**Introduction to System Dynamics Modeling**
**Prof. Jayendran Venkateswaran**
**Department of Industrial Engineering and Operations Research**
**Indian Institute of Technology, Bombay**

**Lecture – 22**
**Modeling Example**
**Societal Ageing**

So, today's class, we will try to take up some simple models and use it to further our understanding of complex issues.

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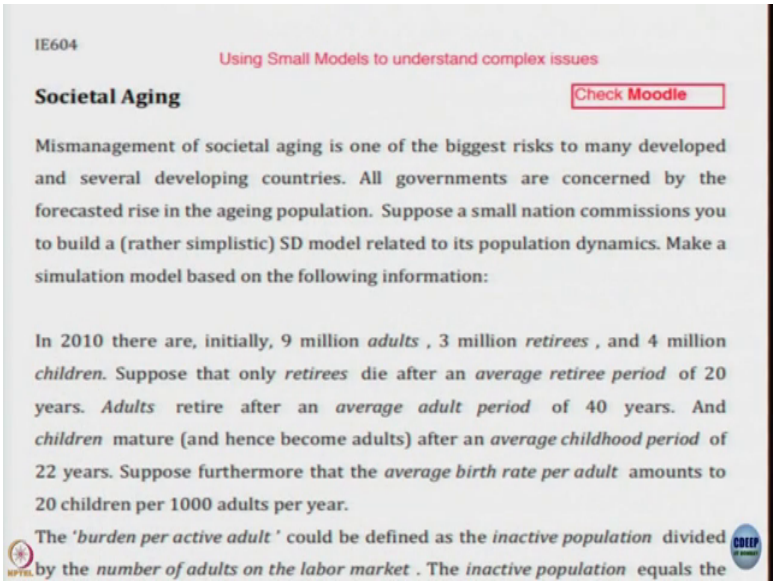


So, first example or first scenario that we are going to consider in using small models to understand complex issues is this this notion of Societal Aging. Societal aging is one of the biggest challenges in many developed that countries as well as in developing countries. In developed countries such as a say Finland or a Japan, the population pyramid is such a way

that the number of people above the age of 50 is much higher than the number of aged people below the age of 15. So, people are worried what is going to happen in future.

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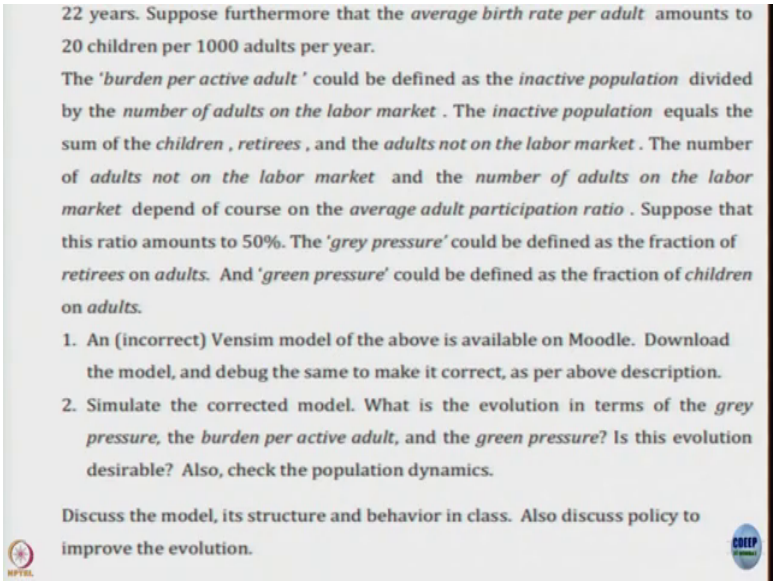


A rather simplistic SD model description is given. Suppose in year 2010 there are initially say 9 million adults, 3 million retirees and 4 million children. Suppose retirees die after an average retiree period of 20 years adults retire after an average adult period of 40 years and children mature and hence become adults after an average childhood period of 22 years. So, here is the total average lifespan you can just add all the three numbers this 40 plus 20 plus 22 that is about 82 years is considered average lifespan here.

Furthermore the average birth rate per adult amounts to 20 children per 1000 adults per year the second is average birth rate, second the burden per active adult is defined as inactive population divided by the number of adults on the labor market. Inactive population equals

the sum of children retirees and adults not on the labor market, the number of adults not on the labor market and the number of adults on the labor market depend on the average adult participation ratio. Suppose that this ratio amounts to 50 percent.

The grey pressure could be defined as fraction of retirees on adult and green pressure could be defined as fraction of children on adults. It is a very very compact and brief description and download that model, go through this description and correct the model. While doing the model and reading the description, why do not you also think about what is this grey pressure, burden on active adult green pressure mean and once you simulate and also discuss some policy to improve the evolution. So, goead download the model and correct it based on the description given is to pay attention for a minute.

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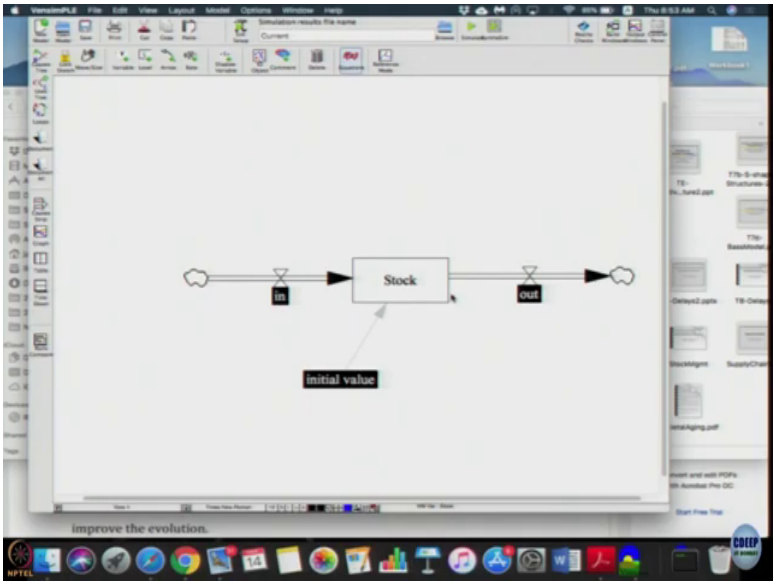

So, we have the stock right inflow of x outflows of x, so that is very obvious in this. But we also want to specify the initial value.

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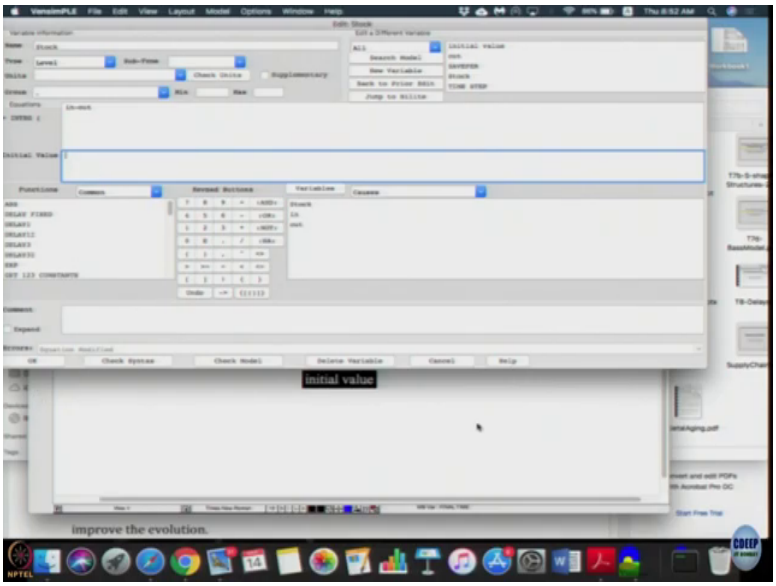


So, suppose you go to the equation of stock, you will find that it is in minus out,]; but initial value does not appear here in this area. So, I have to enter some constants right I cannot do that. So, to avoid that or to include that initial value we first connect that initial value to stock. So, we will get this arrow, then you click equation.

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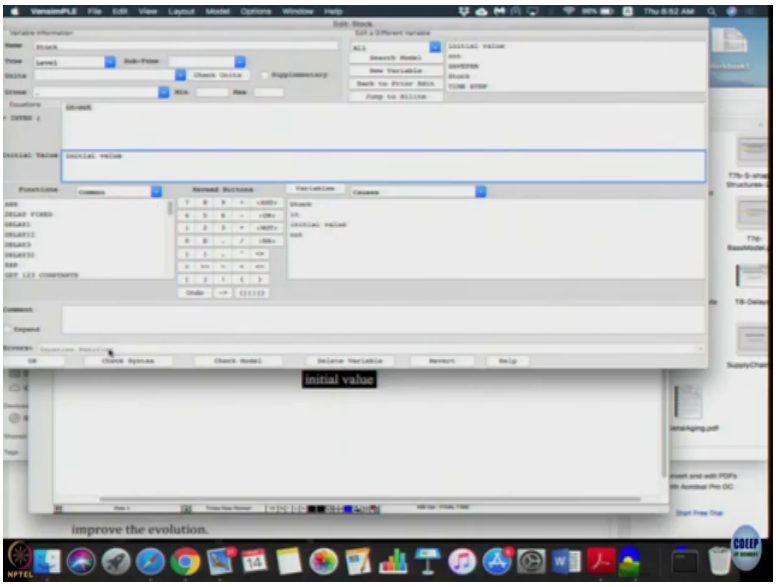


Go to stock; stock is in minus out, you will see the initial value as a variable here you click it and put it under initial value and click. The arrow becomes grey and it can disappear. Altogether in your model depending on your setting, indicating that it is a initial value if it was grey you would have been happy, but in the model it is color is removed right. So, in case you want to add it this how you do ok.

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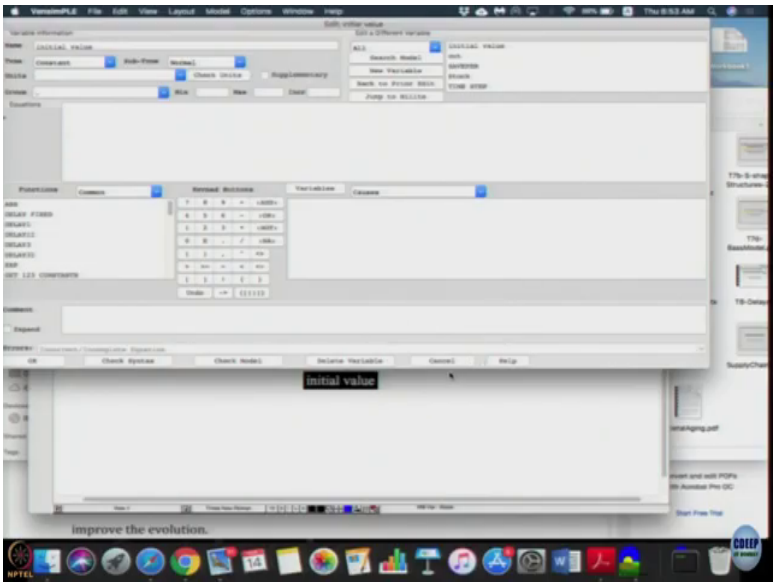


If you define initial value first you connect the initial value to the stock. But how go some in connected to stock.

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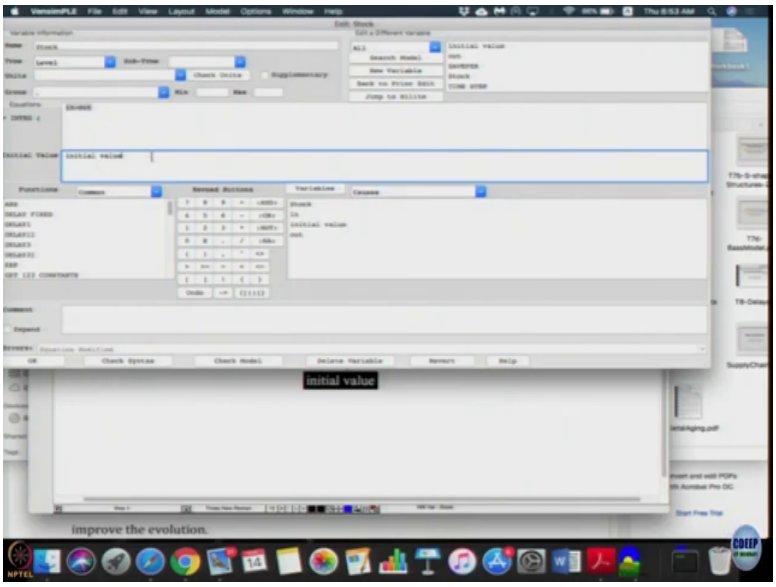


Then go to the stock and under the initial value you select the initial value whatever variable name initial value click. Then that arrow from blue becomes grey here, but in your screen it may just disappear altogether also. The arrow may not be visible, but still you will take the value. So, do not worry about it that is it. In your model all this stocks has initial value some are variable name, but you will find that that variable is not connected to the stock. I am trying to explain why it is not connected that is all ok.

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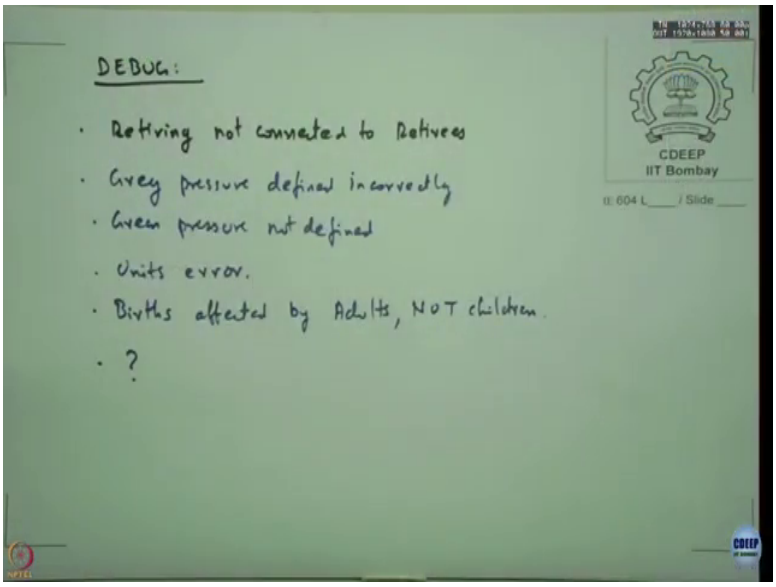


So, these are all the things I think I can remember, but I had to figure out I forgot what are all the that day introduce. Retiring is not connected to retirees, you need to connect to that flow and then update your a balance equations. Grey pressure is defined incorrectly, green pressure is not defined.

There will be units error at least at least minimum two locations if will not more. Both are affected by adults not children check that, so that these are logical errors. None of these errors will actually cause runtime error I mean they are just logical errors. So, little more difficult to spot and along with it hope you fully you have got ideas of how to you know represent large numbers millions you can see how then seem represents it, how to give initial values outside the stock. So, that there is no constants inside the equations and we have all the variables explicitly defined what else yeah. So, this is what we have.

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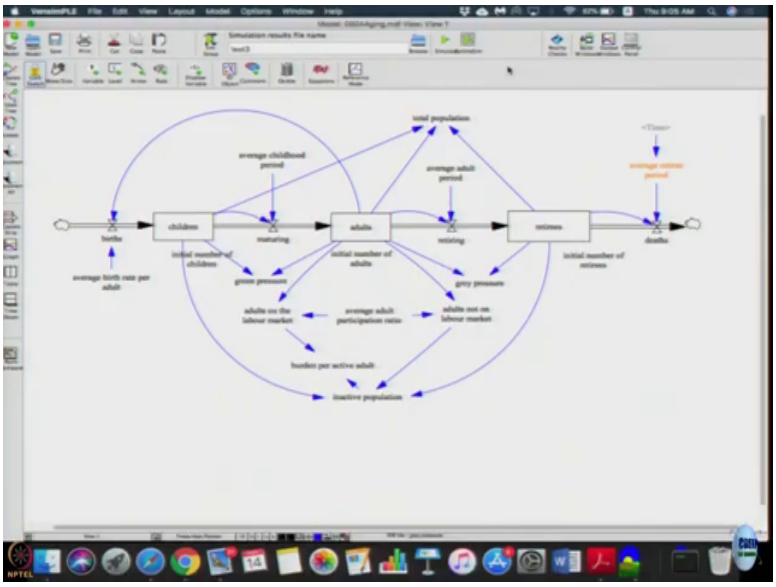
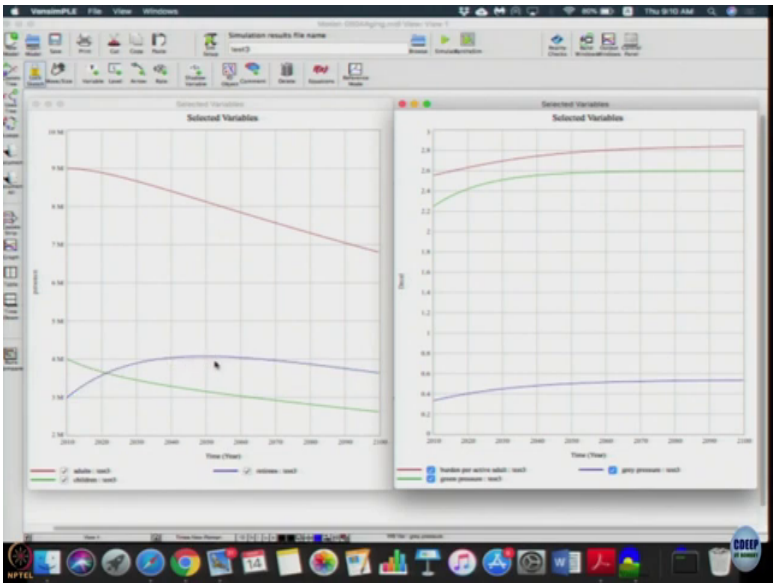


Let me open the Vensim hand I do not know got it. So, this is should be the model you have, do not worry about the right part, yet we will come to that. (Refer Slide Time: 06:38)




So once you simulate let us do children adults and retirees as a graph. And let us do grey pressure green pressure and burden on active adult as a graph. So, we will have two graphs one for the population stratus that is strata, the other for the burdens. So, the population graph if you see the adult population starts at 9 million and goes down to less than 7 million. The children population on the other hand starts at 4 million and drops down to 2 and half in the next 2010 to 21. And another next 90 years and retirees increases until 2040 or 2050 and then slowly starts to decline until 2100.

Did you guys figure out how to write these years earlier in all the graphs ? Just started at 0 right? To start with the year, all you have to do is go to model settings and give the start year as 2010 and then it will start the counting right. Now if you observe the burden the burden starts at around little say around 2.5 and then saturates at around 2.8, green pressure starts at

2.2 and then saturates at 2.6 and grey pressure starts at less than 0.4 and saturates around little closed to 0.58 or something.

Though your population dynamics is reducing still these variables stabilized because the ratio did not change right, these are things that you can see. Now the purpose of this model is not just to get this graph, I do expect you to this is a first introduction to discuss on this. So, you looked at the model structure right, let us go back to the model structure. Now what you think this burden per active adult actually means in reality, what is this burden per active adult? Go ahead venture a guess tax payers, what else? Lot of the people from whom he as to you he earns yeah.

So, that is what it is trying to capture, if you look at it burden and per active adult is defined as total inactive population divided by the adults on the market correct. So, for each adult person how many person has keep to support he has to support children, he has to support elderly people he has to also support nonworking adults, (Refer Time: 09:48) every adult has to work. There are nonworking adults right. So, the person is not only working for them he has to work for a bigger group of people.

So, here are results show they are not an average people has to work for nearly each person has to work for 3 people apart from oneself, so that is what it means. What is this grey pressure and green pressure and how do you think it can what is the implication of that? Let us take the green pressure green pressure is defined as the ratio of children to adults right. So that means, that is a kind of proportion of children who are being supported by the adults and not children. We have to provide education that is another primary thing healthcare education others facilities that is you provided to them.

Gray pressure; the grey pressure not people above as per this say above the age of 40 plus 60 on an average about 62 years of age as reffered as grey population and this assume that they are not earning. So, what then it is a grey pressure what is the kind of pressure it is going to exert, in green pressure we saw that the pressure will be for say to do it better education or complete education yeah, let us keep there.

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Health care right, so as a retiree is more then the as grey pressure increases you need to provide better health care facilities, old age home or other support facilities has to provide at one of primary being the health care. So, that is the pressure that is being captured by this variable called as grey pressure right. So now, when we start looking at these kind of demographic changes, this model can help link this model is not complete we have to improve on the model in various dimensions right. So, simple things can be maybe we have to include death rate for every stock fine, it is a minor thing we can definitely include it or that is one.

Otherwise we can actually expand the model by incorporating. Suppose you know if we expect an average adult participation ratio and the adults on labor market is going to affect or be affected by the actual jobs available in the market. So, if the less number of jobs are available, so that means only that much portion of the active adults can actually participate, even if everybody wants to there is not enough jobs.

So, this average adult participation ratio need not be external, you can actually expand the model to make it ok. We have some jobs; suppose this is a total jobs available then what happens to the adults or labor market. So, even if there is one person is working right, we cannot say give jobs to everyone. So, we are taken a average of say 50 percent get jobs, but even if you take 50 percent of the working adults get job you find that; that means, one in two is getting job. But still we are supporting three more people because while doing this we fail to account for children and retirees. Whenever jobs are considered it only looked at people are unemployed that is adults not on labor market unemployed adults and then say I have to fill that gap.

But even if you do that still there will be a burden, even if I average adult participation ratio is 1, you will still get burden on active adults, because children and retirees also contribute to that correct. So, that has to be also factored in when actually jobs are provided and that affects

the level of jobs that is being provided, jobs huge spectrum minimum wage. If at all it exists in India to whatever see your top position where you are running millions per month.

So the entire spectrum is there so well distribution need not be unique. So, including that aspect we will also make this much more interesting, the number of retirees in the grey pressure can actually impact how much effort the government needs to spend on health care geriatrics health care. So, this grey pressure is supposed to be the pressure felt by the government to provide geriatrics health care, provide support for people above the age of 60 65 62 in this case. Green pressure is the pressure that you have to provide immediate education and other facilities for children for their whatever what can I say best development of them things like that.

So this the green pressure may show what is the in future how much people are going to come into work first. Today's children are tomorrows workforce 10 years later. So, though initially now we are fine we have a lot of adults working, if we look at the graph now adults are 9 million, we will say there is a lot of people are there we do not need to worry about it. But your birth rate your children is also falling. So, less children here means less adults in future.

But initially this two graphs of adults actually result in increasing population of the retirees that is interesting, there only have 50 of retirees are going to fall down. So, there we want to invest to this kind of models when help increase that dialogue, which is thing you have to start looking at it and start understanding what it is, where it can link to what is external variable good catch, thank you.

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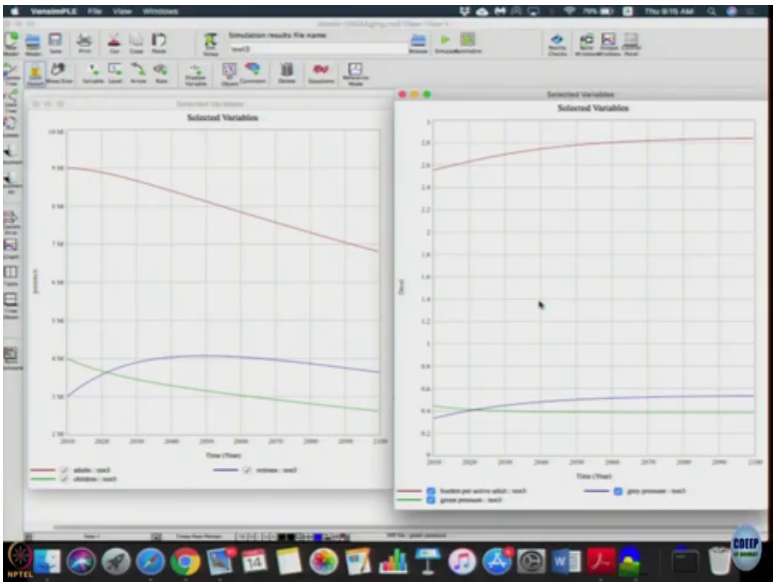


You are good catch, but it did not change; only this one changed. Yeah it is not as I was told one more thing to do there good thanks. So, you got it, yeah green pressure reduce your time; yeah population reduced and this increased. So, even later on population of retirees fall down, since adults population also falling down the ratios saturated ok. I corrected the equation for green pressure, I wrongly written as adults by children, then it should be children by adult good catch. Thank you ok.

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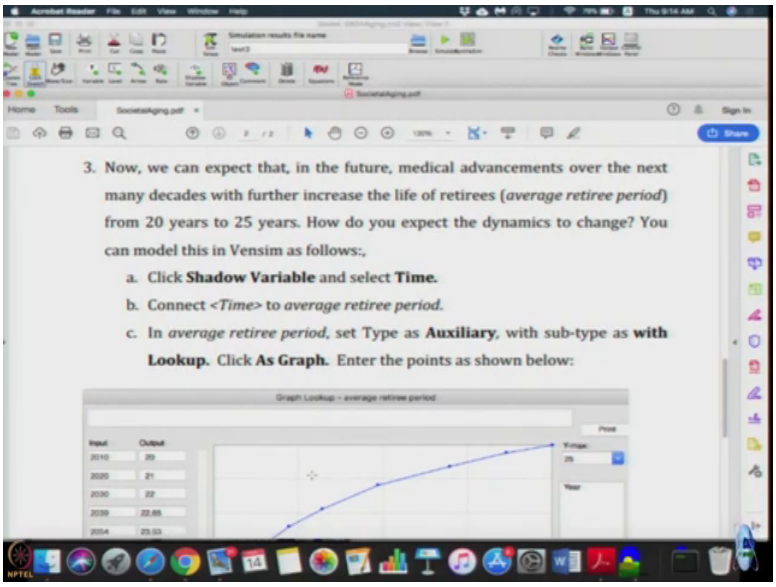


Now, you have it so let us take various things can happen, let us take of different scenarios to see what happens we cannot stop progress or technological advancements. So, now the most common technological advancement where people work towards is increasing life expectancy right. With increasing better healthcare facilities comes increasing life expectancy or average lifespan. So, let us suppose that in future medical advancement next many decades will further increase a life of retirees, average retiree period from 20 years to 25 years right.

So over all the life expectancy is just increased by 5 years. How do you expect the dynamics to change first then it shows how to model it. But intuitively what do you feel what should happen to dynamics, if average life expectancy of retirees increases, grey pressure should increase system green pressure not. So, there is not change in that part of the model it should

remain roughly. The same great pressure should increase, but how much will it increase not sure.

What about burden on active adult it should also increase, population will reduce or what kind of graph we may get to keep increasing or gradual increase or it will graph will increase first and then decrease we may not be very clear, but just fine.

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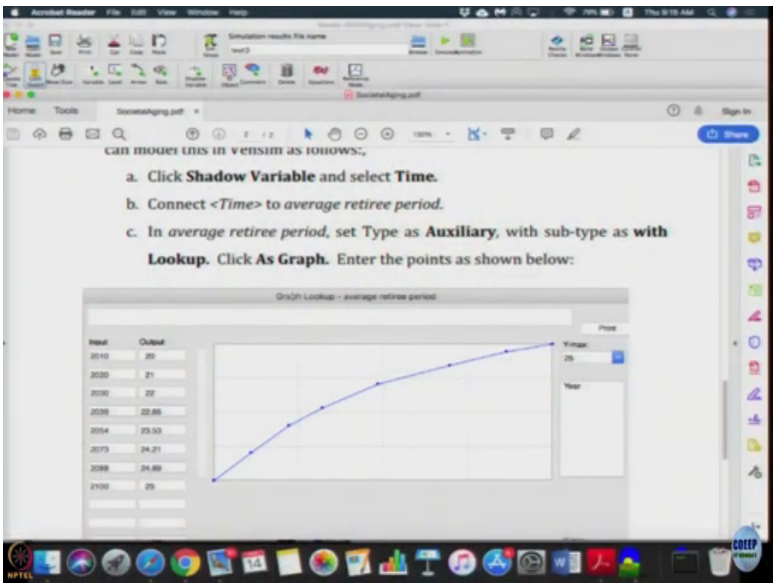


So, go ahead and implement this the next 5 minutes, then done no as per this build the table function connected. Again these models are I wanted to add just simple models to initiate dialogue and see what it is and how we can build it improve modeling skills. To make a very realistic model, then if you research areas in population dynamics we will start discussing. So, does each one will take a lot of time to build and implement and have the real thing implement this.

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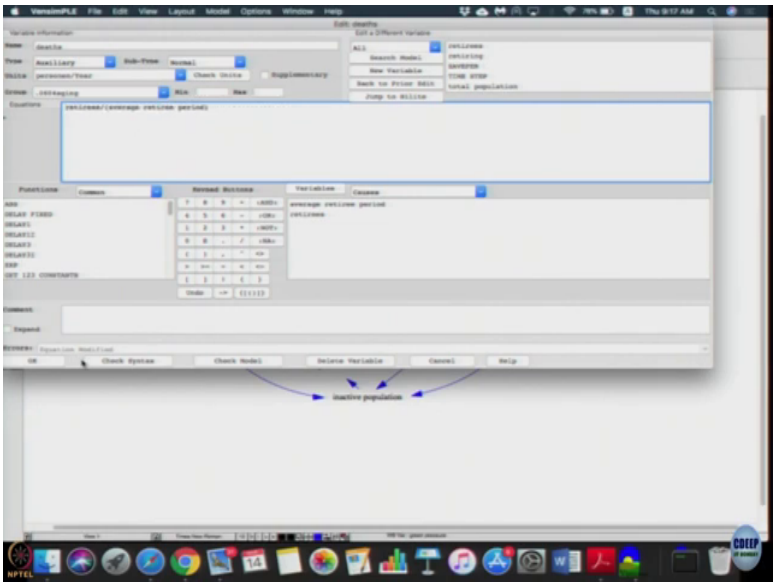

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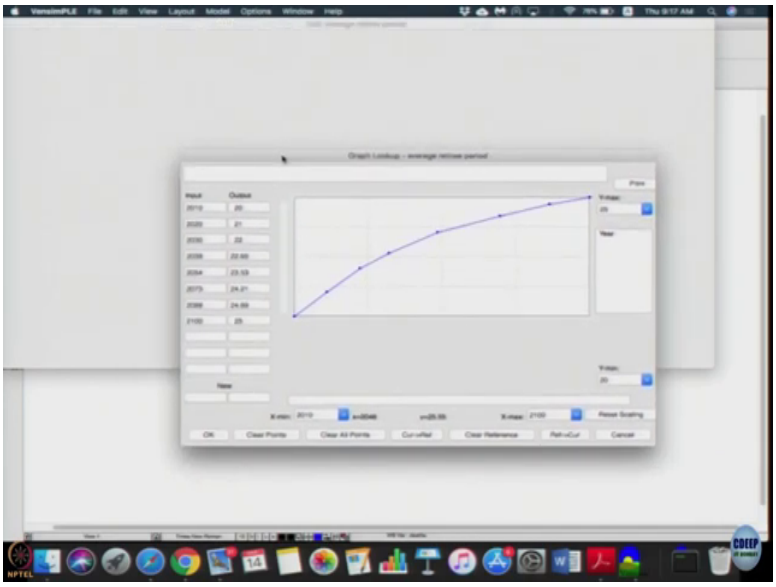

Now, you showing the same thing in Vensim here, it is the graph look up inside the average retiree period variable.

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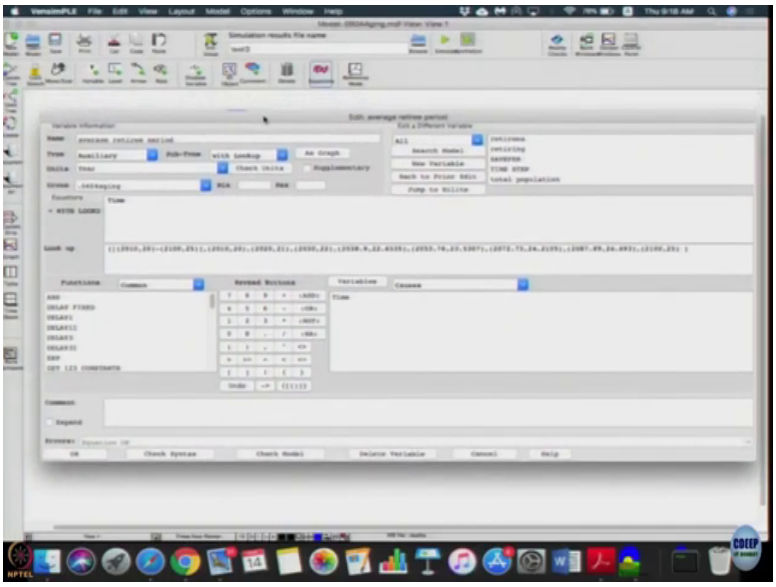

So, in the right side brown and orange color, so to create time connected to that and write now draw the graph as given, values are given graph shape is given you just have to use that.

As I mentioned from the start of the class one of the main purposes of the SD models is to help builder intuition, many times we may not have intuition many of these complex issues. So, we can use this to conduct what if analysis to build our intuition, like one of the assumption we have made is average children's age is 20 22 when they become adults and then 40 years service and then they become retirees right. So, that actually 62 years the average retirement age became 65 then we get from 40 it becomes 43, does that 3 years additional service what impact will it make. Or what if the retirement age is 70 additional 10 years or additional 8 years, how it life it.

Here you have taken for children the age as 22 years average that is assuming you finish your this thing and get a 4 year degree and then start working at 21, 22 and you start working. But if that age is lesser then how is it going to impact. Again this average so there will be some proportional proportion of children who start working early. Some people who have start working very late like me we will start doing masters and PHD etcetera, so we start late.

So, you can actually change the numbers and see whether that is population increase at any point as it is only constantly decreasing, that is as a separate exercise you can think about it I am going to just change the test ids simulate.

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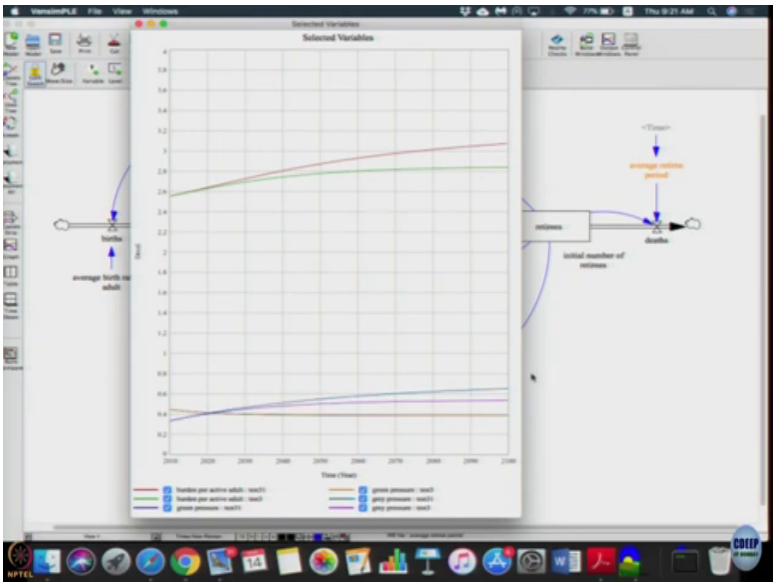


Look at the pressure graphs first pressure graph, if you look at burden per adult is exactly the burden per adult has increased, the red line is the new one burden per adult when from less than 3 to slightly above 3. So, look at green pressure, there is no change in green pressure is

the same. Grey pressure also increased from less than 0.6 to greater than 0.6 slight increase and stabilize at higher value because of that extension of whatever it is longevity increases.

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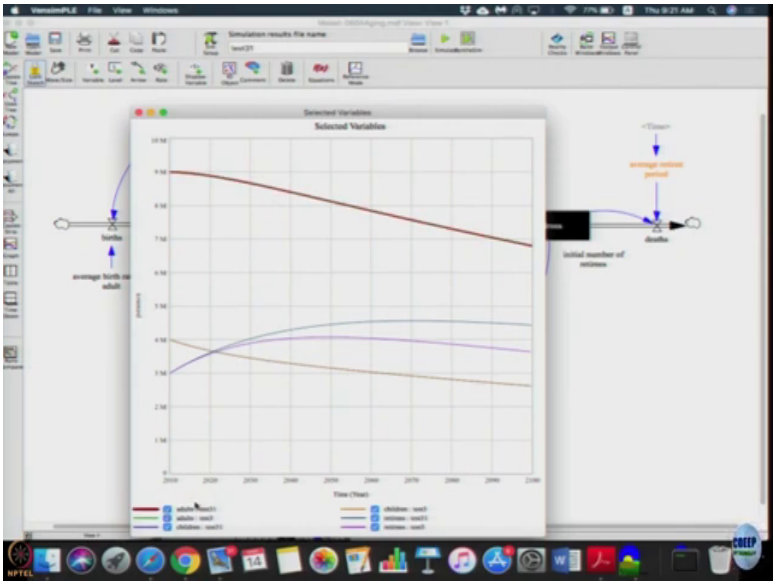


Let us look at the actual population, the adult population no change children population no change the retirees population after increasing the 20 to year 2050 then decreasing. It is no keeps increasing until year 2070 and then slowly at decreases much more at a slower case.

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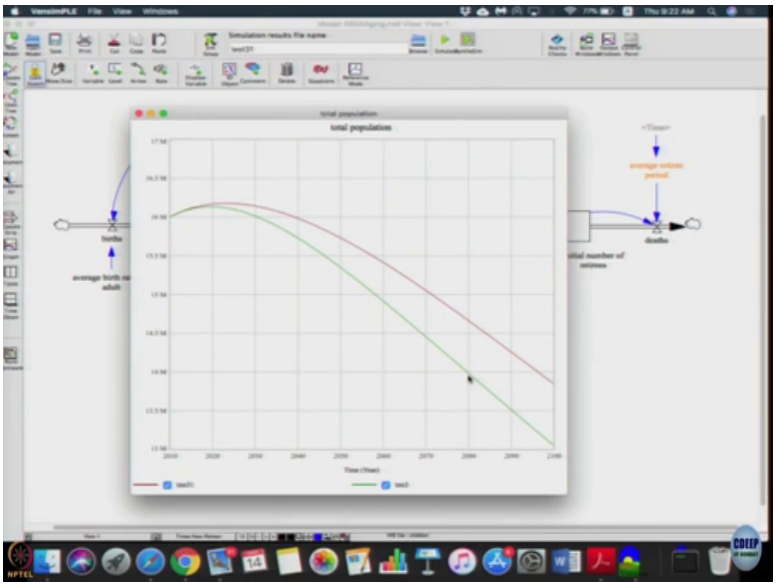


So this going to constantly increase getting that to observe the total population. The total population assuring initial increase for next 10 years and then it starts to decrease in the of original case, because of better health facilities the peak occurs now 5 years later and then population slowly starts to decrease overall correct. So, this is significant, even if you can see better health care facilities is going to instead of fourteen million in year 2080. It is 14.8 million 2080 that is about how much percent increase 5 percent, approximately 5 percent increase in the population more than would be want right.

So those are interesting things to note what is going, even that seems like a small percentage, but that many jobs has to come or the other way. So, many people are retire age, but then who is going to do all the jobs. So, as soon as you put a job one available jobs maybe more than the number of active adults who are able to do the jobs. What will that what will that result in, if there is more jobs and less people to do the job in a region? It will attract people from other

regions to move in. It is going to it is going to cause migration if people perceive look at job opportunities are available and locally they are unable to fulfill it, either they themselves will invite people from elsewhere to fulfill the job opportunities right. Where the jobs have to be done, even if it is health care somebody has to you know take care of the health and provide the basic services, so that becomes interesting.

Even in case of India in another more another 25 years is expected, the proportion of grey population in South of India will be much larger. So, resulting in huge migration from North to South to support that facilities and provide the services. What kind of population dynamics it is going to create and conflicts and strives, we do not know that separate discussion.

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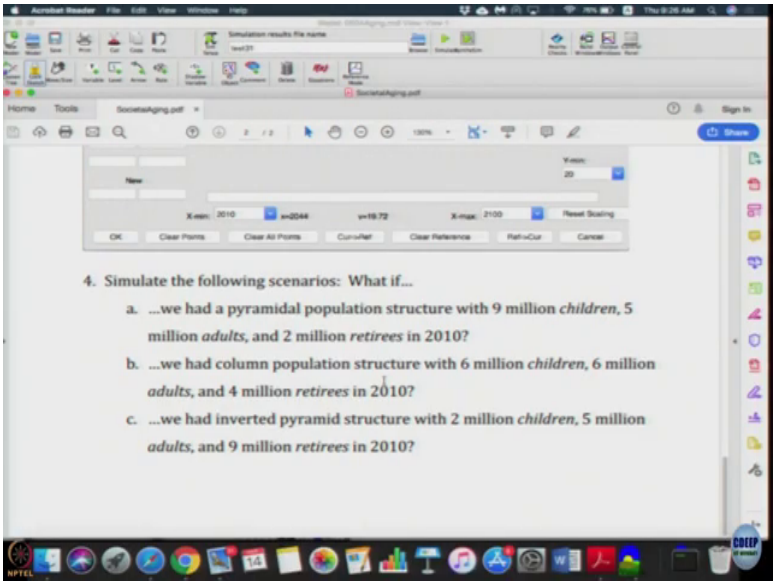


Going to try this one, three what if scenarios what is the simply set change the initial condition and for each you observed the total population, this total population increase or

decrease. The pyramidal population that is currently population has lot of children less adults and less retirees versus a column population we have proportion of I mean 6 million children 6 million adults and say 4 million retirees almost comparable. Or we have inverted pyramid where we have less children 5 million adults and 9 million retirees.

So then what kind of dynamics are we forcing when this population collapse faster or slower or is that a population growth at all, you can simulate it and see it. And what is happening to the burden as we go along in each of these scenarios. Without running also you can think about it a minute how it works, like when there are more children in the first case they are going to become adults. So, in future we can expect that the burden will go down, but what happens over 100 years remains to be same.

A inverted pyramid sector the pressure is at least in grey population is very high. So overtime, but eventually it will be lesser because initial children population is less and adults are less then retirees. But look at it a and c the adults are exactly the same and b is also quite similar. Let us see what happens when only children adult proportion changes, simulate it check it and think about it. I will stop here.