Introduction to System Dynamics Modeling
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Lecture – 24.2
Model Validation Sensitivity and Policy Analysis
Sensitivity analysis and policy analysis

We will take a some sample models and scenarios and try to perform Sensitive analysis and policy analysis. And, I will walkthrough on how i and w the sensitive analysis and you can adapt it and further improve it to ensure that we are able to do these things in a proper manner.

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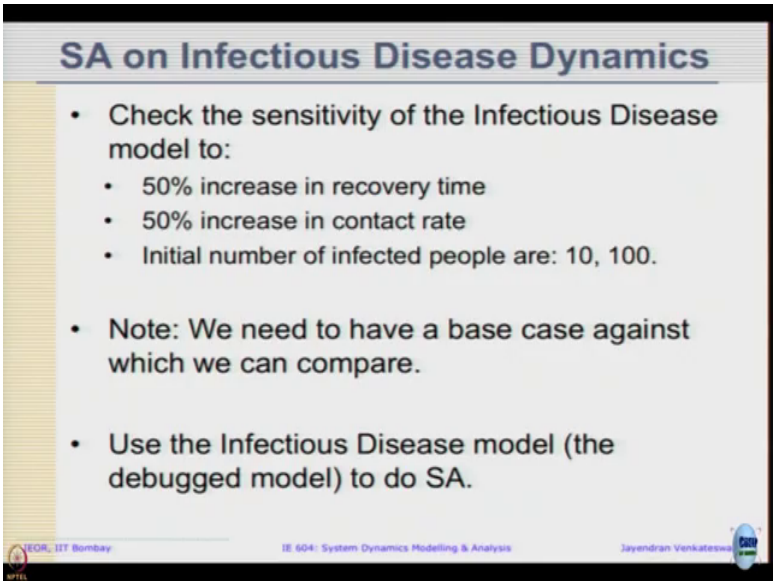

Let us take a first example the infectious disease dynamics we, it builds on what are model we did the debugged disease model that we had yesterday. Now, we like to check the

sensitivity of the infectious disease model to say 50 percent increase in recovery time or 50 percent increase in contact rate on the initial number of infected people, instead of 1 it can be 10 or 100. We want to see what happens to the dynamics and we need to have a base case against which we want to compare the same. So, let me just quickly go over how we do sensitivity analysis in a first let me open.

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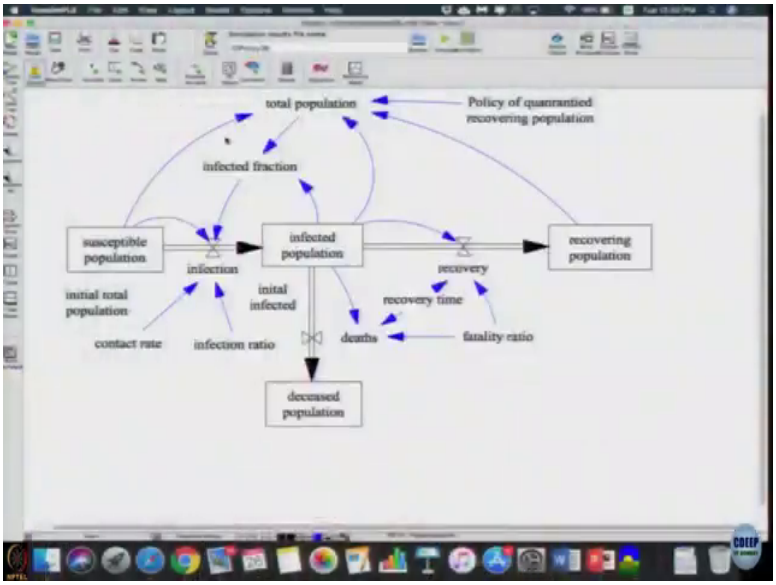

So, these are model we are lot of things happening.

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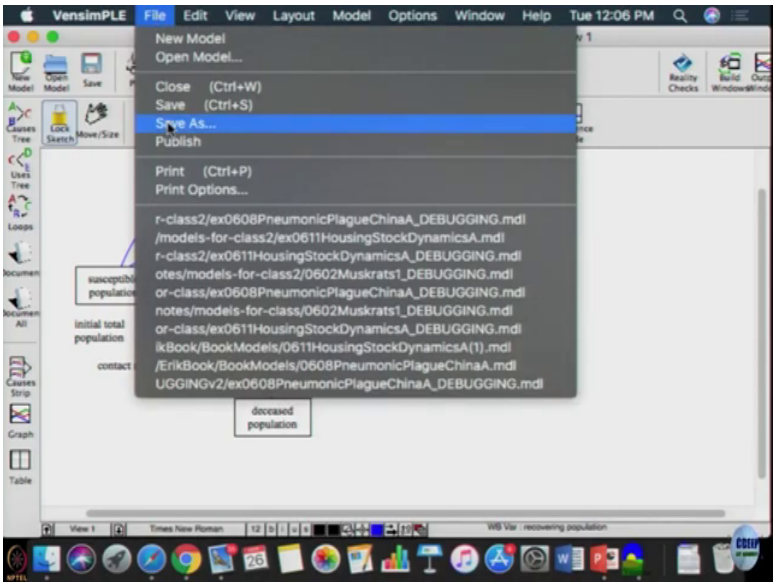

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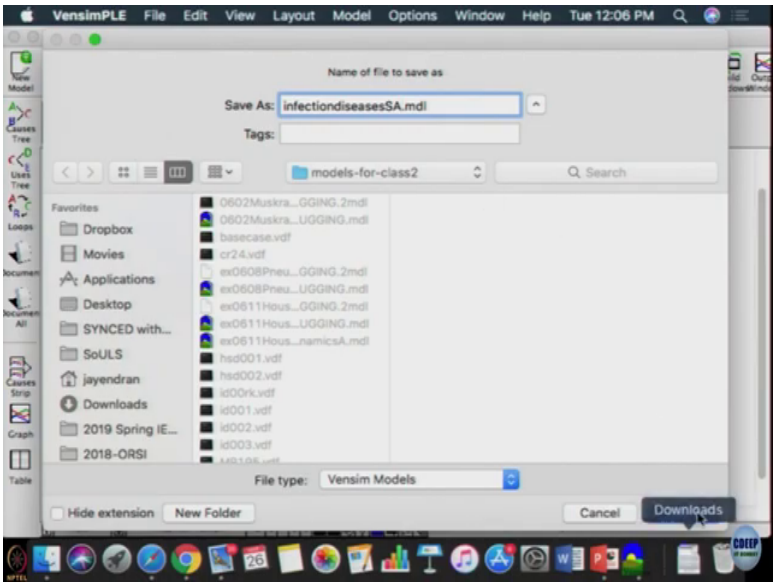

So, first I am these going to save as into a new model.

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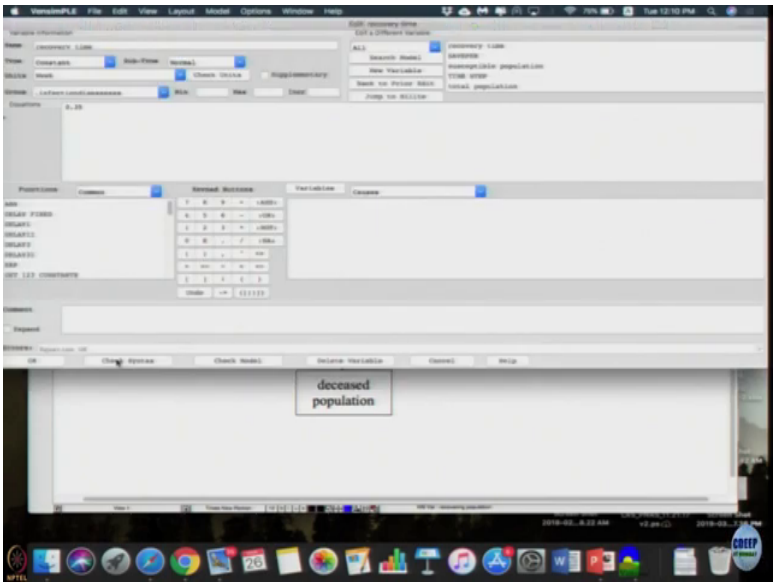

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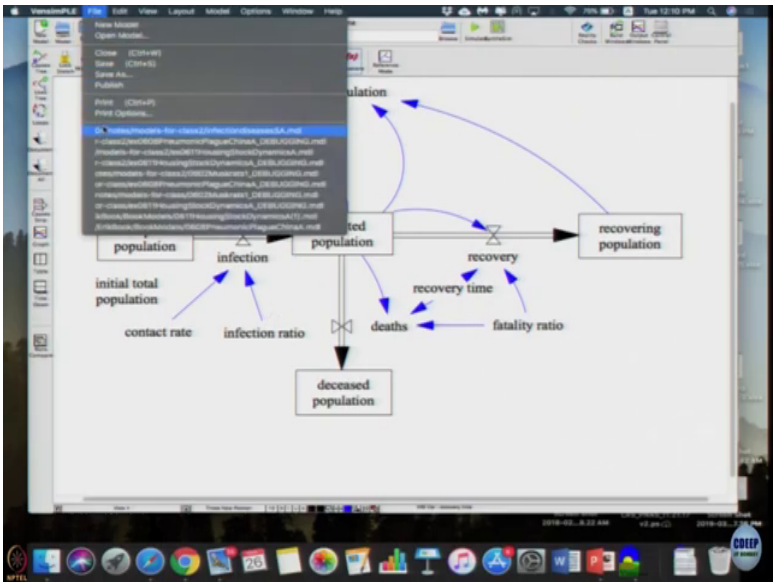

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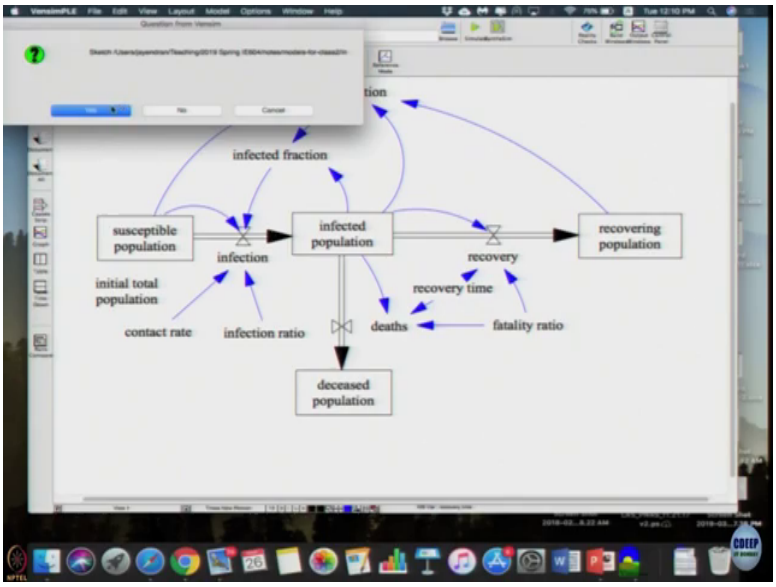

So, first we have to check whether our model is a first thing I saved it as sorry open a infectious diseases model which I saved.

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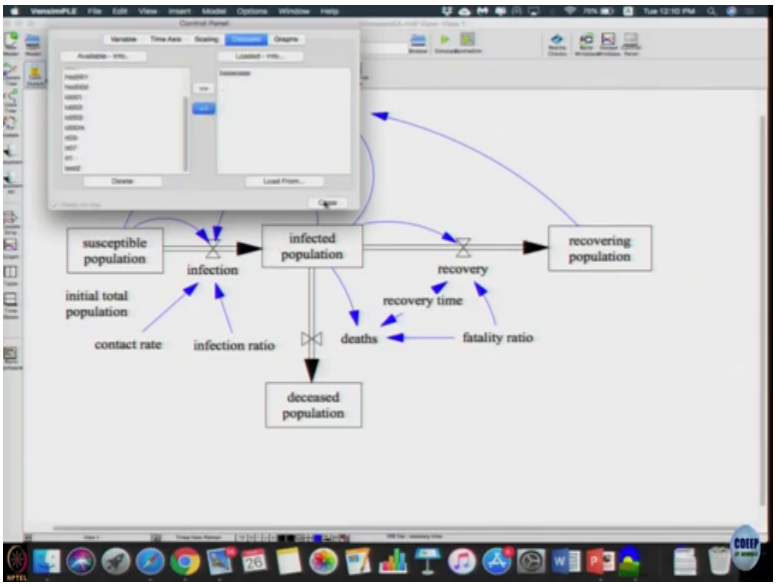

And, if you actually go to the control panel data sets that we lot of data sets you might have used in the previous cases, it is best to get rid of all of that. So, we have only the base case. So, first is to write here the base case simulate it and keep it ready. So, that is a base case against which you are going to compare. So, now, to do sensitivity analysis and since all these all these are parameter changes, we can actually do it without trying to using what is called as a sim setup without trying to open and save all the settings. So, what you are going to do is I am going to just click this sim set up.

So, first case we are going to do is doubling the recovery time right. So, let us just call it ID recovery time now instead of so, recovery time original was 0.35 weeks, we are going to double it. So, its going to be 0.7 right. So, let us just call it a 0 7 (Refer Time: 03:12) 5 7, I am just there is some names right, then you click recovery time. So, as soon as you click the recovery time, when I first I click sun sim then I got this I change the title. Once you click

recovery time it will show 0.35, we changed it to 0.7 right and then click enter, then when we click simulate it would already simulated with this one setting that is.

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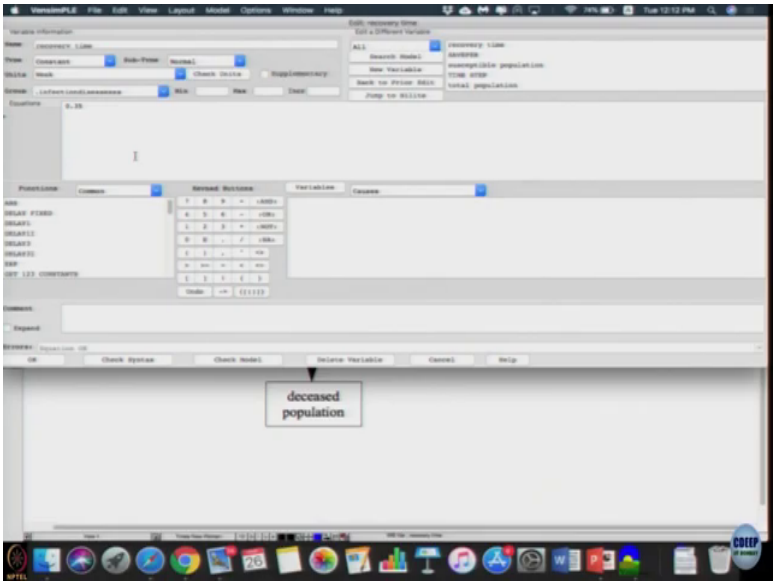

So, now if you actually open recovery time you will find there is still 0.35, when you 0.7 was only use for that simulation run, but it did not change your fundamental base model which is quite useful. Because, the sensitive analysis then if you end up changing many things and it you will not know what combination is you are actually comparing with after some point right. So, this is only change that has occurred.

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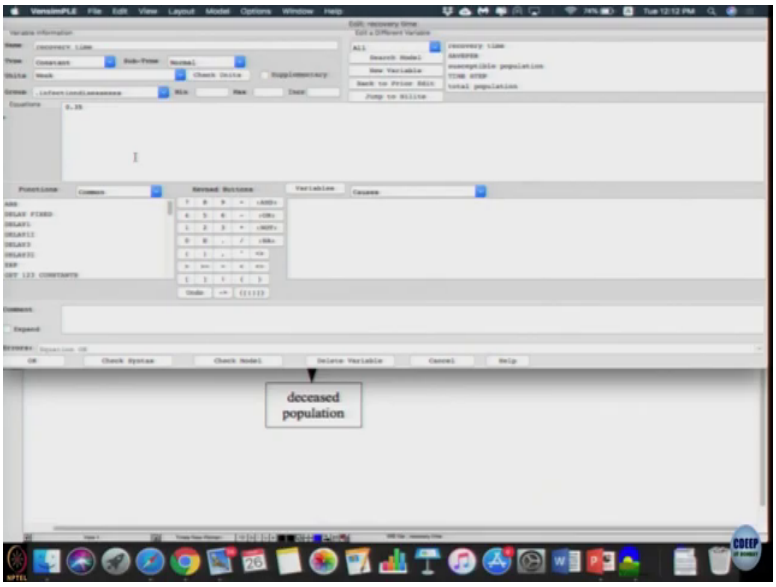

Not actually see the results, if you click infected population and click graphs.

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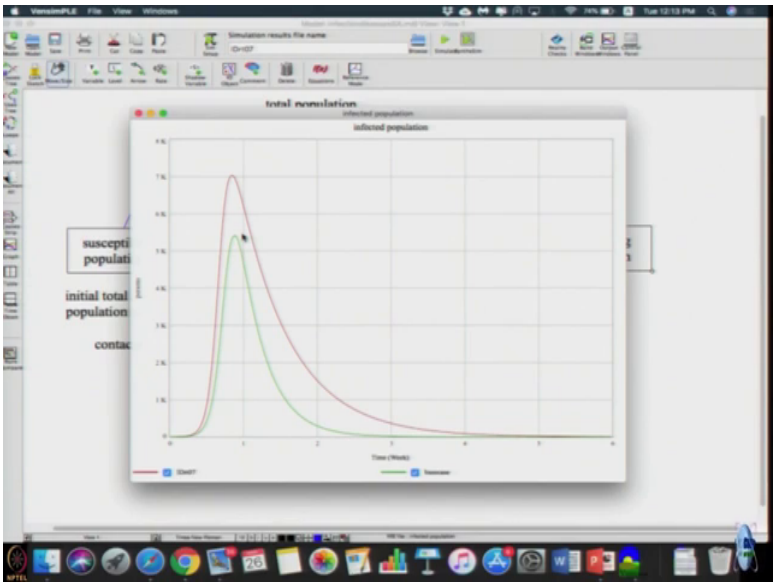

Now, you can see both the graphs base case as well as this IDRT 0 4 is what I given recovery time 0.7. So, it look like for 50 percent increase or double the increase from 0.35 to 0.7; it actually increased about say 5500 to 7000 could be whatever 25 percent increase in the infected population ok, we will do more. So, even if we did not see it the previous one we can see it now, I am just check out ok.

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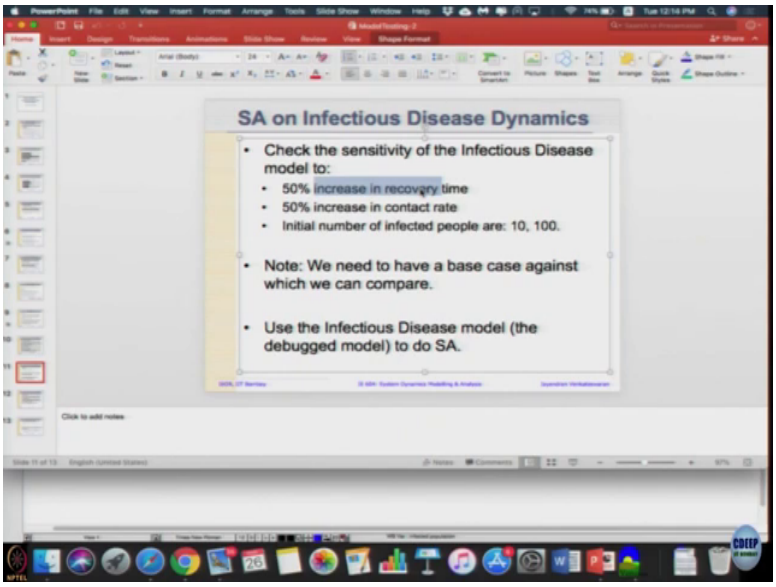

So, actually it is not double the we ran double the recovery time actually the scenario given is 50 percent increase in recovery time. So, recovery time is a 2.5 days; 50 percent increase would be how much? 1.25s or 2 3 3.75 days.

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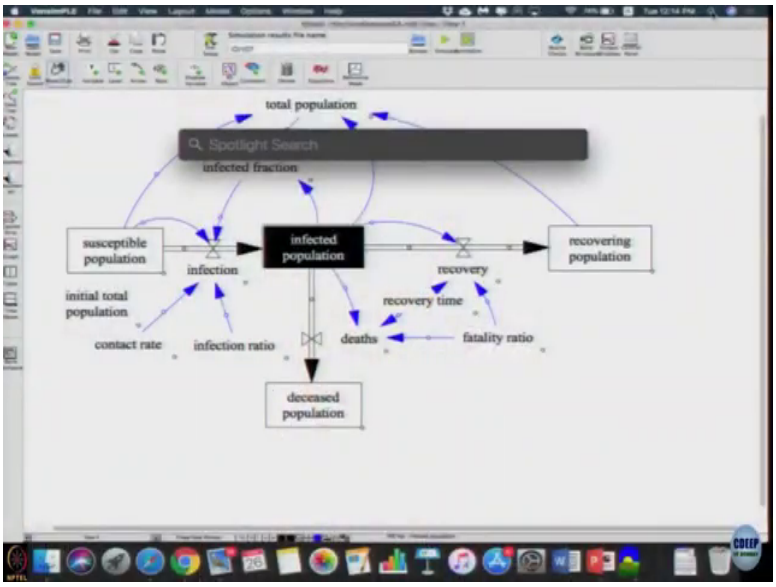

So, 3.75 by 7 would be 0.5 0.525; so, that is a setting that we should have simulated so, let us just do that. So, again 50 percent increase. So, I am going to click sim setup rt say 55 click recovery time instead of 0.35 write 0.52, what was it? 525. So, instead of 50 percent increase in the time and the recovery time when I click enter and then I have to click this play button, I click infected population.

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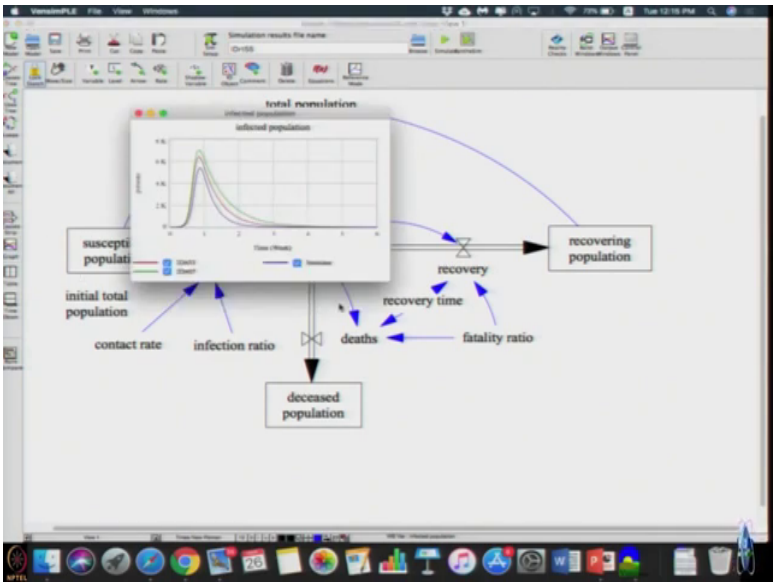

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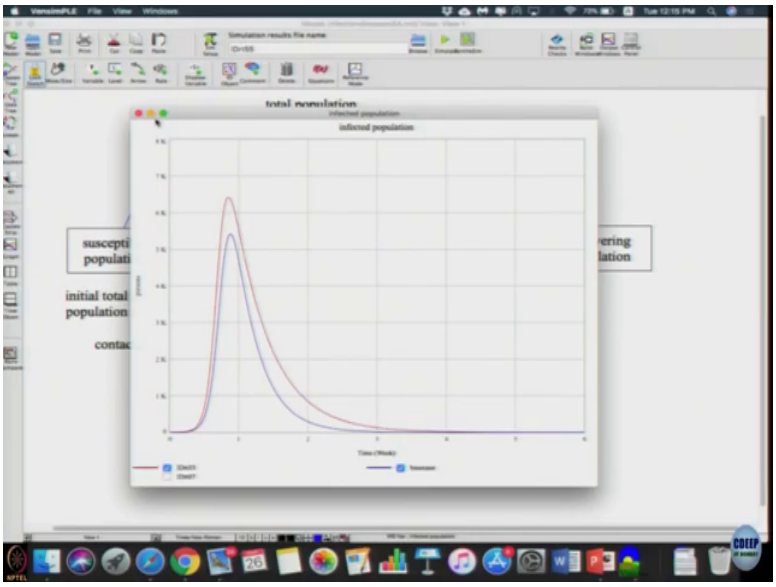

So, this was doubling the recovery time we just want 50 percent increase, I am just remove that graph. So, 50 percent increase in the recovery time cause just to peak at much higher. So, recovery time is longer; that means, people are taking more time to get I mean being infected right. And, that is adversely affecting how? How many new people are getting infected that is infected persons? That increases about 10 percent, 5500 to 6500 to 20 percent ok. Now, let us do a 50 percent increase in contact rate.

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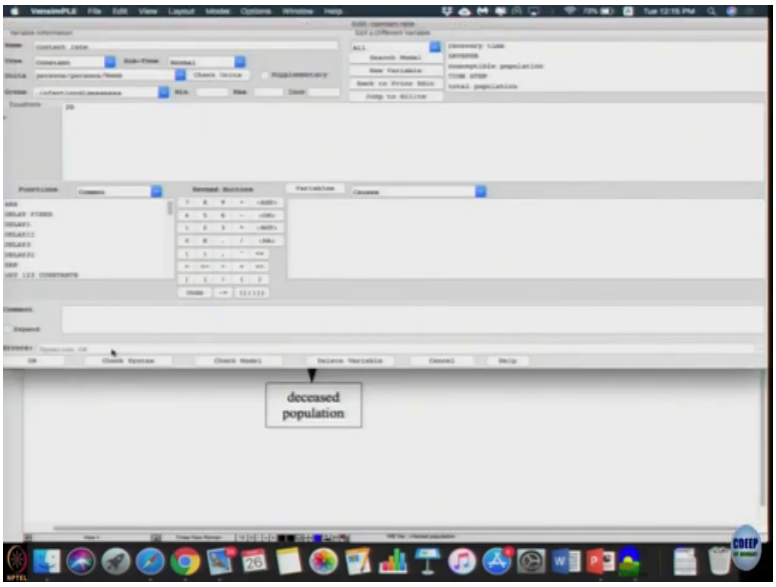

The current contact rate is 20 50 percent increase means it should be become 30. So, let us just sim setup the contact rate 30 then contact rate 20, I change it to 30; remember when I change this why what is the recovery time we are using? Recovery time is still 0.35; so, sensitivity analysis we change only one parameter a time and this helps us avoid other errors, that you play or infected population are plotted. Let me again remove this ID 07.

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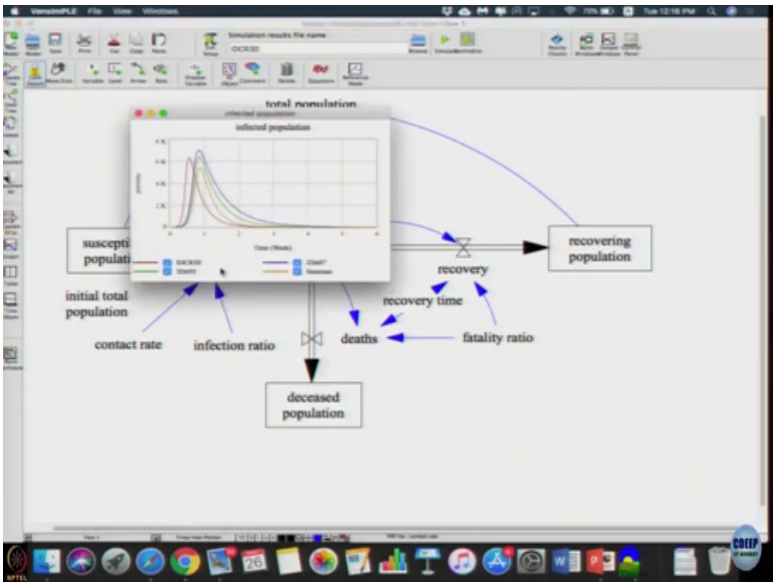

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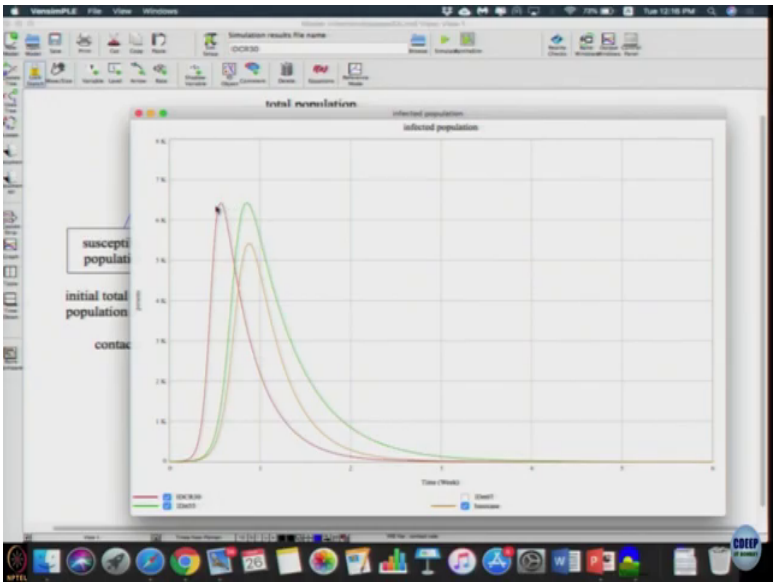

So, compared to the base case when the contact rate increases also we are getting similar peak, but much earlier. So, if contact rate increased by 50 percent or the recovery rate increased by 50 percent the total infected is the same that is interesting, that is 1. 2 in this case more contacted happens, more people are getting infected earlier. So, it the peak shifts by a few days here which can have impact on our policy in the sense of how much you want to have beds and things like that.

So, this is how sensitivity we do and say how much then we compare how much now reduction in days is about 2 to two and half days has reduced. And, peak has increased by 25 percent for 50 percent increase in these changes, it resulted 35 percent these changes this is how we record it. What is the next one? Initial number of infected people are 10 and 100. So, let us see what happens to that.

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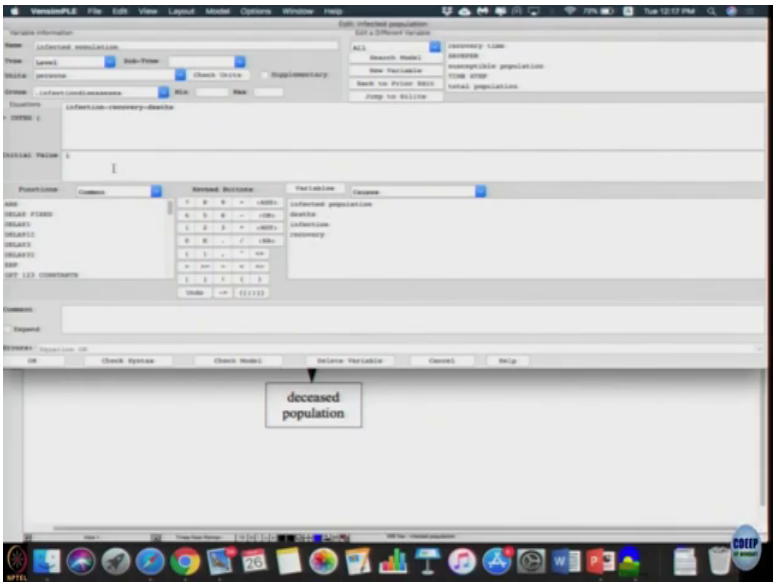

But, infected people if you look at the function, it is actually written as a variable inside, if it is inside that then we cannot change it. When we do sim the sim, it does not allow us to change the initial value of stock, to make it change we need introduce a new variable. Let us got call it initial infected, (Refer Time: 09:16) initial infected. I am connecting an arrow, connecting initial infected to initial population; click equation.

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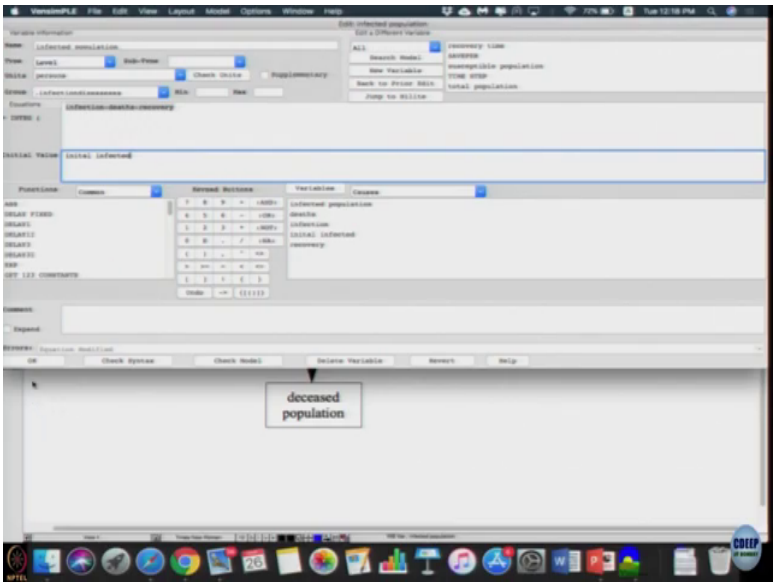

And make the initial value as initial infected, click go to the equation keep this as 1.

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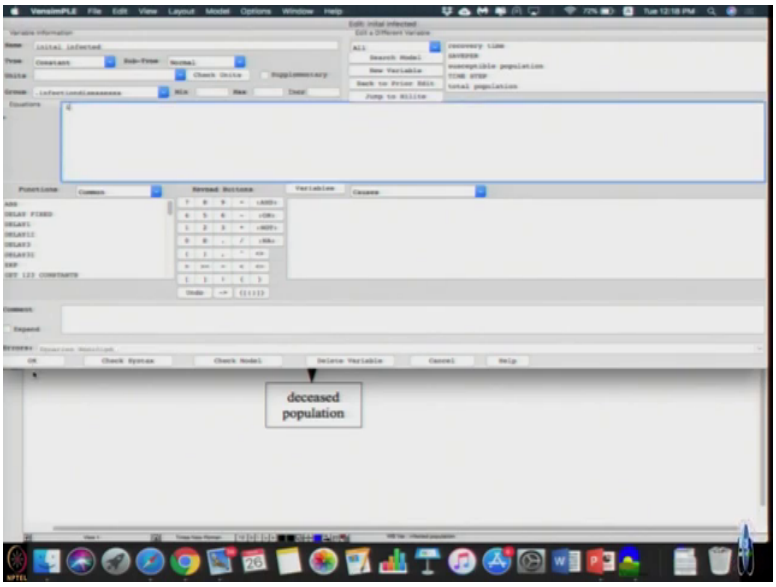

So, with this as 1 is already the base case we have right. So, now, we can again sim the sim IR initial 10, if you change initial infected to 10 let us run it and let us do initial infected to 100. Again is ran 2 runs with different values of initial infected.

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If you look at the infected population now, you get all sorts of interesting graphs, this what which is the base case which is this purple line. So, when initial 10 from the base case to initial was 10, the peak actually shifted.

So, as more initial people were there the peak is now occurring earlier because now the probability of getting infected person is much higher so peak. So, more people get infected early on. So, peak just shifts left when initial is 100 it peaks it moves left even more ok, but the maximum continuous remain the same, it does not change. So, look at recovering population.

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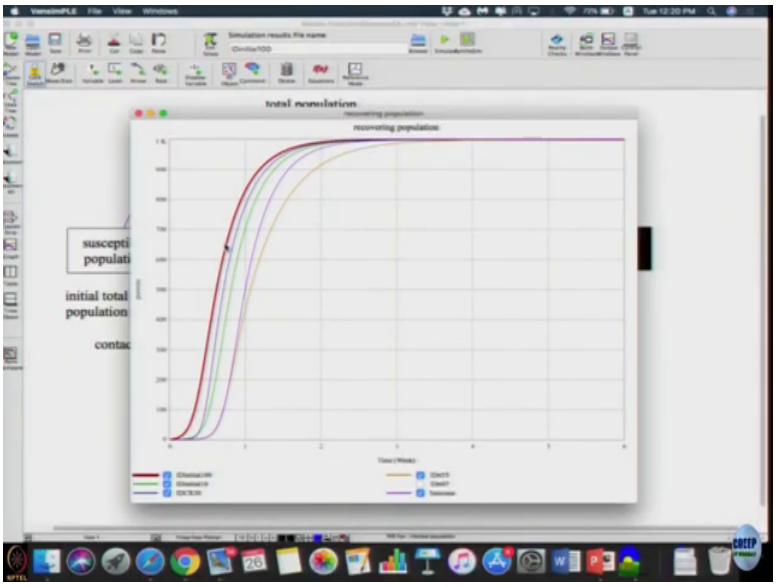

You can observe that what are the value you have put the number of people who recovered as although same 1000 which does not change; eventually everybody gets infected, because it is very basic model. And, this is certain followed 0, the only changes are the trajectories that as happened compared to the base case which is in purple here. So, there are some scenarios which delayed the recovery versus there has some scenarios which resulted in more people getting recovered much earlier, that is its peaking much more.

As expected when we double the recovery time it tooks longer to people to recover right, for all other cases there are more people already infected. So, they will recover faster, I mean in the same amount of time; so, only that is why we are getting (Refer Time: 11:56) rates. So, this so in example how we can do basic sensitive analysis using sim setup, we are we are all using (Refer Time: 12:10) sim student edition. There is a (Refer Time: 12:13) sim pro edition which allows you to automate it to some extent where you can give the range of these

parameters. It will do all these runs for you and give it of course, you have to pay for it so, I am not showing that.

So, there will be an additional setup, icons for doing automated sensitivity analysis. This is the manual version, but the logic is to understand how to do it automation comes later ok. Now, we have all these settings.

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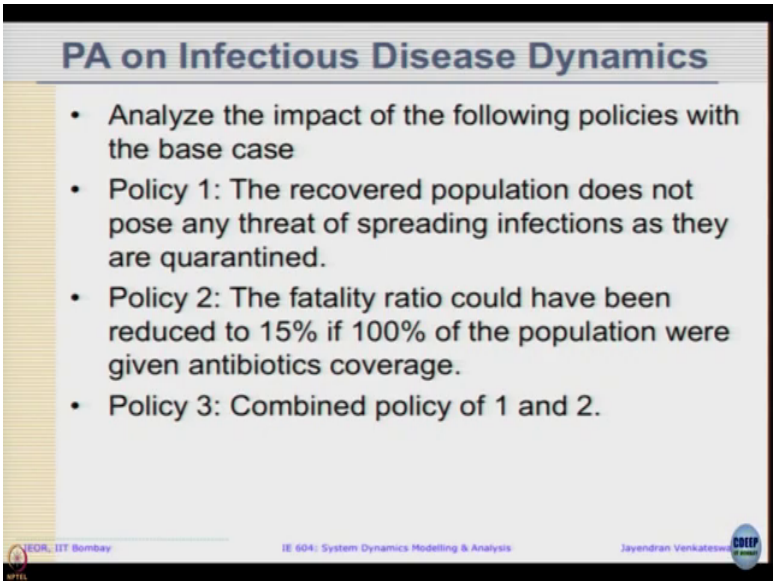

Now, let us go back to a model, let us do policy analysis on the same model. Analyze the impact of following policies with the base case. Policy 1: recovered population does not pose any threat of spreading infect disease as they are quarantined. Once they recover they leave the place or something or they got immuned so much that they are not spreading decease anymore. Once you got the disease you have so much say antibiotics in you that you are not able to you are you are not spreading the disease that is in the policy ah.

Policy 2 is the fatality ratio could have been reduced to 15 percent, if 100 percent of population are given antibiotics coverage upfront in anticipation. Currently, the fatality ratio is 90 percent, if you recall the question; what it says is all the people were given antibiotic injection, major driver happened. Then the fatality ratio will come to 15 percent. So, when these two policies we want to implement or policy 3 is combined policy 1 and 2. When you record population still quarantine and we are doing antibiotics coverage, we are incurring double the cost this thing happen.

But what will be dynamics? Will less people get infected? Will it take much longer or shorter? Will the peak be taller or shorter? So, these are questions we will not understand and based on these policies recommend which is the best ones so that people can actually implement it in the field. So, let us go back to our model, first one says that recovered population does not posed any threat as they are quarantined. So, how do you change the model to reflect that? So, now, it is said that the recovering population does not affect new people getting infected right.

So, this link should disappear that is policy 1, second one was this fatality ratio it said that if you do 15 percent 100 percent of people get antibiotics then fatality ratio goes from current 0.9 90 percent to 15 percent 15.

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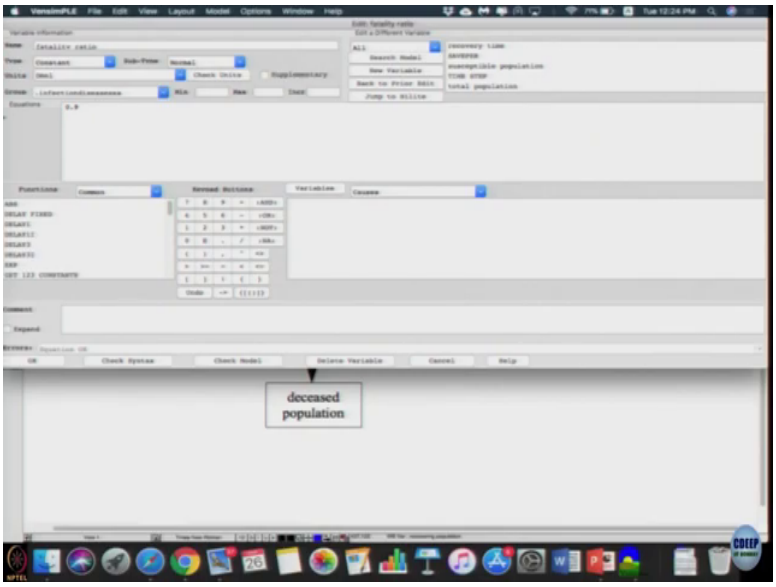

So, this is a parameter change quite easy we can do it, but this is the structural change we want to enable right. So, to do that let us just create a new variable call policy of quarantined recover, I am going to have a big name policy of quarantined recovering population.

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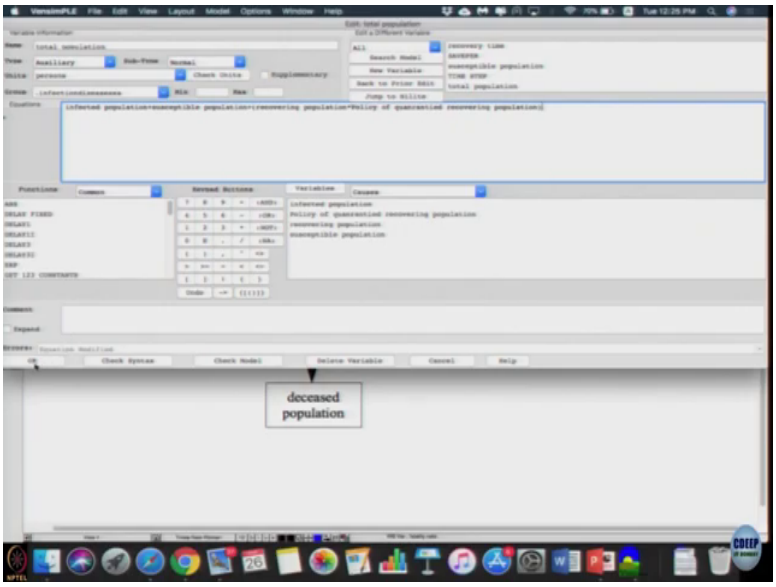

Let I just link it, alright just looking at the model; so, infected population, the total population is infected plus recovering plus susceptible. So, I am just going to move these goes here. So, now recovering population I am going to multiply by the policy of quarantined recovering population.

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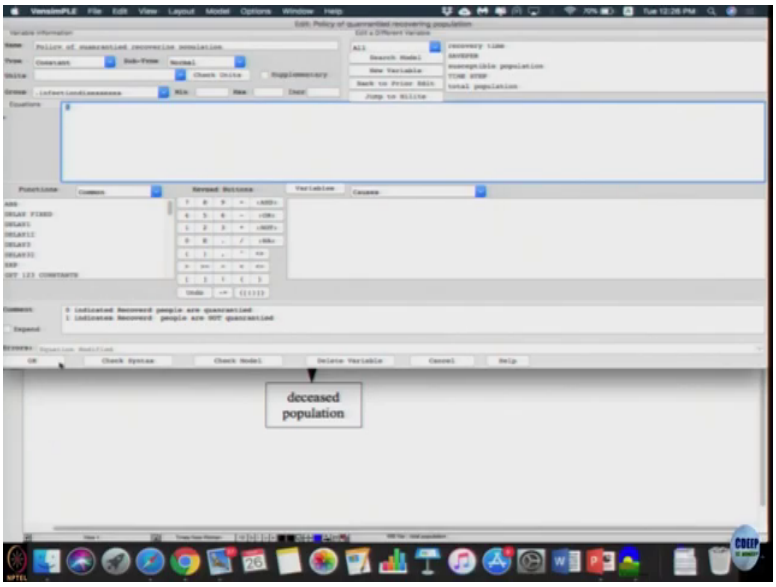

This policy let us set it to 0 with the commence and 0 indicates people are quarantined, 1 indicates people are not quarantined and recovered people such (Refer Time: 16:41) reducing any variable there. So, 0 indicates they are being quarantined so; that means, the policy is in effect when it is 0. It is up to us to define whether policy is on or off and what it is to be so, I am just defining it that way.

So, this helps us understand what is the better modeling factors. Now, I can again use the sim setup tool to set the policies, let us do sim setup and let us call it ID policy 1, policy of quarantine instead of 0 let us just make it; now 0 is zero means its already quarantined right. Let me escape it, stop it. What is the base case we want?

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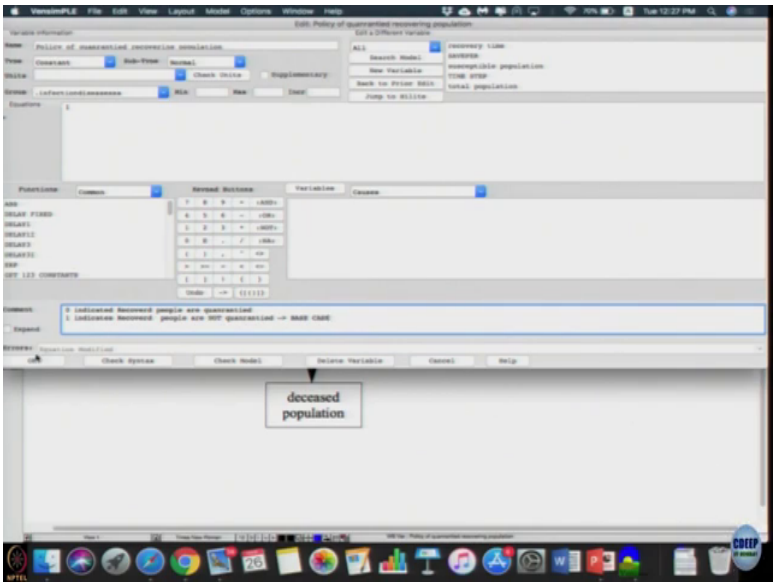

We want the base case to be 1 indicates recovered people are not quarantined. So, let us just call that as the base case and as you can observe we are using the comment box to do documentations or it becomes easier for us to figure out what is happening. Now, let us give sim to sim policy of quarantined.

So, suppose 0; that means, people are being quarantined policy 1 happens, let us play it, now for policy 2 let us sim the sim and fatality ratio goes to 15 percent. So, I am changing fatality ratio to 0.15 clicking enter and running it and policy 3 is people are quarantined that is become 0 and fatality ratio is 0.15, both the changes has occurred. I am going to simulate it, I have three different runs, three different policies are evaluated.

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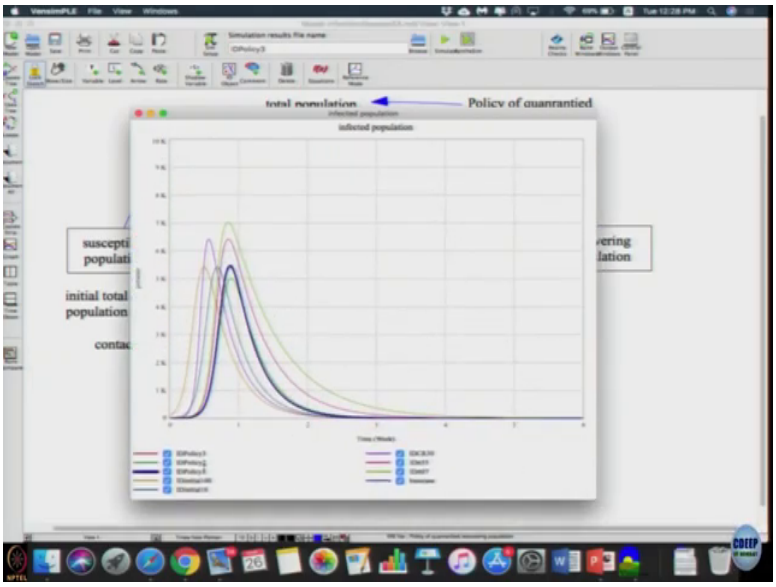

Go to the infected population, all are sensitive analysis runs are there; I am going to just command it all out.

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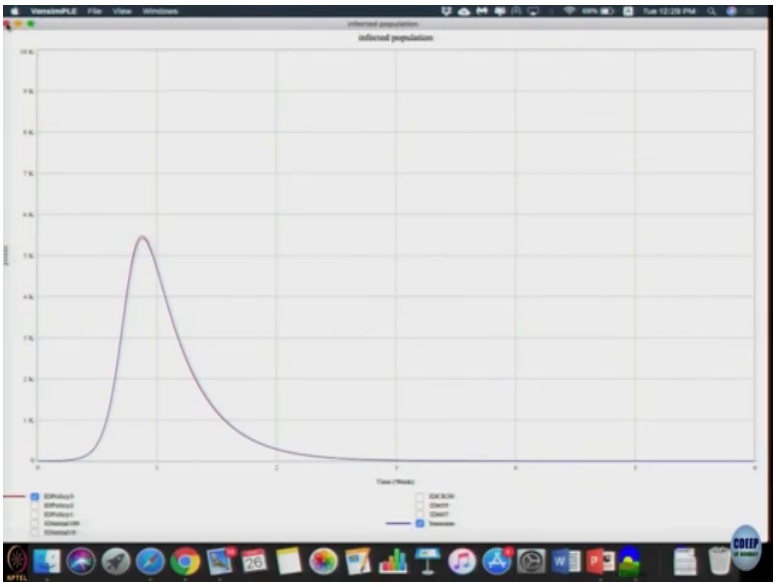

So, that we can compare what we actually want, this is the changes we see if we have the base case which is right here. Now, let us do one policy at a time, policy 1 actually had no impact, even if I removed the recovered population it did not have any impact right. It did not have any impact, its almost the same. Policy 2 it reduced the peak infected because; that means, putting antibiotics is much more effective. When you did policy 3, when all are there again that does not needs to be any impact that is quite interesting.

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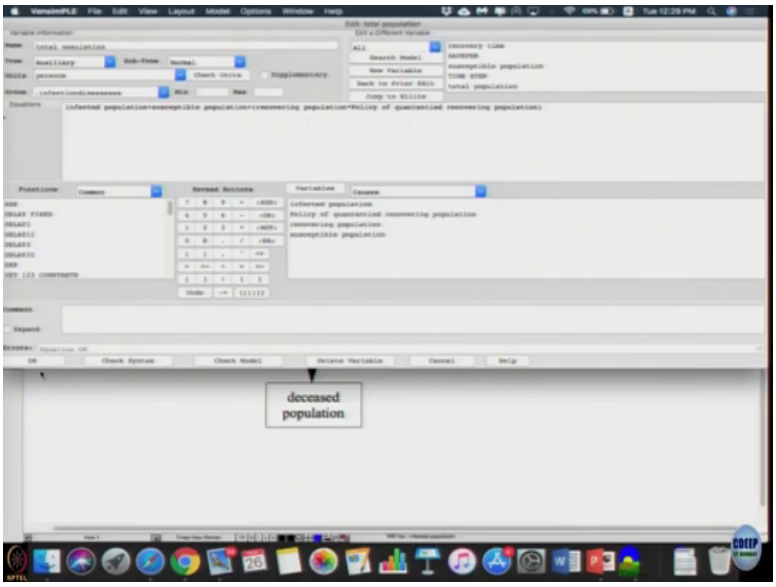

If we get the policies rights, we get the policy equations right; policy of quarantined initially it is 1.

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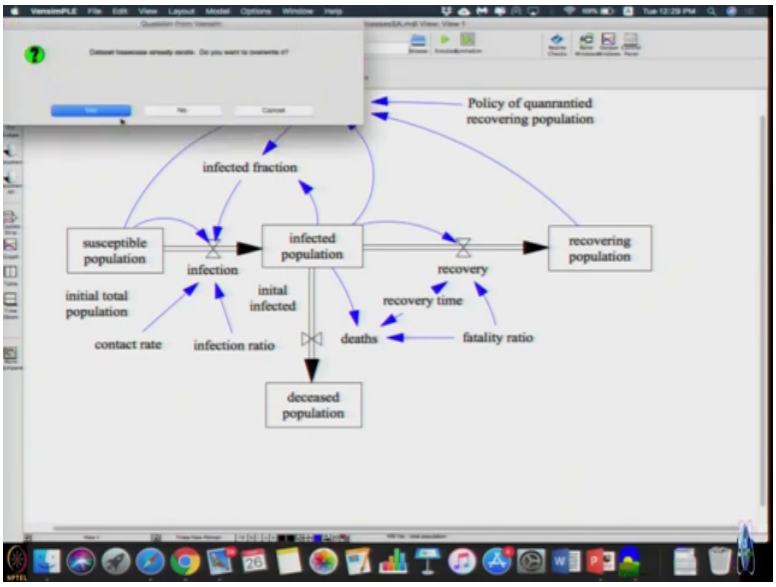

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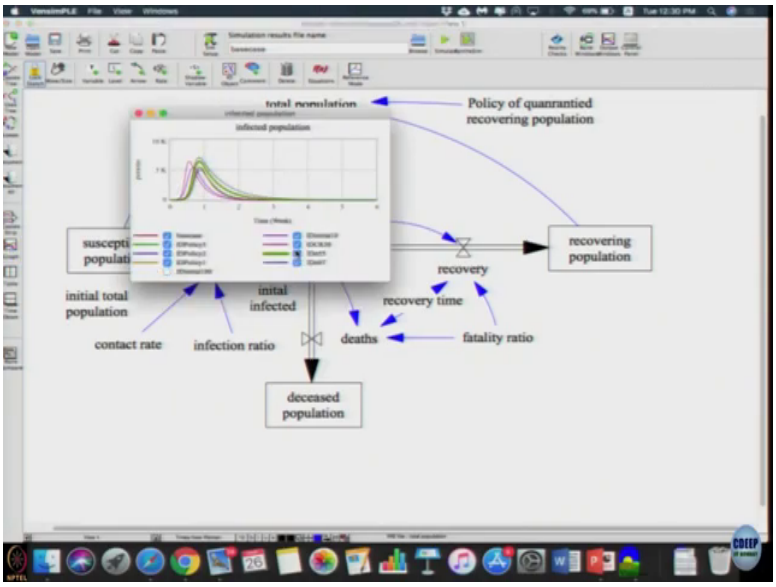

Let me just simulate the base case again.

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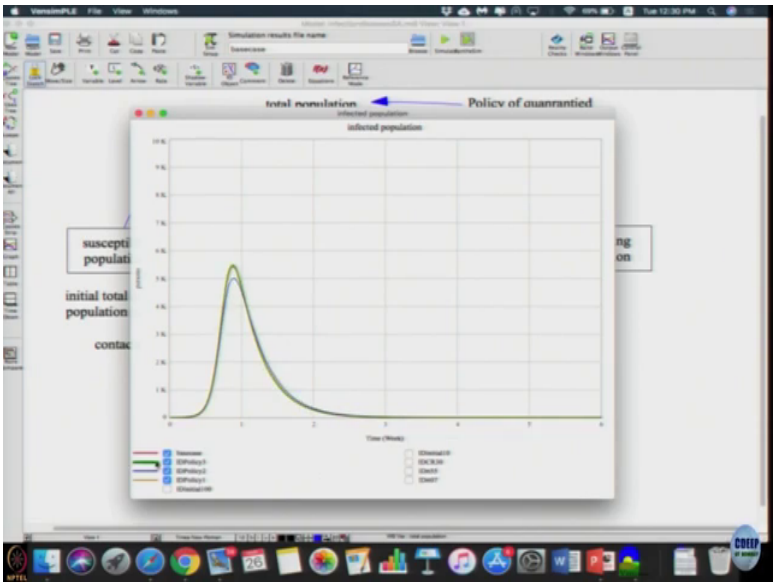

It is policy 3 we expect policy 3 to be similar to be policy 1 right, at least it should be similar, but it did not. Let me just let us again check policy 3, let me call it b. Now, since I have not happy with sim; sim what I am going to do is I am going to hard change it here.

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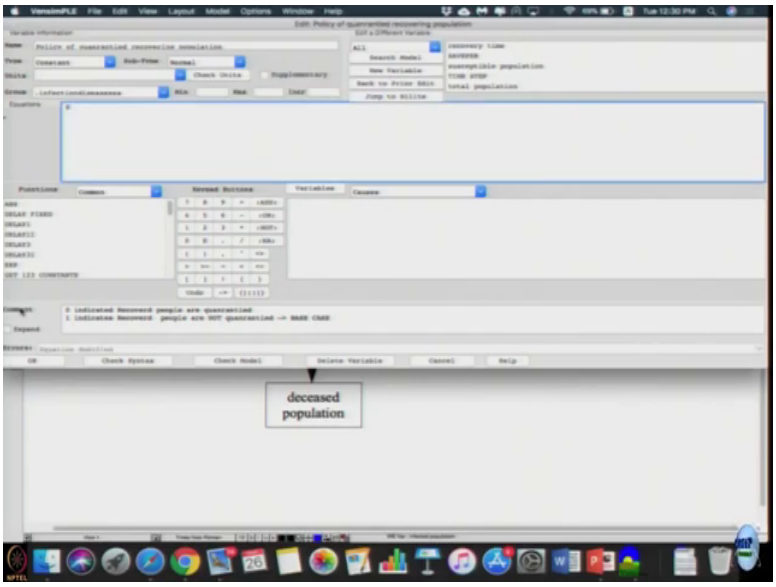

So, people are quarantined and fatality ratio is 0.15.

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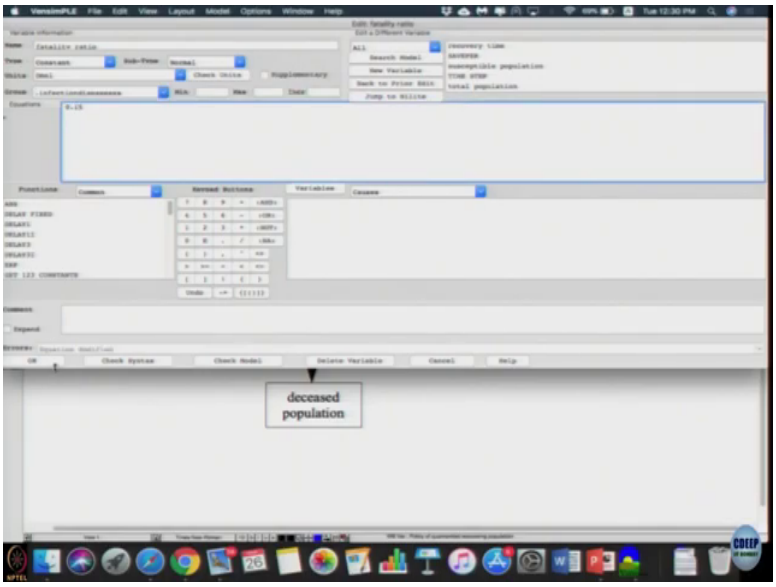

So, I am going to hard change in this model so, that I can run it (Refer Time: 21:34) yeah.

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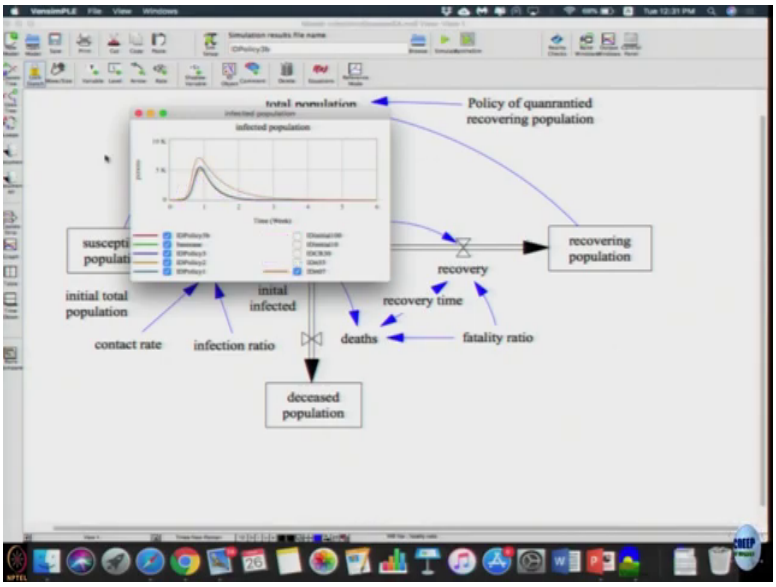

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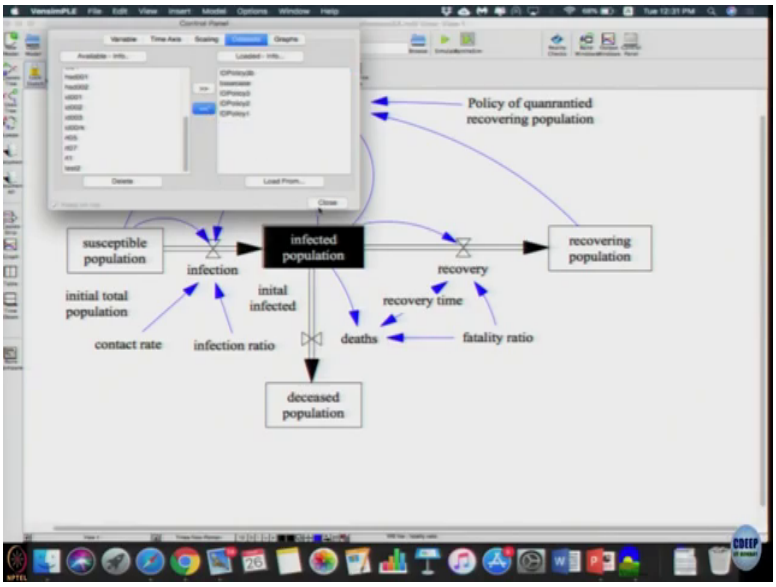

Let us do base case and policy, policy 3 here doing both seems to have an adverse effect which is quiet counter intuitive result that we are getting. We ensured fatality is small and we quarantined people; that means, once I go and recovered then they are not influencing. Fatality is high then more people go into diseased stock right and diseased stock does not affect our population we know that.

Disease stock is not affecting our the number of people getting infected. But, when they go into recovered mode then and we are removing them from that still they should have the similar impact, but interesting it is showing this one.

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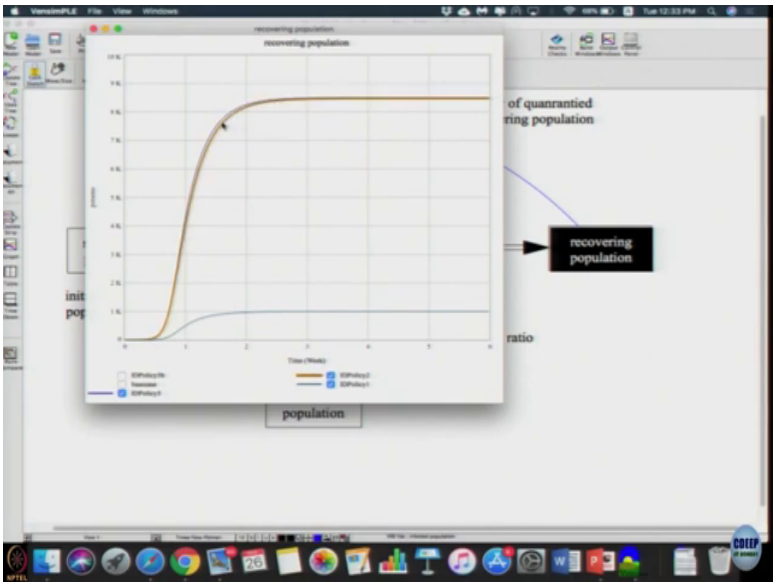

Let us try say recovering population graph ok, now we are getting some very rushing results. Base case is here, in policy 3 because a policy 3 3 b is the same more people are recovering of course, because we gave them the injection I guess the antibiotics. Policy 2 also more people are recovering which is again because antibiotics are fed. In policy 1 the number of people compared to the baseline, policy 1 just mimics the same baseline case, the same number of people that are recovered.

So, it is quite counter intuitive result that we are able to get even in a such a simple model that the number of people who are just providing them with the antibiotics, there is a subtle change here if you observe, with policy I am going to remove base case between policy 2 and policy 3 there is a subtle difference. So, including or excluding the recovered population affecting them did not matter, antibiotics had a much big better effect. So, doing antibiotics

and quarantine people did not have much effect, that is one of the interesting thing that comes out with this model.

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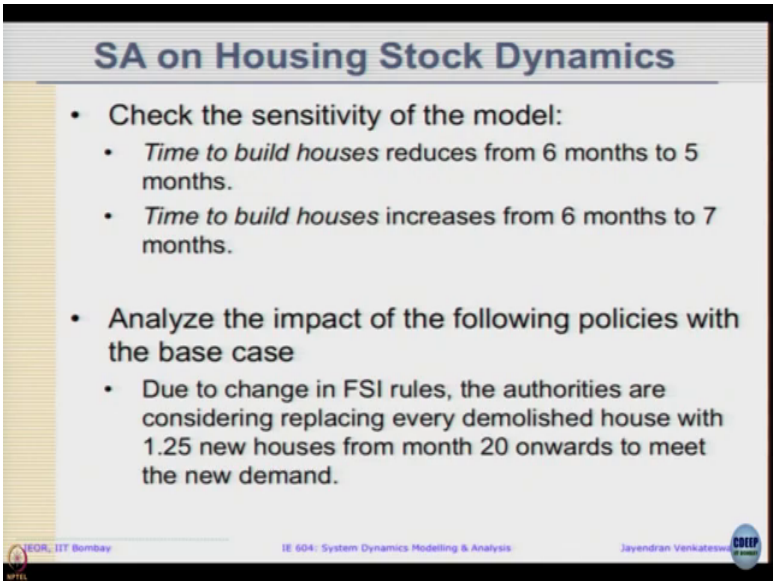

If you done this housing stock dynamics, we are going to check the sensitivity of the model to say for example, one parameter time to build houses 6 to 5 months or time to build houses increases from 6 months to 7 months. And, we can analyze the impact of one new policy also saying due to change in FSI rules, authorities are considering replacing every demolished house with 1.25 new houses from month 20 onwards to meet the new demand. If you look at the model, the number of houses design number of houses increases 50,000 units in month 20. So, along with this there is a policy also being considered so, why do not you work on this.