International Economics
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Module No. # 01

Lecture No. # 20

Good afternoon we are talking of the empirical work on the Indian exchange rate today. And I would like to draw your attention to a spread sheet here excel spread sheet, where I have put the data of the U S dollar Indian rupee exchange rate and the s d r Indian rupee exchange rate. The exchange rate data is from the r b I reserve bank of India hand book of statistics. You can visit the r b I website to collect the data. And the other data on the other right hand side factors, which is the pound sterling detach mark euro Japanese yen exchange rate. Differential inflation rate, differential real interest rates, the money supply, the GDP is there all from the World Bank world development indicators.

So, finally, the sheet that I would use is this, where in these are the years. And these are the U S dollar Indian rupee exchange rate. The first column a column is the s d r Indian rupee exchange rate, b c d are pound euro yen exchange rate, e n f are differential inflation rate, differential real interest rate g is money supply. Here h is the money supply in the foreign country I is the G D P in India, j is the G D P in the u s. So, now, I could either take it to eviews or I could take it to state. So, let us take it to if you want state eviews as forty one year's data. Once you open e views it is easy you go to work file and you have to put annual data from 1971 to 2011. And you get this icon go to quick edit series and you paste the data.

So, series 10 will become my dependent variable and series 1 to series 9 will be the set of explanatory variables. So, go to quick and then estimate equations. So, we will apply squares S E R 10 C for the constant

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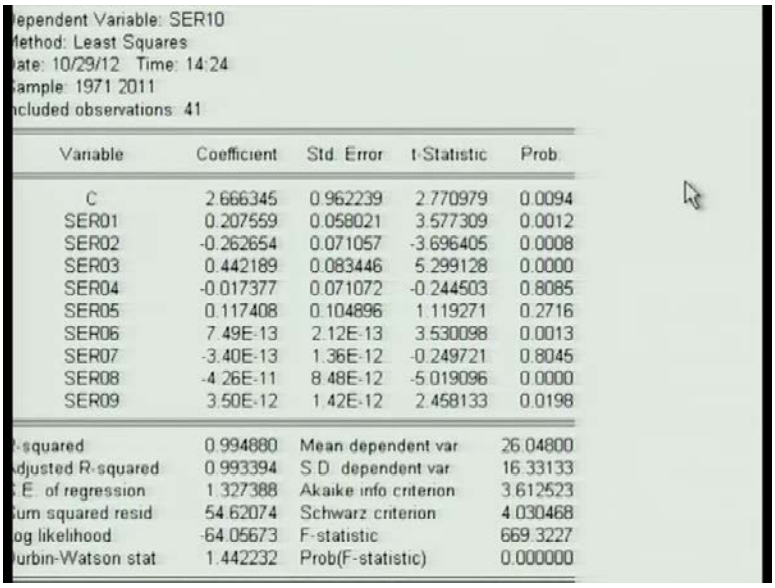

So, that is the OL results that I get. This is the R square that I get 0.994. 99.4 percent of the variability in the dependent variable is explained by all these explanatory variables, which is on the higher side. Also the durbinwatson statistics is 1.44. So, if you recall if the durbinwatson statistics is nearing 0 there is an evidence of positive auto correlation.

So, one has to take care of this durbinwatson statistics. And here is the results look at S E R 01, which is the pound rupee exchange rate. So, it comes with a positive sign and it significant the rule of the thumb is say. If the t values are greater than two then it has a significant impact. So, if pound appreciates India the U S dollar in terms of Indian rupee also appreciates. So, pound has an impact mark or German mark or euro has a negative sign. So, if euro depreciates then only U S dollar appreciates dollar in terms of Indian rupee. So, there is an inverse relationship. Yen has a positive impact four is differential inflation rate it does not have any significant impact, because you can see the value is 0.80.

Series 5 if you apply simple O L S again differential real interest rates does not have a significant impact. But, then 6 and 7. 6 is money supply. It has a significant impact on the Indian rupee on the U S dollar Indian rupee exchange rate excess supply of money. Remember excess supply of money is means leads to reduction in savings it is equivalent to excess demand for goods and securities leads to balance of payment deficit. If there is

a deficit and it is a flexible exchange rate you will see a depreciation of Indian rupee or an appreciation of the U S dollar.

So, that is reflected here the money supply in the foreign country does not have a significant impact, but, 8 is the G D P of our country. Now it is comes with the negative sign because, remember higher the G D P larger is the demand for money. More is the savings lesser is the demand for goods and securities. There will be a balance of payment surplus leading to appreciation of Indian rupee or a depreciation of the U S dollar. That is why you see a negative sign at a c r 08. And then even GDP of the foreign country have impact on the rupee U S dollar rupee exchange rates.

So, this is the result that you get, when you apply simple O L S, but, in time series you have to be careful about two things auto correlation and about the unit root. So, when I checked for unit root each of these variables was had a unit root problem. That means, the series is non stationary. If the series is non stationary at the levels then you first check for co integration.

After differencing the series if all are I one then you can have co integration. If all of them are not of the same order then you will then you do v A R vector auto regression. And in vector auto regression what is more important is this impulse response and variance decomposition. That says for example, if you if the pound changes how much impact will be there on the U S dollar Indian rupee. And in how many time periods that can be checked through various variance decomposition.

So, if you give a shock to the system how will the variables be affected after certain time periods. That is the information that you get from impulse response and variance decomposition.

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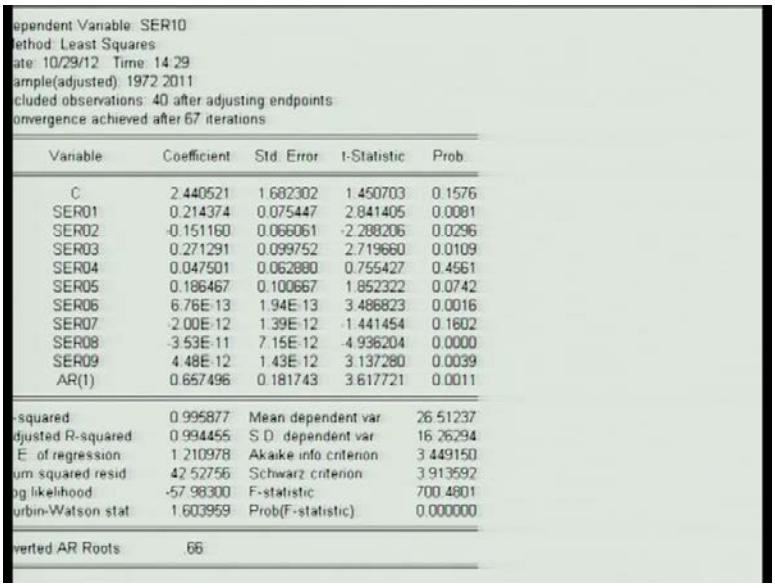

So, we will do that two things first let us apply the remedial measure. It is very simple if you have to apply G L S. What you need to do is two A R 1 A R 1 and this is auto regressive. One it is the first order auto correlation coefficient and here are the results. That is the remedial measure you up this is G L S O L S applied to the transformed model. What is the transformed model?

You transform the original model in such a way that it starts obeying all the assumptions of the classical linear regression model can show you the econometrics of this. But, see the set of results you get again 1 2 and 3 pound euro and yen have a significant impact on our exchange rates. This is the data from 71 to 2011 and then differential real interest rates have become a significant factor in explaining the Indian rupee exchange rate. And it comes to the positive sign.

Now, one would have expected that if the differential if the interest rate goes up here. There will be more money coming in. If more money comes in it may leads to appreciation of Indian rupee or depreciation of the U S dollar. But, this is with a positive sign. Now the reason that it comes with the positive sign is that that differential interest rate is the lending rate minus deposit rate. It is not the deposit rate minus lending rate. It is the lending rate minus deposit rate. That is how it is defined the real and it is adjusted for inflation that is why you see a positive thing.

So, higher the real interest rate means lower the deposit rates. Lower the deposit rate lower is the money coming in lower is the money coming in. So, you will not see an appreciation of the currency you will see a depreciation of the Indian rupee or an appreciation of the U S dollar. That this series see 1 2 3 4 and this is 5 it is significant say at 10 percent at 5 percent no, but, at 10 percent yes and 6 yeah you right. It is not significant at 5 percent it is significant at 10 percent.

So, these two factors that we talked about inflation differential inflation, differential interest rates in Indian context. It does not work I mean marginally if differential interest rates do. So, that may be one of the reasons when R B I, So, it is not a good predictor the good predictors for Indian rupee are the movement in the other exchange rates. Our money supplies our G D P. That may be one of the reasons that r b I does not announce a pre announced path for the Indian rupee.

It does not say that we follow these parameters only it talks about having orderly conditions in the foreign exchange market. No speculation nothing of that sort, but, it is not a crawling peg it is a managed floating. Whenever there is a difficult situation in the foreign exchange market it intervenes that may be one of the reasons and. So, 7 and 8. 8 is the our Indian G D P and it comes with a negative sign and nine is the G D P in the foreign country and A R.

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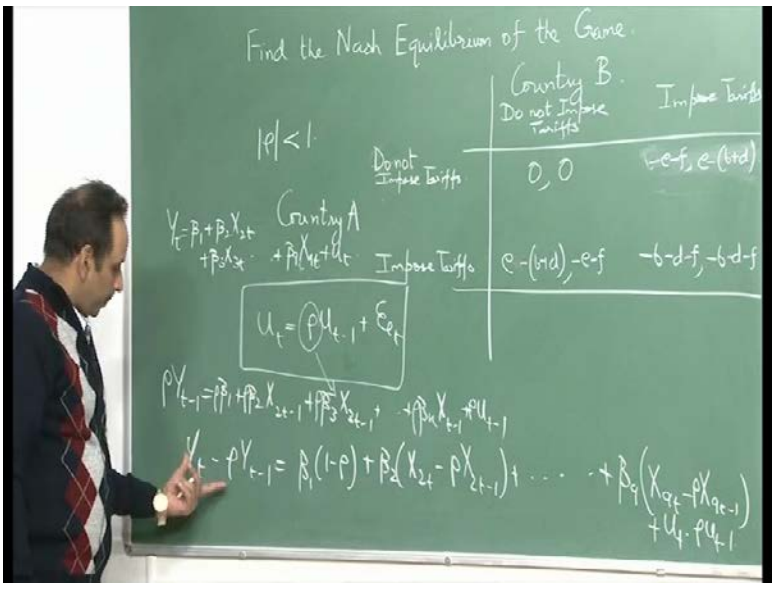

One please recall if it is auto regressive structure of order. One this is the this is this is our model how many 10, 9 this is our model. This is the classical linear regression model and this U T is rho U T minus one plus xi t and this is working out to be point six five seven.

So, it is on the higher side remembered this rho is like the product movement correlation coefficient. It varies from minus 1 to plus 1. And you saw the durbinwatson was moving towards zero. It was 1.4. And after you have applied the remedial measure durbinwatson has gone up to 1.60 and this a a r roots. It is this rho for stability this is less than one. So, it works out to be 0.66. Remember that how do you do the remedial thing you do y t minus 1 b 1 plus b 2x 2t minus 1 plus d 3 x 3 t minus 1 and so, b k x t minus 1 plus U T minus 1. Then you multiply it with rho and then you do y t minus rho y t minus 1.

So, you will get beta 1 1 minus rho plus beta 2 x 2 t minus rho times x 2 t minus 1. So, this is the transformation that you have done you had this original model. You transformed it in into this. And if you know rho then you can apply o l s to this transformed model. So, this you apply O L S to the transformed model because when you do U T minus rho U T minus one you get xi t xi t is white noise expected values xi t zero variance of xi t is sigma square co variance is 0. So, U T minus rho U T minus one is xi t earlier in this U T was following an A R structure.

Now, it is transformed i t x i t. So, you can apply o l s to the transformed model. And if rho is known then you can simply apply O L S to this transform model. That is G L S now problem comes is rho is unknown. So, you have to get an estimate of rho once you put an estimate of rho. It is called the feasible generalized least square silencers feasible generalized least squares because that omega matrix is an estimated one. So, do you do you recall the cochraneorcutt procedure. So, that is this is the cochraneorcuttit's the feasible generalized cochraneorcutt or the feasible generalized least squares you estimate rho. You when you estimate rho or there are two ways of doing it you can start with taking rho as 0. When you take rho as 0 it is like applying regressing y t on all these explanatory variable generate getting the regression generating the residuals e t series.

Now, regress e t on e t minus 1 and. So, this is step one take rho as 0 regress y t. On all the explanatory variables get the estimates find out the residual series e t series. You have e series you have e t minus one series regress e t on e t minus one. That will be an

estimate of rho. So, you get rho in step 2 then put it back here again then regress new set of y variables on new set of x variables generate the residuals e t series regress e t on e t minus 1 get an estimate of rho. Put it back here keep doing this two step iterative procedure keep doing it till you find convergence in rho you that converged value of rho. And the estimates of alpha and beta are the feasible generalized least squares estimated.

So, state does the (( )) is little more enterprising it does the non-linear least squares, what is non-linear least squares. If you had taken this here on the right hand side. So, then if you had taken this on the right hand side you would get y t is equal to rho y t minus 1 plus b 1 1 minus rho plus b 2 x 2 t minus b 2 rho x 2 t minus 1 plus. So, on plus beta 9 x 9 t minus beta nine rho x t minus 1 plus xi t. You have less parameter, but, you have more equations more normal equations. So, if you apply o l s you cannot get the unique estimates because the number of unknowns are less than the number of normal equations.

So, then what you do is you apply non-linear least squares non-linear least squares is like you start giving initial values for all the parameters and then you minimize the residual sum of squares. So, that is like trial and error start with the initial value see, whether the residual sum of squares are minimized or not keep doing it. But, that is not an easy way.

So, you need an algorithm where in you there should be a proper way of giving the initial values. And what would be the next values and what will be the final values? So, non-linear least squares like you apply the Taylor's expansion to any function right and in that way you get an algorithm of how betas are related with each other.

So, views with a click of mouse does on-linear least squares. It was difficult in the 60,70s, when you have computing. But, now they have already have an inbuilt algorithm different algorithm gauss Newton Raphson and. So, on there are. So, many algorithms going so it gives the estimates. So, the last point on this is that I will now take it to I will take it to state to show you how this cochraneorcutt procedure works.

And, whether we get the same set of results, that we are getting here from our non-linear estimation whether we get the same thing from the cochraneorcutt. Because cochraneorcutt enterprising thing was that what he did was he just took this term on the left hand side. And then he said you do not even have to apply non-linear least squares.

you apply O L S to this, but, he had these two steps two steps were because one was how to get an estimate of rho and then second was the iteration procedure right

So, cochraneorcuttor feasible generalized least squares. It is a two-step iterative procedure. So, I quickly take this data set to state now the these are the results. That I get by applying non-linear least squares I will just leave you with the command that you have to do next time. If someone asks you that if you are working on time series how would you take remedial measures. You take remedial measures by imposing this term A R 1. That is all and then you should know what you are doing because, what it does is that at the end. At the end it is giving you an estimate of rho, which is 0.657

So, you should know that this is the coefficient, which is attached to y t minus 1 you should know it S E R 01. So, you have a constant. So, this will be a constant this is the constant that you get. So, this entire term is a constant and if you know rho you can know b 1. So, this constant is this b 1 then beta 2 x 2 t beta 2 x 2 t. It will be se r 0 2 then for the coefficient, which is attached to x 2 t minus 1. It is minus beta 2 rho x 2 t minus 1 now, when you already have beta 2 and you know rho you should be aware that this is the coefficient, which is attached to x 2 t minus 1

So, again with then we will have beta 3 x 3 t. With then there will be a term, which will be minus b 3 rho x 3 t minus 1. So, this is not giving the complete picture this is this only gives you this beta 2 beta 3 b 1 you have to know about this equation. So, that is this now ha unit root again if you have this view. So, this is the series that you have y a look at this series statistics unit root test se R 0 1. So, se R 0 1 unit root now would you like to use augmented dickey fuller. The first thing that you do is click on trend and intercept test for unit root in levels and the lag difference by default views gives it as one. Otherwise there are criterion to know what will be the lagged difference

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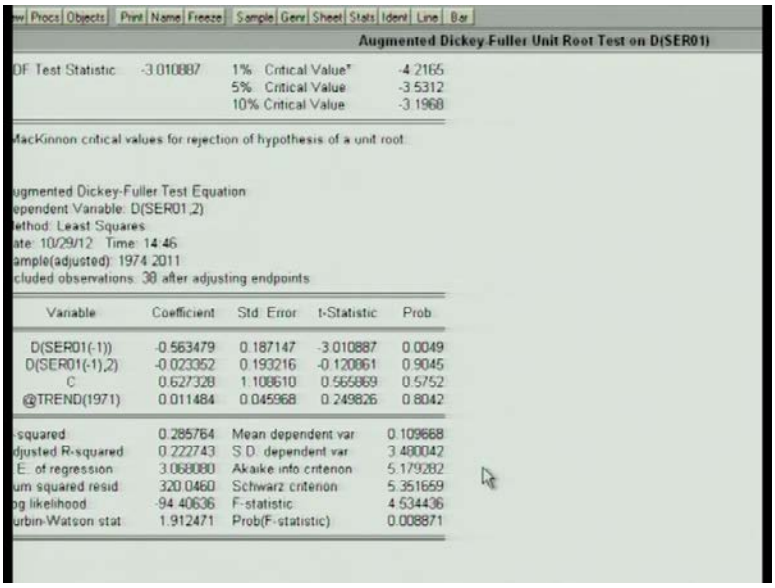

So, you click and this is the result that you get minus 2.20. So, if the absolute value of this is less than the critical values then there is a presence of unit root in the series. So, at levels this series is has is non stationary. Now, you go to view there is unit root test again. Now, see the first difference and then click look at this even after differencing it once the absolute value is still less than the critical values. So, it has not become stationary even after differencing it once. So, then again go to view do unit root go to the second difference click and see now that it is become minus 0.44.70 take the absolute value this is greater than this.

So, this series is I 2 the series one was pound rupee. It is I 2 now you check for each of these if all of them are of the same levels are integrated of the same levels. Then you can apply co integration. If not then you cannot apply co integration then you have to apply V A R. So, that is what we found that the series some are I two some are I one some are I 0. So, you end up doing v A R and in V R. Now that I am in views look at this quick you have to put all the endogenous variables. These are the V A R results impulse response you have to click into variance decomposition and you need a table. So, you click.

Now, if you because our interest is series 10 series 10 is the rupee dollar exchange rate. So, most of the variability in series 10 is explained by look at series. one which was the pound rupee exchange rate 34 percent of the variable. In 10 time period is explained by series 1 euro explains 3.5 percent Japanese yen 16 percent differential inflation rate. 0.66

differential interest rate 196 money supply 4 money supply in the foreign 58 is GDP in them less, what was series? one let just hold on series 1 series 2. So, series 5 and 6 series 1 was pound series 2 was euro mark series three was Japanese yen series four differential inflation rate. Series 5 differential interest rate series 6 money supply series 7 money supply in the foreign country. Eight G D P 9 G D P in the foreign country 10 rupee dollar .So, 10 in we are interested in 10. So, we are we are interested in the variance decomposition or series 10

Now, So, a series 91.78 percent. Now here if you go read through V A R analysis this ordering also matters. If I had put series 10 here and the others it would have given me. It is possible that it gives me another set of results right. So, ordering matters when you do VAR, but, this is the result that you get. So, we had an impression when we started reading about Indian exchange rate. That may be that differential inflation rate interest rates the we were not very sure about, whether how does pound have an impact.

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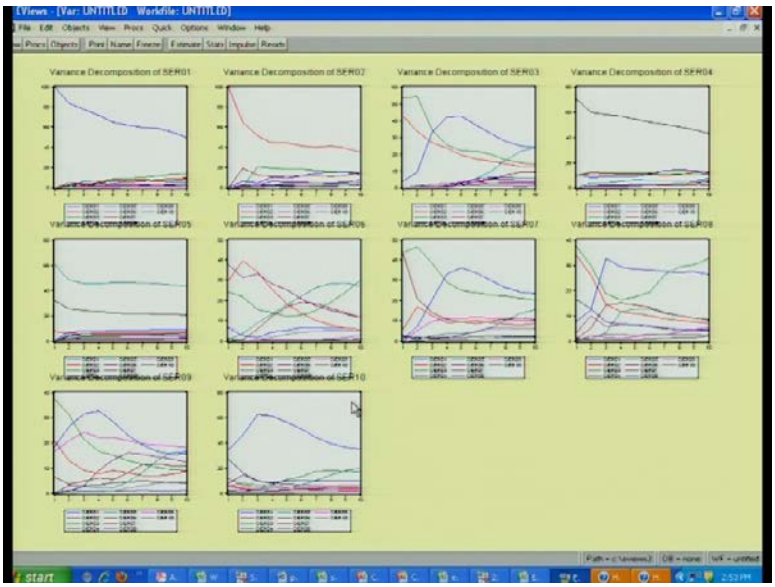

So, pound euro yen they do have an impact on our Indian exchange rates. So, that is what you do when you do V A R. You do impulse response in an impulse response see the graphs. That you would get these will be the graphs that you get say if you give a shock to the if the pound changes abruptly how will it have an impact on it is own series and the other series. So, you have to closely see this and it comes with this colored line. So,

you can you can you can see the trend. So, I have not had a good look at it just 8 or 9 days work.

So, I will have a look at all this impulse response and see how the other variables get impacted. So, these are the results that I get quickly. If I take this data set to states I have already put the data state you go to time series. And then you apply a price winstonregression and look at this cochraneorcutt transformation. This cochraneorcutt transformation and you click now see the iteration. This iteration remember this rho starts with 0. So, you regress y t on the explanatory variables. Then you generate the residuals E T 1 t minus 1. It does the iteration keeps doing it keeps doing it till you find this convergence and. So, and here you are see the results variable one was the pound

So, it is significant again euro has a negative impact yen positive look at a variable 5, which was differential real interest rate. Now, it is become significant 6 was money supply, 7 was money supply in the foreign country, 8 was G D P in the home, 9 was G D P in the foreign. The durbinwatson statistics after transformed has g 1 up from 1.44 to 1.60. So, the same set of results that we got when we applied non-linear least squares similar. So, this is what you would get you can consider this is as a regression equation you can forecast the values using this, but, at the end as I said when you do time series you have to check for unit root and every variable has a unit root.

So, if you this regression become invalid if you have a unit root problem. So, then you have to end up doing either co integration or verso, that is why for beginners, whenever I teach that econometric class. I say that you use the cross sectional data because in time series you end up doing this you have done the remedial measure you have taken care of auto correlation, but, you have not taken care of the unit root problem.

So, then you do the V A R analysis. I will end up here tomorrow I will be back on trade policy, but, people who are working on the exchange rates. Now, you have taken the clue out of this you put the data on the spread sheet. You do there gression then you do the remedial measures and then probably you have to check for unit root and this is what.

So, you can do it for any of the other exchange rate Chinese renminbi or any other and see the factors, which have an impact. And then I can break this into different samples from 1971 as the time, when the Breton wood system broke till 93.

When we had our exchange rate, where the R B I use to determine the exchange rate. And after 93 it was market determined. So, intuitively it will be interesting to know, whether the same set of factors are important after 93 and before 93. Then you can do some other transformation you can take the logs on both sides. If you take the logs on both sides left and the right hand side.

You will get elasticity of output with respect to output here is elasticity of the U S dollar visa v. The real interest rates and the other variables the other thing is in state you can also get standardized beta coefficients. Standardized beta coefficients will tell you, which of the variables have more significant impact than the other variables

For example just for a say in the statistics if I do time series price Winston and see the, whether I can. Let me see if simple linear regression yan ormalized beta coefficients. It is like putting all variables on the same platform. You normalize the variables. Because normalized variable has mean 0 variance. One the beauty about regression is that even if you have variables in different units. You can establish a relationship, but, sometimes you want to compare the performance of each of the explanatory variables, which have a more significant impact. That in that case you have to normalize the variables. And then once you normalize it the look at these these standardized beta.

So, from here it seems one point one four this G D P of our home country has the most significant impact because absolute value is 1.14. Followed by the G D P of the foreign country then the money supply so, this. So, simple regression you can show many things. So, in Indias case it is like the G D P and the money supply which has a greater impact on our in rho U S dollar Indian rupee exchange rate because see the pound is significant, but, the absolute beta value is lower 0.33. So, this is significant. So, it has a greater impact.

So, one can write a neat paper on all these results. Then you can do V A R you can write this 10 page paper 11 page paper on this. You know what are the right hand side variables? you have a theoretical backing for each one of them. Then you have the results you know the V A R. It is a complete exercise. So, I am looking forward I have after 18. I will start writing. If you can come supplement it we can have a joint work, where we can put it somewhere. No that is how it works otherwise you keep planning that we will do it and never happens I will end up thank you so much.