Lecture No. # 13

Contemporary Issues In Modeling Population Processes

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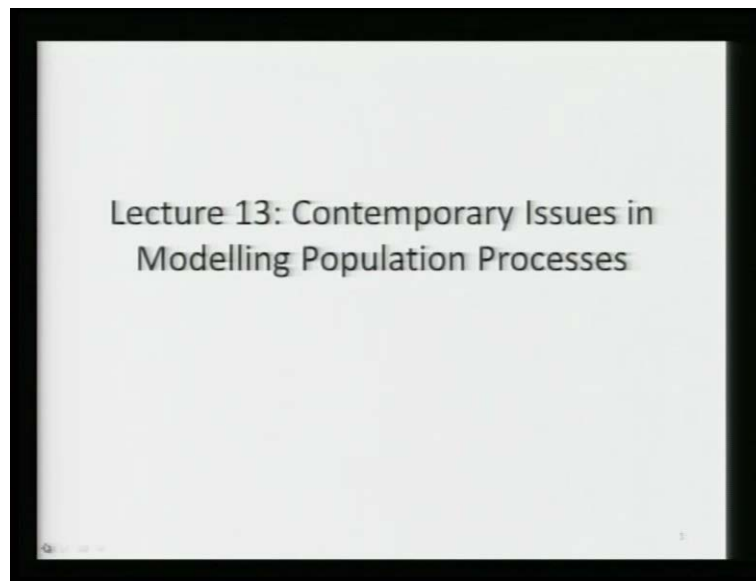
Ok friends so, this is our third lecture on the issue of modeling I know that with your background in sociology you will not be very comfortable with the issues in modeling but, you must know at least what are the models are and you if you ever see any discussion of a model in any paper on population in processes you must understand what the author is trying to achieve by using modeling.

So in the first lecture I talked about what is model, importance of model, what kind of questions can be answered with the help of models and in the second lecture I showed some examples of models in fertility and mortality. Now, I will go to some other issues in modeling to some other areas and to some examples of models, which have been in used in population literature in the recent times and issues in modeling like how to build a model, how to estimate parameters validation and estimation.

So, let me begin with modeling in the field of migration. So far much of modeling in population, in studies has been done in the field of fertility and mortality and the reason was that, earlier we did not have estimates of them and models were required to estimate birth and death rates with help of partial data from census's and surveys.

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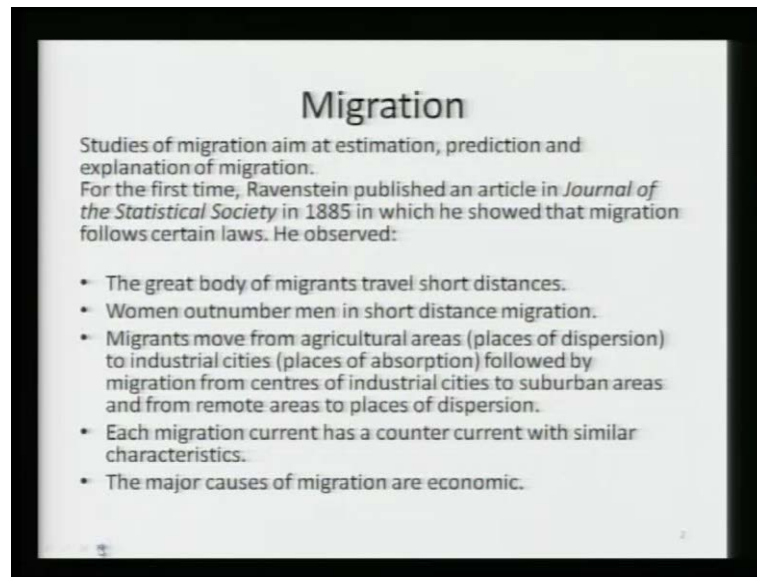
In the field of migration I will show you one simple, but interesting model of migration this all started in 1885, when Ravenstein published an article in the journal of statistical society about patterns of migration based on and date on migration investing countries, which were available to you at that time he said that the great body of migrant travel short distances, women out number of men in short distance migration.

Interestingly some of these observations of Ravenstein can be found to be valid even today and in the context of India to, if you analyzed data on migrations based on place of birth or place of all these things come true, that the great body of migrates have a short distances within district or within state as compared to between states and short distance migrations between districts women outnumber men, then migrants move from agricultural areas followed by migration. Migrants move from agricultural areas to industrial cities means, rural to urban migration followed by migration from centers of industrial cities to suburban areas.

So, there are two types of migration patterns is talking about simultaneously, rural to urban and in within urban areas from heart of city to peri urban villages or peri urban
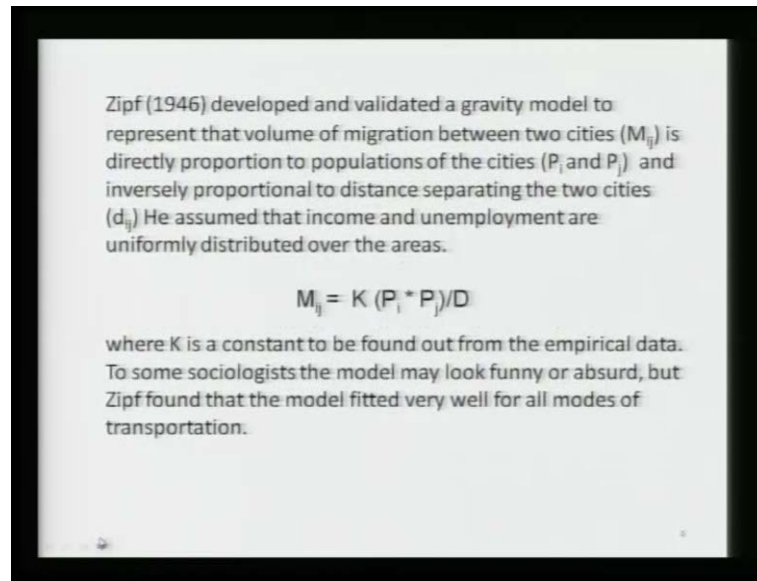
wards in the city. Then each migration current has a counter current with stimulate characteristics and the major causes of migration are economic now, in census we have lots of data on causes of migration also and we can see that, in India today in 2010 the major cause of migration is economic, is specially rural to urban migration or migration from heart to city to peri urban area.

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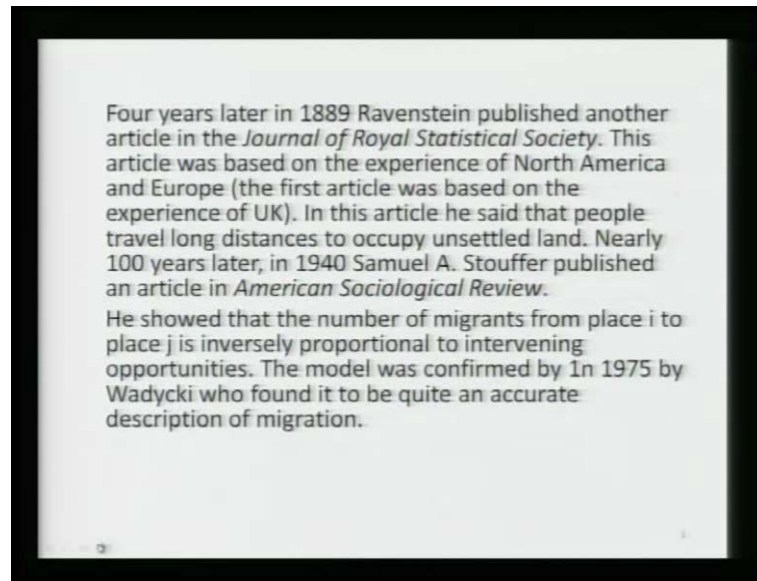
Four year's 1889 Ravenstein published another article in journal of royal statistical society. This article was based on the experience of North America and Europe. In this article he said that people travel long distances to occupy unsettled land. Nearly 100 years later, in 1940 Samuel Stouffer published an article in American sociological review and he showed that the number of migrant from place I to place j is inversely proportional to intervening opportunities. The model was conformed 1975 by Wadycki who found that it to be quite accurate description of migration.

Actually, it is quite interest to see how in the field of sociology some people have you some basic ideas of modeling, in case of migration whenever, we discuss anything about modeling of migration, we always remember this Zipf in 1946 developed and validated what is called a gravity model of migration. To represent that volume of migration between two cities MIJ migration between place I and place j, it directly proportional to populations of the cities I and j that means, P i and P j and inversely proportional to distance separating the two cities D i j.

You can use Stouffer's theory of migration of intervening opportunities also and that fixed quite well with this model of migration, D is the distance between the two places interacts with intervening opportunities and you can combine Zipf model of migration with Stouffer's model of migration.

Now, Zipf assume that income and unemployment are uniformly distributed over the areas. So, this model will be ok, if employment and income are uniformly distributed you see that later on, when this migration was improvised researchers included explicitly the variables of income and employment wage rate income employment labor force size to develop this model further, that should not be seen as rejecting the model of Zipf, because Zipf is saying assuming income and unemployment are uniformly distributed over the areas then this happens. Other models of migration should simply be seen as

more complex model depiction of more complex aspects of migration rather than rejection or Zipf model.

Here, k is a constant of proportionality that can be found from the empirical data. So, the model can be fitted to empirical data for a number of countries and k can be estimated to some sociology. The model may look funny or absurd, but Zipf found that the model fitted very well for all modes of transportation, that is a interesting part of it at the end I have given you reference of all these things. So, if i and Zipf is publishing his article this model of migration not in any mathematical or statistical journal, but in the top journal of sociology.

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In 1975 Using a similar argument Dorigo and Tobler (1983) expressed:

$$M_{ij} = k(U_i W_i / U_j W_j) L_i L_j / d_{ij}$$

Also

$$R_i - E_j = k(U_i W_j / U_j W_i) L_i L_j$$

where M_{ij} refers to migration from place i to place j. R refers to rejecting, repelling, or repulsing, "push" away factors. E refers to enticing or "pull" toward factors. U, W and L refer to unemployment rate, wage rate and number of people in the labour market.
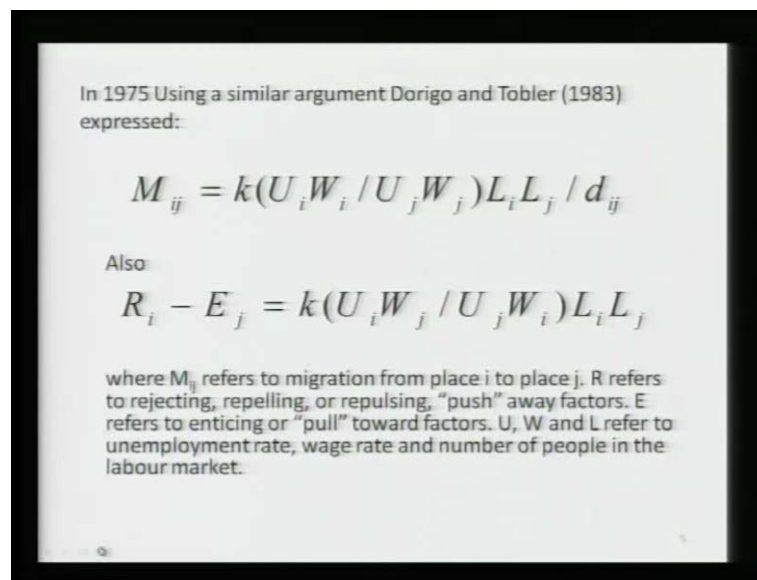
And later on 1975, using a similar argument Dorigo and Tobler in 1983 expressed MIJ migration again between i and j two places, place i and place j, as K constant of proportionality, u I, here u stand for unemployment rate w stand for wage rate. So, U I, W i divided by U j, W j into L i L j here one represents the size of labor force. So, l i is size of labor force at place i and L j is size of labor force at place j, divided by D i j which is the distance separating the two cities they also decompose migration into two parts a factor of repulsiveness and a factor of attraction what in sociological language, we call push and pull factors.

Pull and push factors which push away migrants from the place of origin and pull factors which draw migrants towards the place of destination. Analogues to equation to for MIJ

you can also write equation for R i repulsiveness and e attractiveness or an equation showing R i minus e j repulsiveness minus enticing or pull factors as K, U I, W j divided by U j, W I, L I, L j the constant of proportionality k again can be Obtained by using empirical data on a number of countries for which this model is to be fitted.

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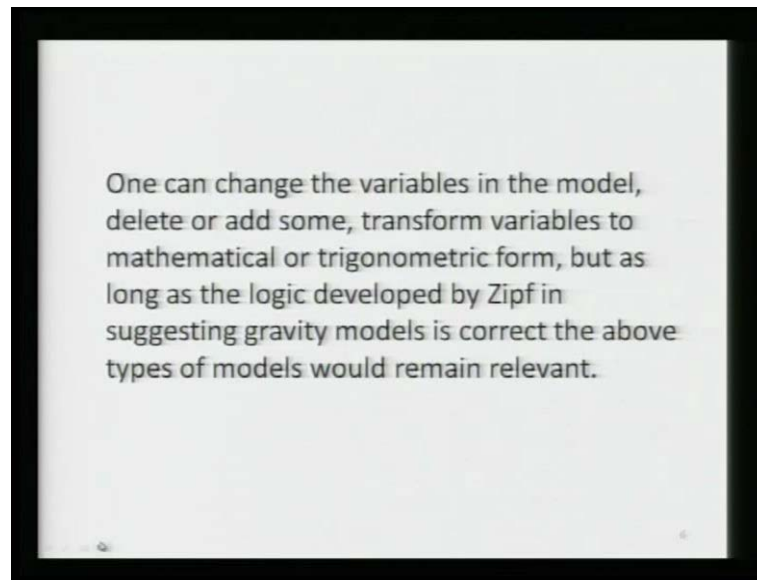
One can change the variables in the model delete or add some transform variables to mathematical or trigonometric form, but as long as the logic developed by Zipf in suggesting gravity models is correct, the above types of models will remain relevant other people have done. Subsequently, after this 1983 article some people said that in place of U, you can take U raise to power alpha or in place of D you can take D raise to powers some beta like that or labor force i l, i l, j, in place of taking l I, l j, as such you can take their powers of alpha beta gamma something and then you have accordingly a model with three or more parameters.

And these parameters can be estimated again from empirical data, it is expected that more is the number of parameters of constant of the model, better feed your model will show, but behind all these your models of migration. The basic idea of Zipf is still hold, that migration between two places is caused by pull factors at the place of destination, push factors at the place of horizon, It is inversely proportional to distance separating the two places or as to purchase intervening opportunities. If we go into literature on

migration, then they are many other factors and people will say that migration also will depends on a personality factors or psychological factors.

Yes migration can depend on psychological factors accordingly; you have sociological models and psychological model. Sociological models focuses on what is the reason that people from certain place are moving towards another place. Psychological model will focus on what are the reasons that in the same situation from the same place to same place some people migrate others do not.

So, what are the differences in personality wherever, say locus of control and need for power, need for affiliation, what is that in personality, because of this some people migrate some people do not and there can be interaction of sociological and psychological variables, this is the line that modeling in the field of migrations adopts.

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Economic-demographic models

Coale and Hoover (1958) pioneered the modelling of demographic and economic variables through which they showed what the short term and long term effects of population growth on economic development are. Their model paved the way for large scale computer simulation models in population and development (Arthur and McNicoll, 1975).
These models are developed on the basis of certain axioms, empirical relationships and theoretical understanding of the issues involved.

There is another type of modeling in population studies which will be called economic demographic models Coale and Hoover 1958 pioneered this modeling in the context of developing countries and a develop this model for India, through which they showed that the short term and long term effects of population growth. On economic development can be a positive or negative and the distinguish between short term and long term, It may happen that population growth is harmful in the short run, but it may be beneficial in the long run there model paved the way for large scale computer simulation models in

population and development, these models are developed on the basis of certain, axioms, empirical relationships and theoretical understanding of the issues involved.

What Coale Hoover thought, they said that growth rate of income depends on investment industry. In directly protective items in capital goods and this investment depends on how much can be saved, out of national income money value of goods and services produced in a country in a year, how much can be saved and how much can be invested. Now, this are this saving part depends on consumption requirement and consumption requirements depend on two thing, consumption requirement of the existing and consumption requirement of the additional population due to population growth.

So, by decomposing national income into various components consumption and saving and by showing transformation of saving into investment a Coale Hoover were able to see. What will be the rate of capital accumulation under different assumption of population growth and what do they found, that in the beginning for some years to come rapid growth of population in India will be back, because you are increasing population you are increasing you are increasing consumption. You are increasing consumption of existing population; you are increasing consumption requirement due to additional population. So, money left for investment is less, but in the long run say after 15 or 20 years, when children born today join labor force and they start contributing to production and that time they can be useful for national economy.

Right now, my purpose is not to discuss the connection between economy and population studies. I just wanted to say that, here is another type of modeling in the fields of population studies, which relates issues of population growth to issues of economic Development Coale and Hoover model developed 1958 is still remain the classical the best model to illustrate this kind of connection and this was developed for India and particular.
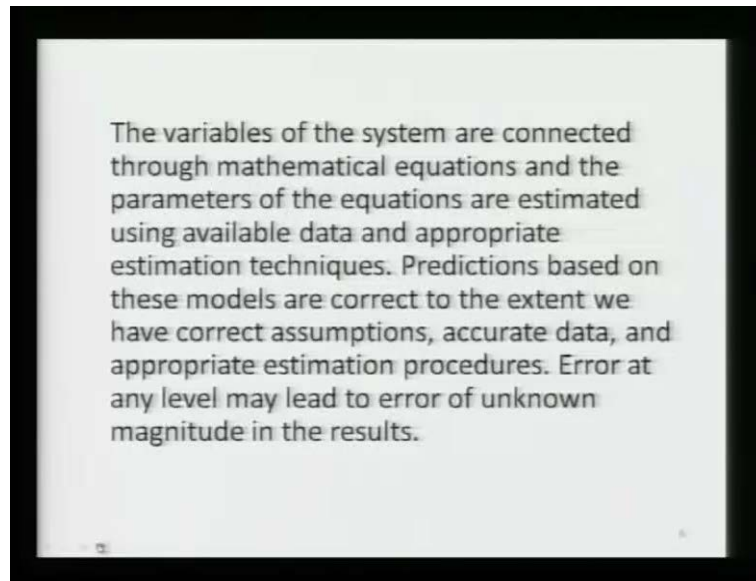
The variables of the system are connected through mathematical equations, if you want to develop a model of this kind, you have to identify your variables and you have to develop mathematical equations between these variables and the parameters of the equations are estimated using available data and appropriate estimation technique. Predictions based on the models are correct to the extent that, we have correct assumption; accurate data and appropriate estimation procedure, error at any level may lead to error of unknown magnitude in the results.
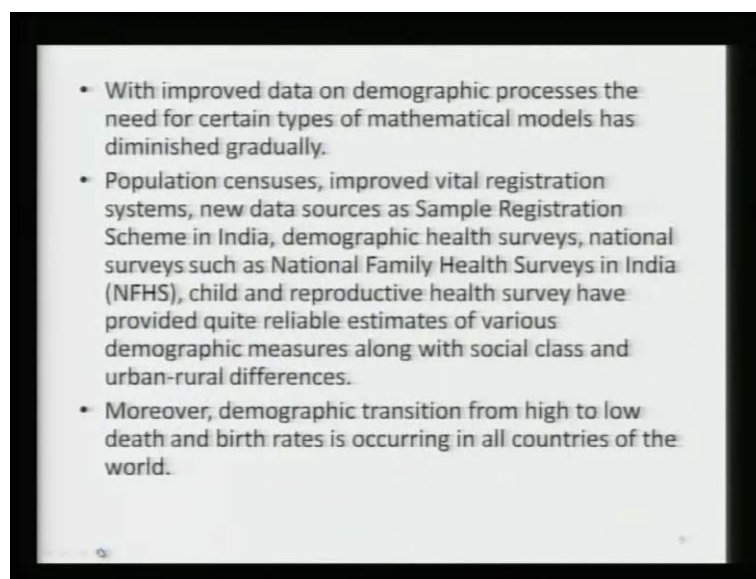
Now, last time I said that as such, because of availability of better demographic data from census, sample registration scheme, national family has survey, district level has survey and youth survey, have met our requirements of finding estimates of birth rate, death rate, life expectancy or age of marriage or related issues. So, for these things we do not depend on models like stable population. In a last lecture I thought now, what is stable population and quasi stable population. We do not depend on stable quasi stable population for estimation or projection, but we still need modeling, for what purpose do we need modeling. I will show one or two questions which can better be answered by using mathematical models.

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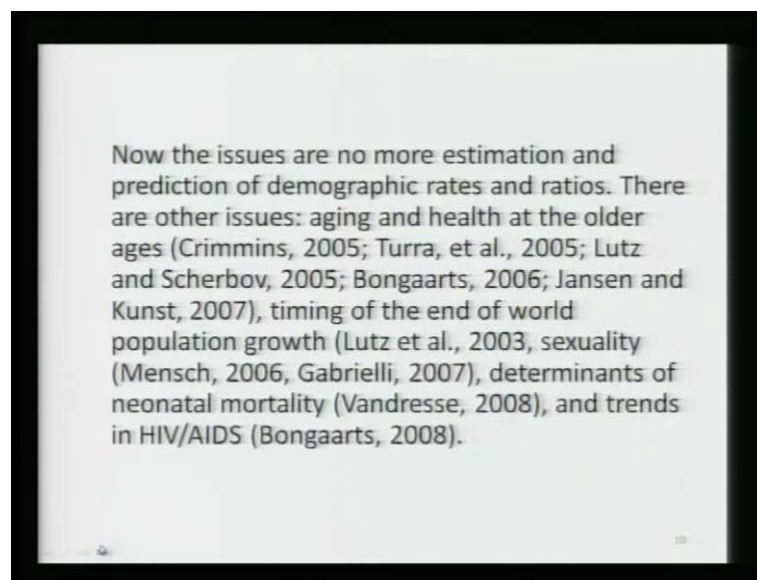
Now the issues are no more estimation and prediction of demographic rates and ratios. There are other issues: aging and health at the older ages (Crimmins, 2005; Turra, et al., 2005; Lutz and Scherbov, 2005; Bongaarts, 2006; Jansen and Kunst, 2007), timing of the end of world population growth (Lutz et al., 2003, sexuality (Mensch, 2006, Gabrielli, 2007), determinants of neonatal mortality (Vandresse, 2008), and trends in HIV/AIDS (Bongaarts, 2008).

Now, the issues are no more estimation and prediction of demographic rates and ratios, there are other issues aging and health, at the older ages timing at the end of world population growth. We all knows that we are moving toward establishing of population but, when will this happen. When will world population is stabilized, when will china population stabilized, when will India's population stabilized, when will US population stabilized are some population going to decline, what will be their effect on world population stabilizations, a causes behind determinations of the timings of stabilization of population, then determinants of neonatal mortality, perinatal mortality determinants of child mortality and trends in a HIV aids, these are some new issues in which modeling is required.

Lot of modeling is going on in the field of HIV aids aim is to understand the process by which h i v virus express from small number of cases to larger population, how much time it takes in some countries I think the last lecture I gave you the example of Africa that only 20 years ago very few persons, a handful of persons actually were affected by HIV virus there and in 20 years time in some countries as many as 20 percent, 25 percent, 30 percent of all the adult population is suffering from HIV virus.

So, what is that process of diffuse and a progress or growth transmission from one part of population to another part or from high raise group to general population, that can be understood with the help of modeling of HIV aids.

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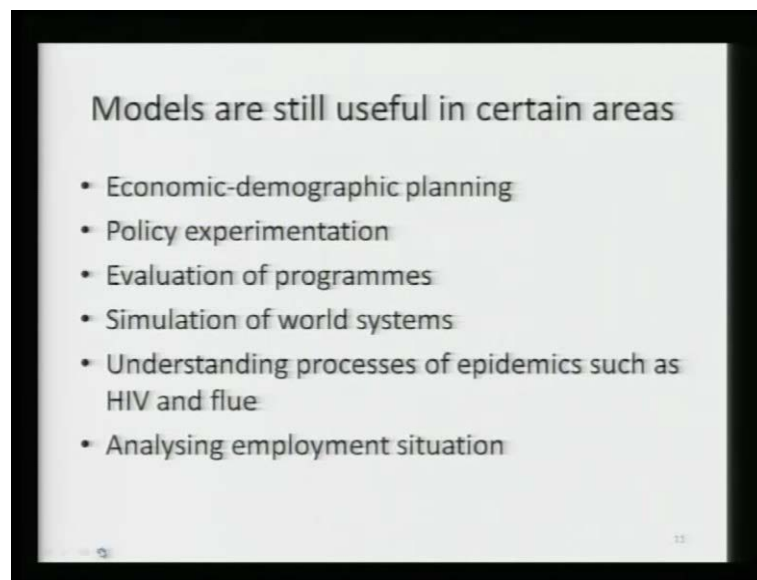
So, these are some new issues, new concerns models are still therefore, useful in certain area economic and demographic planning, policy experimentation. Policy experimentation, if I want to know we are able to raise our couple protection rate from the current level to 60 percent, what will be its impact on birth rate. If we are able to raise couple protection rate to 80 percent what will be its impact on total fertility rate or if you are able to reduce death due to aids by 30 percent, what will be its impact on life expectancy and so on. That is policy experimentation, then evaluation of programmes, evaluation of family planning programmes, there are very specific models.

On the line of models of or marriages, which can be used for studying impact of family planning program on birth rate. Imagine, that we have to find out what is the impact on

family planning program? Nearly statistic of how many people are using family planning method is not enough, you must also know for how much period they use them means, what are the rates of continuation and you must know how effective those methods are and for estimating continuation rates, one can very well use life stable or stationary population model.

Then for simulation of words systems, connecting quality, environment, agriculture industry, education, food, you can builds word system orders, then can understanding processes of epidemics such as HIV and flu. In India ICMR is particularly interested in these days and transmission of flu virus, a swine flu, H 1 and N 1 HIV, how these spreading, if somebody you know these are the models which government of India needs today very much and not much is known in this field

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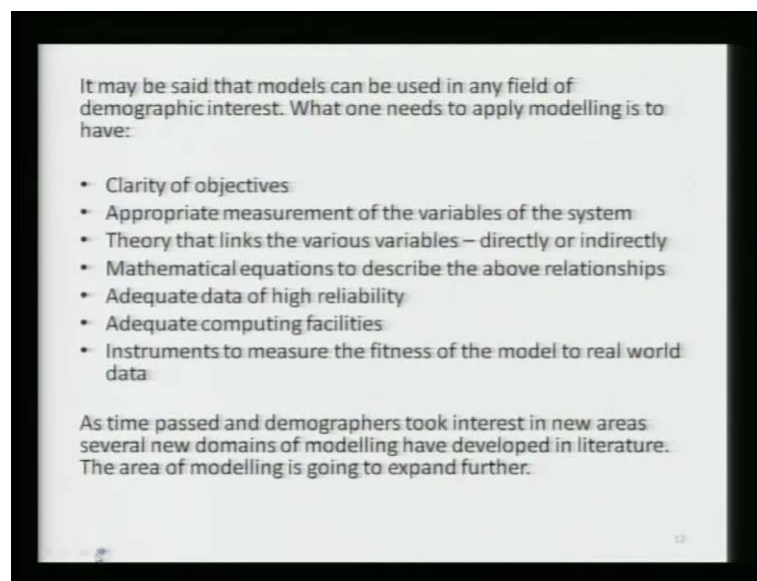
Then analyzing employment situation also requires modeling, it may be said that models maybe used in any field of demographic interest. What one needs to apply modeling is to have clarity of objectives, if you are to build models then the first thing is that you must be clear about objectives, what you want to achieve model can be simple, model can be complex.

Zipf model of migration is an example of very simple model, but subsequent developments. In the field of modeling of migration, in which lot more variables have been added, apart from population size of labor force is added, wage rate is added,

unemployment rate is added, in some models I have seen social distance between cities are also added, linguistic differences are added. So, the model become more and more complex, more aspects of reality, you want to represent through your models, more complex your models will become, depending on your need depending on your objectives you can go for simple or complex model.

Then, appropriate measurement of the variables of the system this is another requirement. How will you measure wage rate, how will you measure? You know there can be several wage rates or how will you measure attractiveness of a city or repulsiveness of a city or how will you measure unemployment rate and measuring unemployment, even defining unemployment is a big problem and measurement of unemployment are going to effects estimation of your parameters very much, then you require a theory.

Theory, that links the various variables of the model directly or indirectly, what are independent variables, what are depended variables, what are mediator variables, approximate variables, what are moderator variables, you must have a clear understanding of different variables involve in the system. Then you require mathematical equations to describe the above relationships.

Then, adequate data of high reliability, adequate computing facility, if you have simple model maybe you can do manual calculations, but if you are going for word system simulation or you are going for Monte Carlo simulation method, then you required a high speed computers and then instruments to measure the fitness of the model. Finally, you have to check whether you can fit all kinds of models to all kinds of data, but you must also know whether the models you are fitted are actually appropriate model or they serve the purpose they fit well, they help you in achieving your objectives and for that purpose some test of goodness and fit would be required.

As time pass the demographers took interest in new areas, several new domains of modeling have developed in literature. The area of modeling is going to expand further there are lots of journals population studies, demography among internationals journal, we study the family planning and India you have journals, demographic India, journal of health and family welfare and which I have been publishing articles based on modeling.
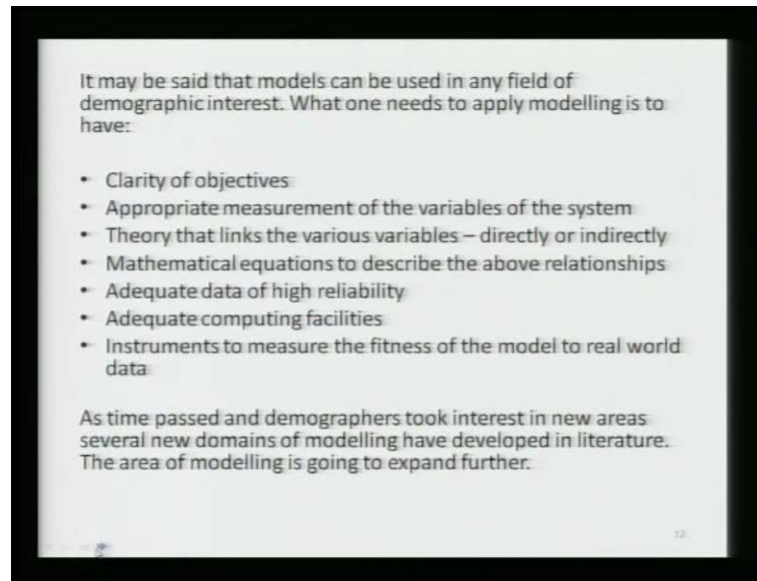
Models are provided inside into causes of change in the demographic variables, for example so, models are used not only for representing reality or for estimation of future, but they have also been used in developing insights into causes of change in the demographic variables. For example, using the simple multivariate regression with total fertility rate as dependent variable and GDP means, gross domestic product per capita life expectancy and gross primary and secondary school enrollment rate, percent urban and agriculture as percent of GDP as independent variables brand do the following conclusion. This article was published in recent issues of population in development of interview.

The model was simple multiple regression analysis and the depended variable GDP depended variable is total fertility rate and GDP life expectancy is school enrollment rates percent urban agriculture percent of GDP they appear as independent variables in model if fitted. Actually, variant of that model were fitted on the basis of his study of data with help of this multiple regression analysis, he drew the following conclusions. One that fertility decline in countries with no scores on development means, in developing countries cannot be explained by socio economic theory.

So, demographic transition theory which explains changes in fertility and mortality, in terms of economic, variables industrialization, urbanization, economic development did not explain, demographic transition in the less developed countries or developing

countries this was one conclusion. The relationship between development indicator these are all development indicators, life expectancy, life expectancy GDP percent these are all socio economic or development indicators. The relationship between these development indicators and fertility is weaker in developing countries and then watch the case with developed countries.

Under the demographic transition theory was what we learnt about relationship between fertility and socio economic variables. The relationship was not found to be that strong in less developed country, what does that mean? If socio economic development factors are not in suppose, the model shows and his model showed this what does it mean? If the socio economic factors do not explain demographic factors or the relationship between socio economic factors and demographic factors is rather week and also.

Third very interesting conclusion that the, relationship between development indicators and fertility has shifted over time. So, what does that mean that, there are factors other than socio economic factors which explain transition in fertility. In less developed countries and this model than a favors the family planning theory or sociological theory of modernization and westernization, that behind transition in fertility. In the less developed countries are family planning programmes and also and the change in values cause by modernization and westernization, it is not simply socio economic development.

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Some of the above conclusions would not be possible to make if the appropriate data did not exist or if the technique of multivariate regression analysis was not known. In an interesting article using data on homicide rates Cole and Gramajo (2009) showed that as female education increases the homicide rates also increase. It was an unexpected finding. Then they posited a number of factors that explain this unexpected relationship.

Some of the above conclusion would not be possible to make if the appropriate data did not exist or if the technique of multivariate regression analysis was not known. In an interesting article using data on homicide rates Cole and Gramajo in 2009 this article was also publish in population and development interview, showed that as female education increases, the homicide rates also increase something interesting and at sometimes models come up with interesting and unexpected answer. Actually, in my class in introductory sociology I give this example of Cole and Gramajo model, to show what positive is our what comparative sociology mean.

In our times Cole and Gramajo are using exactly the same methodology, which long back Durkheim used for studying suicide, here in place of suicide they are studying homicide and in place of variables like marriage or religion or change in income they have their own variable. Now, one of the interesting findings of this is that homicide rates increase with female education. Normally, we will think that with education and development more awareness, more legal consciousness, (())modernization, westernization, homicides rate, should come down.

Now, it was found that with improvement in literacy and education among males homicide rate comes down, but with improvement education among women homicide rate goes up. It was an unexpected finding and sociologies were than required to explain, they have their own reasons and then deposited number of factors that explain this unexpected relationship, but this has opened a new area of research, in which sociologist can now work and explain why is it that you find a negative relationship between a decline in homicide rate and women education.

Another very interesting research in which modeling has been used if the research by Bongaart this was also published in population and development interview the theme of this research was like this that it has been a matter of great interest to established.

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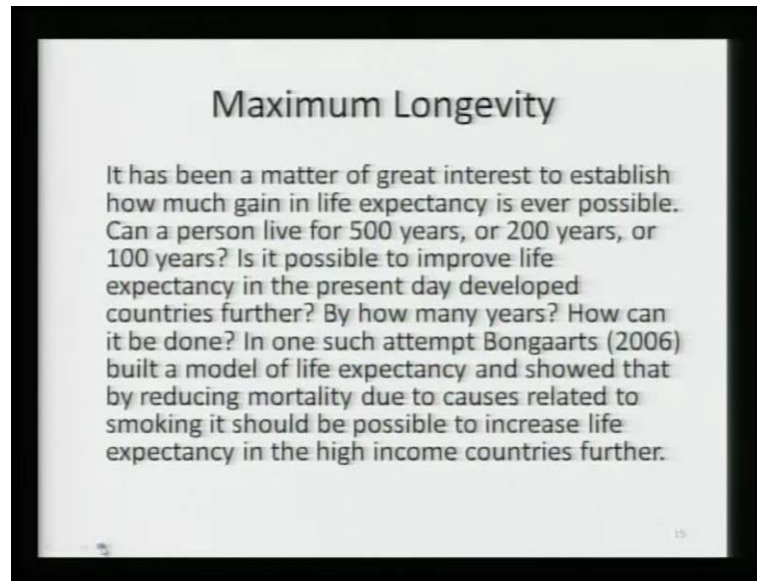
How much gain in life expectancy is ever possible there is lot of debate on this? There was a time and not in distant pass only 100 years ago, when life expectancy was as lowest 20 years, today life expectancy in some of the developed countries at least for females as reach the level 82 years.

In our country also life expectancy has gone to 64, then demographers epidemiologist medical experts biologist, they are asking the question how much more gain in life expectancy is possible.

Some people think that 82, we have already reached perhaps we are close to maximum life expectancy, we can have or maybe some people will say that it can be further extended to 84, some believed that it is possible to go up to 100, but it is it is all a matter of believe Bongaart for the first time using modeling gave us a method by which we can really argue wage on hard facts, whether it is possible to have further gain in life expectancy.

And what Bongaarts did they project that in the future longevity improvements will be larger and population ageing will be more rapid, than many governments of high income countries expect. Ageing has already become a problems for government in high income countries Bongaarts is very optimistic that there will be more gains in life expectancy or longevity in develop countries in the future, but the negative aspect dark side of that is there is going to be ageing at much higher pace than, if longevity is going to rise to 90 or 95, how can we say this. To demonstrate this point he decompose life expectancy as defined by him, the conventional life expectancy at any time equals senescent life expectancy, minus the lon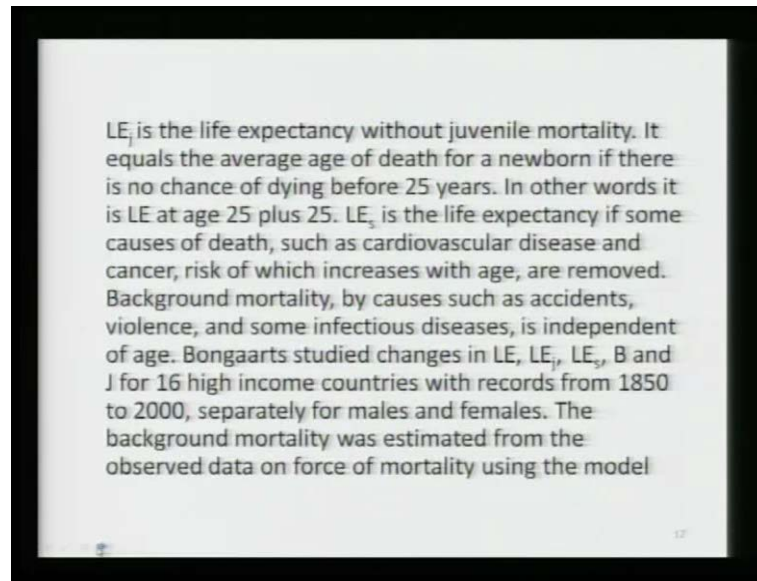gevity reducing effects of background and juvenile mortality, life expectancy j juvenile is the life expectancy without juvenile mortality

LE$_j$ is the life expectancy without juvenile mortality. It equals the average age of death for a newborn if there is no chance of dying before 25 years. In other words it is LE at age 25 plus 25. LE$_s$ is the life expectancy if some causes of death, such as cardiovascular disease and cancer, risk of which increases with age, are removed. Background mortality, by causes such as accidents, violence, and some infectious diseases, is independent of age. Bongaarts studied changes in LE, LE$_j$, LE$_s$, B and J for 16 high income countries with records from 1850 to 2000, separately for males and females. The background mortality was estimated from the observed data on force of mortality using the model

Which means mortality up to say age of 25 now, it equal the average age of that for a newborn if there is no chance of dying before 25, if you want to calculate juvenile life expectancy or life expectancy for India, if there is no juvenile mortality, then you have to find out what will be the life expectancy provided up to the age of 25 nobody dies means, number of death up to the age of 25 is 0, chance of dying that means l 25 small l 20. In the language of life table small l 25 is same as small l 0 or radix of life table or initial birth cohort. LE s and say in the life expectancy if some causes of death, such as card muscular diseases, cancer risk of which increase with age are removed, background mortality by causes, such as accident violence, infection diseases is independent of his Bongaarts study changes in life expectancy.

Life expectancy j juvenile means, without juvenile mortality and life expectancy senescent B and j for 16 high income countries with records from 1850 to 2000 at a, it is a very good thing that at least for the developed countries, we have detailed data on causes of death, rate ages specific of death rate and causes of death separately for males and females. So, it is possible for us to decompose life expectancy into several components like, juvenile mortality, background mortality or mortality due to specific causes.

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$$\mu(a) = \frac{\alpha e^{\beta a}}{1 + \alpha e^{\beta a}} + \gamma$$

In the above equation β measures the rate of increase in mortality with age (a) and γ measures the background mortality. Thus the estimate of senescent mortality by age

$$\mu_s(a,t) = \mu(a,t) - \gamma(a,t)$$

Now, if you do not have a background of mathematics or algebra, you should not be frightened by these alpha and beta, but if you have the background, it is good you can follow it better. What I am trying to say that if in order to estimate what will happen to life expectancy, if certain causes of death are removed, we can form a function mu at age a, which is called force of mortality. Mathematical modeling of life table functions this force of mortality at a, is expressed in the form this equation alpha e raise for beta a divided by 1 plus alpha, e raise to power beta f plus gamma, you can see it is a kind of logistic function. In the above equation beta measures the rate of increasing mortality with age and gamma measure the background mortality.

for ages above 25.

$$LE_s(t)=25+\int_{25}^{\infty} e^{-\int_{25}^{x}(\mu(a,t)-\gamma(t))da}\,dx$$

To consider the effect of specific factors such as prevention of smoking

$$\mu_{NS}(a,t)=(1-s(a,t))\mu_s(a,t)$$

Decomposition of LE, therefore, provides an opportunity for making more informed projections of life expectancy for the future.

So, it is possible to decompose mortality for ages above 25 and he expressed life expectancy at his at time t like this, 25 plus integral 2 5 to infinity and to consider the effect of specific factors, such as prevention of its ultimately his interest lie in studying the smoking as the cause of mortality.

He was able to compute that if smoking habits are controlled, how much will be the gain in life expectancy in the future. So, he was able to say on the basis of detailed data available on causes of death separately for males and female, for developed countries in the world, that we have not reached the plateau it is still possible to raise life expectancy further and that means government should be worried about the problem of ageing which is going to be much more in the future and he was able to sow that if, percentage is smoking is reduce by a certain percentage.

What will be its gain in terms of life expectancy and that he was able to do, but decomposing life expectancy into two or three components. So, that effect of juvenile mortality and background factors accidents, cancer and those factors which make people belonging to higher age groups more have more risk of dying those factors are explicitly taken into consideration.

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Popularity of Statistical Models over Mathematical Models

In the recent past, models based on advanced statistical techniques have become more popular than mathematical models ((Jansen, 2007; Vandresse, 2008)). Poisson regression (expressing log of rates as linear combination of independent variables), logit regression (expressing log odds as linear combination of independent variables) and multiple classification analysis are increasingly used by the social scientists. Guo and Harris (2000) used a structural equation model to examine effect of poverty and other factors on children's intellectual development.

Another field of modeling in sociology is in a recent past, we find that models based on advanced statistical techniques have become more popular than mathematical model. Yesterday I was saying that the field of population study there is more of mathematical Modeling, than statistical. Nowadays, there in sociology at least statistical modeling is coming, a poisson regression; logit regression and multiple classification analysis are increasingly used by social scientist.

In one survey of literature in sociology somebody said there is a great shift in sociology. While sociology is some 25, 30 years ago, you use more of multiple regression analysis, today we they use poisson regression or logit regression.

The advantage of logit regression is, it take care of qualitative variables also.

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Popularity of Statistical Models over Mathematical Models

In the recent past, models based on advanced statistical techniques have become more popular than mathematical models ((Jansen, 2007; Vandresse, 2008)). Poisson regression (expressing log of rates as linear combination of independent variables), logit regression (expressing log odds as linear combination of independent variables) and multiple classification analysis are increasingly used by the social scientists. Guo and Harris (2000) used a structural equation model to examine effect of poverty and other factors on children's intellectual development.

What are the stages in modeling I thought that at the end I was a tally about what are the various steps in modeling most systematically. So, first part of modeling is specification of model, then estimation of parameters, then validation and forecasting specification means

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Specification

Specification refers to the process of expressing relationships between dependent and independent variables in the form of mathematical or statistical equations. These relationships contain variables and some constants. The constants of the equations are called parameters. Specification requires a sound understanding of the field of study and a thorough review of works done in the field, understanding of assumptions on which past models were based, how sound they are, and researcher's judgement. Suppose in a particular field such as study of waiting time in fertility past researchers have used mostly Poisson distribution and the researcher thinks that the population being heterogeneous a mixture of Poisson distributions will fit better. Then the researcher has to specify waiting time as a linear combination of two Poisson distributions containing different parameters.

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It is a process of expressing relationships between dependent and independent variables in the form of mathematical or so, we specify a model then estimate parameter, there are various techniques of estimation of parameter least square maximum likelihood method of moments, those who will do mathematical modeling will read more on this matter and they will know all this technique.

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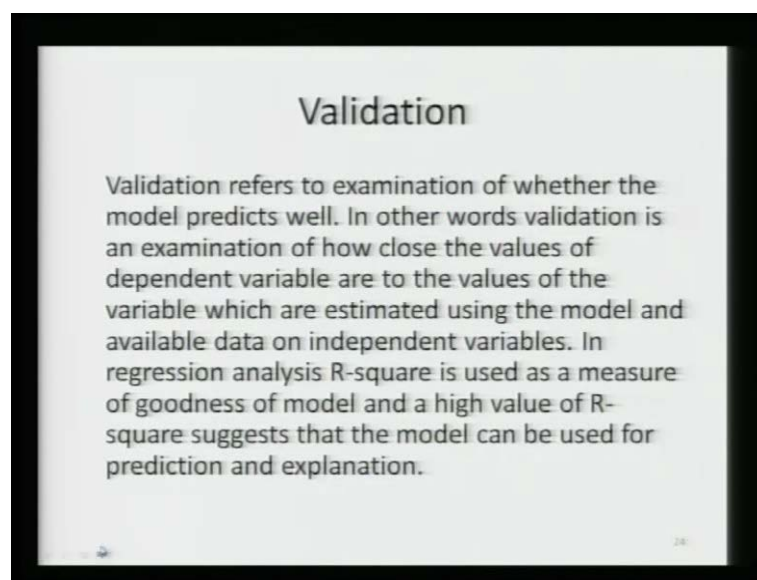
There is validation once you are known the parameters you would like to see whether your model is or not. So, you predict the values dependent variables, on the basis of data

for independent variables and see whether estimated actual, values empirical values are close to each other this is done with the help of capital R square.

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Forecasting

Once the model is ready it can be used for forecasting. It must be noted that **an advanced and complex model is not a guarantee of good forecasts**. Simple models do sometimes result in better prediction than complex models. The accuracy of forecasts depends on a number of factors: (a) model specification; (b) accuracy of data; (c) estimation procedure: (d) stability of the system; and the (d) length of the projection period. Long term forecasts cannot be as good as short term forecasts because longer is the projection period greater is the likelihood of changes in the system dynamics (i.e., relationships between variables).
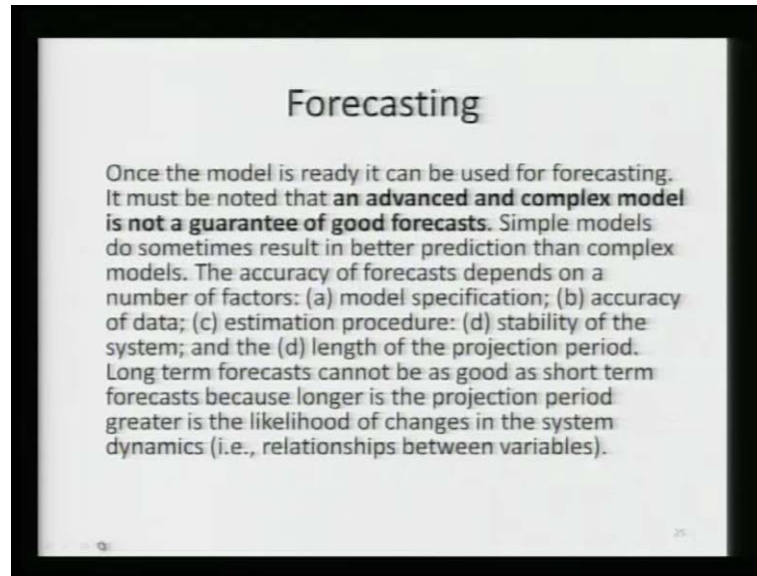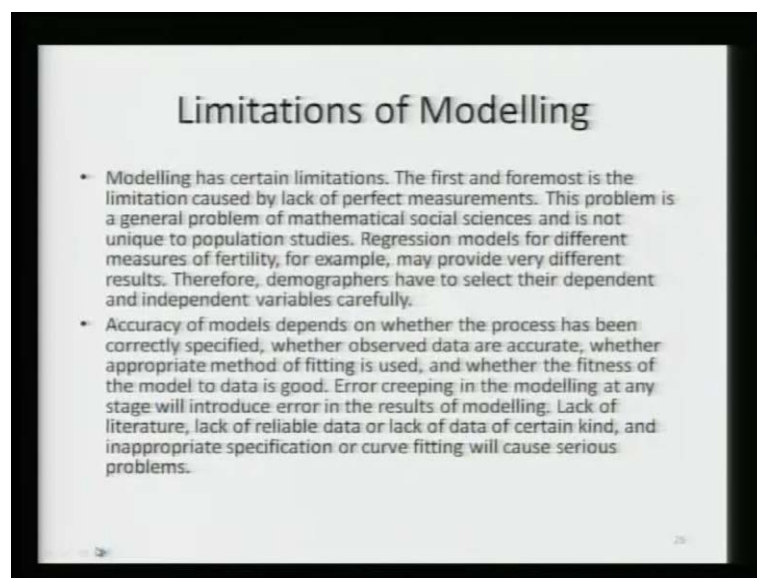
Then if capital R square is good and you are model is fitted, then you can use the model for forecasting.

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Limitations of Modelling

- Modelling has certain limitations. The first and foremost is the limitation caused by lack of perfect measurements. This problem is a general problem of mathematical social sciences and is not unique to population studies. Regression models for different measures of fertility, for example, may provide very different results. Therefore, demographers have to select their dependent and independent variables carefully.
- Accuracy of models depends on whether the process has been correctly specified, whether observed data are accurate, whether appropriate method of fitting is used, and whether the fitness of the model to data is good. Error creeping in the modelling at any stage will introduce error in the results of modelling. Lack of literature, lack of reliable data or lack of data of certain kind, and inappropriate specification or curve fitting will cause serious problems.
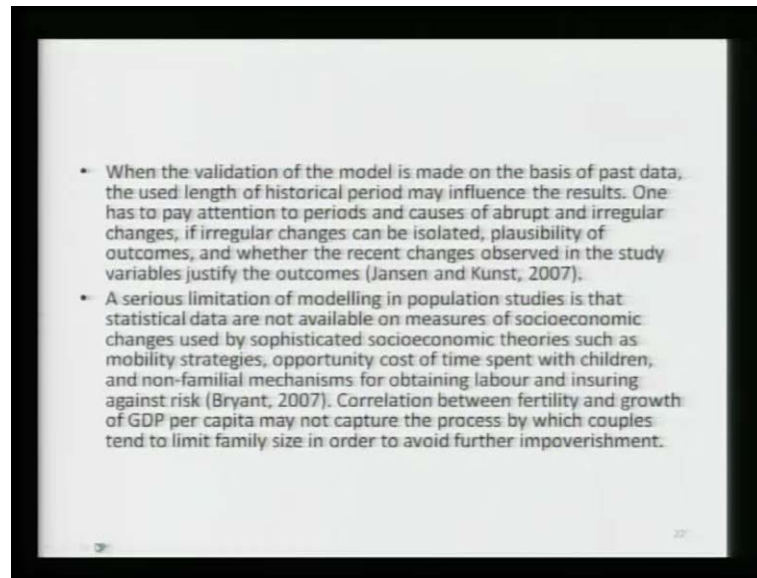
Obviously, modeling has certain limitations, the first and foremost is the limitation caused by lack of perfect measurements, not everything can be measured. This problem is a general problem of mathematical modeling, social sciences and is not unique to

population studies regression models, for different measures of fertility provide very different results. If you are dependent variable is total rate, you have one result, if you are dependent variable is crude worth rate, you may have another results.

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- When the validation of the model is made on the basis of past data, the used length of historical period may influence the results. One has to pay attention to periods and causes of abrupt and irregular changes, if irregular changes can be isolated, plausibility of outcomes, and whether the recent changes observed in the study variables justify the outcomes (Jansen and Kunst, 2007).
- A serious limitation of modelling in population studies is that statistical data are not available on measures of socioeconomic changes used by sophisticated socioeconomic theories such as mobility strategies, opportunity cost of time spent with children, and non-familial mechanisms for obtaining labour and insuring against risk (Bryant, 2007). Correlation between fertility and growth of GDP per capita may not capture the process by which couples tend to limit family size in order to avoid further impoverishment.

So, that is another problem, then when the validation of the model is made on the basis of past data. The huge length of historical period may also influence the results and serious limitation of modeling. In population studies is that statistical data not available on measures of socio economic changes used by sophisticated, socio economic theory, socio economic theories, are going in one direction, mathematical modeling is going in another direction and in socio economic theory sometime sociologist are using terms like mobility strategies, opportunities cost of time expand with children non familiar in mode of production and so on. And it is not an easy job to develop measurements of what sociological concepts are being developed to explain different thing.

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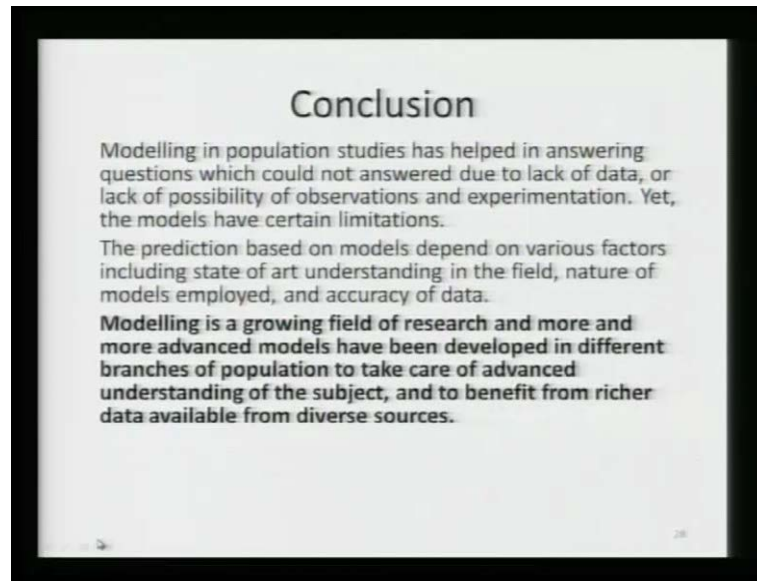
So, at the end I can say that modeling in population studies has helped in answering questions which could not be answer due to lack of data or lack of possibility of observations and experimentation. Yet, the models have certain limitation, that prediction based on models depend on various factors including state of understanding in the field nature of models employed and accuracy of data modeling is growing field of research and more and more, advanced models have been developed in different branches of population, to take care of advance understanding of the subject and to benefit from richer data available from diverse sources.

This is what I would like to say on the issue of modeling. Now, I would like some of you to ask questions, I know that some of these material could have been very heavy for you if you do not have the background of mathematic, but this at least tells you that there is an interesting, an independent branch of population studies.

In which there is scope for mathematicians, statisticians, economist to develop re predicted purposes of policy experimentation, yes thank you.

(Yes sir, i have a question that you have talked about one thing two questions number, one is you talked something about that there is use of modeling for simulation world system is Something, you have to you just clarify to what is that and second question is when you from your discussion, what I was trying to study some of the models that, you have put up like Zipf model. Now, I think that it uses a lot of criteria like unemployment

of poverty of level of education, which are seemingly secular variables now, in a situation like India non developing countries, where I think that the predominant of this way that non secular variables like say communal riots or language problem should have a migration flows for example, do you I means just to half hour can, we actually reprecate modeling of population distribution which is might be secular exercise in develop countries in Indian society or whether there are models which also can capture these developments.)

Thank you very much. Your first question is about simulating word system is simulation, you know in sociological language also we talk of relationship between human population environment or destructive effects of population growth in simulating long ago in limits to growth group argued, that it is not possible to sustain the present processes of development for various reasons.

Now to say so, they have to have a model in terms of his relationship between population growth economic development (( )).