuations of the base value. Beta to smooth the fluctuations of the trend value. So, I am going to use two smoothing constants alpha for base, beta for trend. There may be another complicated situation, where I may use alpha, beta, gamma all three, but we will go for that situation in our coming classes. In this case, we are going to use two smoothing constants alpha and beta. Now in this particular case, we are assuming to start our discussions. We are assuming that the initial base value is 0. Base value is 20 and initial trend value is 0.

Now you see here what we need to do, we have to smooth the base value using this formula. You can say that this is formula A. Then we also need to smooth the trend, this is formula B. And then we also need to know what is the forecast for the next period. So the forecast for the next period is since it is a case of linear trend will be this.

Forecast for the next period will be the sum of the base value or the average value and the trend value, so updated trend plus updated base will be the forecast for the next period. Meaning is if I am forecasting for July, so the base of June and trend of June, their sum will give me the forecast

for July. If I am forecasting for June, so base of May and trend of May will give me the forecast for the month of June.

So this way, earlier in the previous discussion, previous example, the forecasting was only limited to this particular component. The second step trend was not there. But now I am saying that data may have trend and therefore I am taking the advance model where we have this base as well as trend component also present in to my data and here I am going to use two smoothing constant and that is how the forecast, if you see will be the sum of these two.

So this is S naught, this is T naught. So this is F1, so this is F1 equals to S naught plus T naught. Similarly this will be S1, this is T1. So, F2 will be S1 plus T1 and so on if I talking of F July. This is S June, this is T June. So, F July will be S June plus T June. So, the same iterative process will be followed in this case but here, we need to continuously update two values one of the base and second of trend.

And how we are going to do that formula is available to us that first you will update the value of base using alpha Dt plus 1 minus alpha and this you see St minus 1 plus Tt minus 1. This is actually the forecast. This is the actually the forecast this St minus 1 plus Tt minus 1, this is actually the forecast for the current period.

So, you can now relate it with our earlier model that this Tt, this is Tt and Tt means the current trend. So here what we are doing, the component of previous trend and the difference of this since this is a linear trend. So, the updated base minus the previous base that will give you the value of current trend and the previous trend and on the basis of that, you will calculate the updated smooth trend and the sum of these two will give you the value of your forecast. Now, let us do calculation of this and for that purpose, let me have some values with us.

So, we start with the first value of D January, so D January is given to us as 19. S naught is given to us as 20, T naught given to us as 0 and with the help of this. You can also say that F1 or F January equals to 20, 20 plus 0, so F January becomes 20. Now my job is to calculate the value of S January and T January.

S January and T January will give me F February. So, now let us start our calculation for S January and T January. Now formula is again go back to this slide, St equals to alpha Dt plus 1

minus alpha Ft. So S January equals to alpha Dt plus 1 minus alpha Ft. So this becomes alpha is what we have taken as alpha's value, 0.2 So, this we can write as a 0.2 into Dt, Dt is the current demand that is of January 19 plus 1 minus alpha 0.8 and Ft, that is the forecast for January that is 20.

So, this becomes 19 into 2, 3.8 plus 16 that become 19.8. This is the value of S January that is 19.8. Now I want to calculate the T January. Now T January is St minus St minus 1 plus 1 minus beta T January minus 1 means T naught. Now beta's value we have taken here as 0.1, so 0.1 St we have just calculated is 19.8. S naught was 20 plus 0.9, T naught was given as 0. So, here this is 0.1 into minus 0.2 plus 0. So, it becomes minus 0.02 that is the value of trend for the January.

So, you can now put these values that S1 is coming 19.8 and T1 is coming minus 0.02. So, your F2 will become 19.8 minus 0.02. So, F2 will become 19.78. Now, this value will be used for calculation of S2 and T2 and it is possible now that we can do this calculation in this table itself so that we need not to go again to next slides and come back. So, now S2 will be, you see this formula alpha Dt plus 1 minus alpha Ft. So, Alpha is 0.2 into Dt that is 25 plus 0.8 into F2 that is 19.78.

T2 will be beta 0.1, so this value of S2 minus S1, that is 19.8 plus 0.9 into T1 that is minus 0.02, so you get the value of S2 and T2 now by doing this calculation, you can get the values of S2 and T2 and this S2 and T2 will give you the value of F3 that is S2 plus T2. So, now as we just discussed in the previous case, in this case also, you can develop a iterative method of calculation and that iterative method of calculation will help you in doing this calculation in a very simple, straightforward manner.

It is a more cumbersome method because you are simultaneously need to smoothen two values base and trend better if you just develop a standard process in Excel. It is very simple, just by updating the values, you keep on getting the new value and finally, you get the value of F July. That is sum of S June and T June. Now the important point which we need to see that we have done this calculation for the same set of actual demand 19, 25, 19, 21, 20, 25.

In this case, we consider that trend is present in the data and therefore we took these two smoothing values. In the previous case, we did not consider the trend. We only took as our base values and there was no presence of trend with both these methods we got the values of

forecasting. Now it is important to see which method is more useful in the given situation. So as a forecasting manager, as operation manager, it is nobody going to tell you that which method you apply.

It is your wisdom that which method is more suitable for my given data and for that purpose we are going to discuss in one of our coming sessions forecasting errors. Use of the concept of forecasting errors will help us in determining the suitability of a particular method. If our forecasting error measures are giving lower values that method is a suitable method.

If those values are higher, then we need to see some other method because if forecasting is done with a lot of mistakes, if is not accurate, then whole production planning will suffer. You will not be able to take the advantage of the production planning. So, therefore it is important that we understand this particular thing properly and it is not only this suitability of method. In this particular case, we took the value of alpha equals to 0.2 and beta equals to 0.1.

Now since I have shown you manual calculation, you may be a bit afraid, but when we use calculators, when we use our software for this purpose, you can play with the values of smoothing constants also. You can take some other combination you take alpha equals to 0.15, beta equals to 0.05. You can take alpha equals to 0.2, beta equals to 0.15, you can take alpha equals to 0.25, beta equals to 0.15.

So, you can take any combination of alpha and beta's value and just by if you have everything done in your Excel spreadsheet, it becomes very, very convenient to do this kind of play with your data. Now which ever set of alpha beta values give you minimum forecasting errors that is a suitable values of alpha beta for your case because it is very, very difficult from naked eyes to tell that this particular value of alpha and beta is suitable for this particular data.

Only by iterations, only by putting different values of alpha and beta and checking those alpha beta values for forecasting errors will tell you that this set is a suitable value, so we need to see and we will see that when we will discuss the forecasting error in our coming session.

So, with this, we discussed in this particular session that how to apply basic exponential smoothing model and then we also discuss the same set of data for exponential smoothing with

linear trend. In our next session, we will discuss one more example where we see the seasonality component also included in our demand data. So, for this thank you very much.