Urban Landuse and Transportation Planning
Prof. Debapratim Pandit
Department of Architecture and Regional planning
Indian Institute of Technology – Kharagpur

Lecture – 25
Land Price Model

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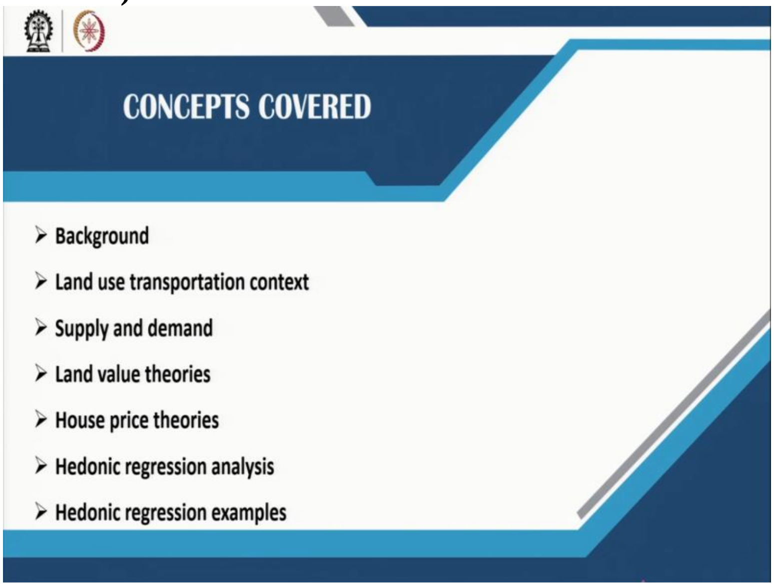

The different concepts covered in this lecture are, background of land price model, the land use transportation context, supply and demand, land value theories, house price theories, hedonic regression analysis, and hedonic regression examples.

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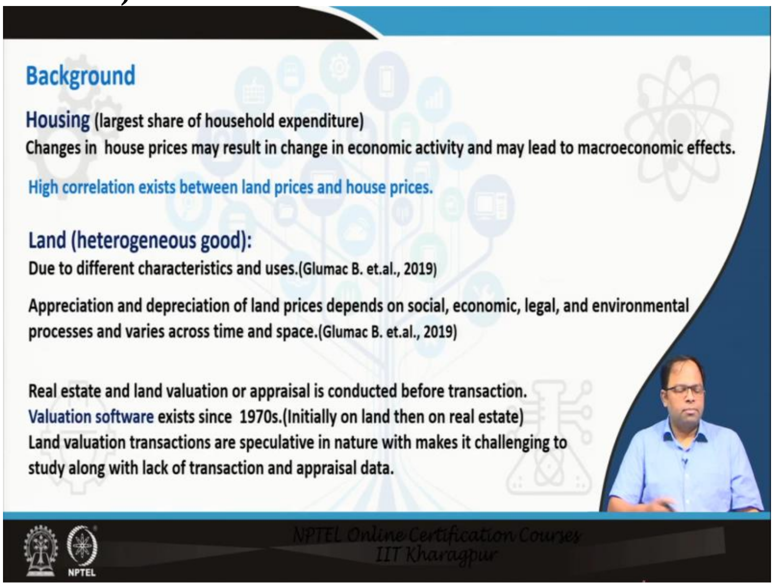

Background

Land prices and accessibility values have a substantial impact on the way how cities grow, or how households choose different locations to live in the cities and where real estate developers would like to build their housing complexes, or commercial centers and so on. It is important to understand how land price, housing price, or building price changes in an urban area. This change also needs to be tracked in a land-use transportation model to know if any change in certain activities will result in a change in the land price. Change in the land price also brings in change in other things such as residential location choice, development choice by real estate developers, and so on. This is a cyclic process. Therefore, there is a need to understand the way land prices change in an urban area, or, how to determine prices for different plots or buildings in an urban area.

Housing constitutes the largest share of household expenditure. Housing also plays an important role in the economy of a particular country. Change in housing prices may result in change in economic activity and even lead to macroeconomic effects. For example, the subprime crisis that hit the world economy a few years back was also related to housing prices, housing loans and so on. There is a also a high correlation between land prices and house prices. So, when land prices increase, house prices also increase, and vice versa.

Land is considered a heterogeneous good since it has different characteristics and different uses. Appreciation and depreciation of land prices depend on many things such as social, economic, legal, and environmental processes. Also, land prices can vary across different time periods and spaces. So, land price at time ‘t’ and ‘t+1’ will be different and similarly, it will be different at different locations.

The land price change over time could be tracked by tracking the prices for a particular area as well as determining what factors have changed during a particular period. Additionally, at a particular point in time, the land price of a particular area is different from land price in another area.

Real estate and land valuation or appraisal is conducted before the transaction i.e., before a real estate developer starts building or buying a plot of land, he does some valuation exercise to understand what could be the benefit of buying this particular land, what kind of returns he can get, so that, the decision of buying or building on the plot of land is on a more solid footing. Valuation software used are used extensively and exists since the 1970s.

Even though, there are various software, or methodologies to understand what factors contribute to the land price before a transaction takes place, land valuation transactions are very speculative. So, it is quite challenging to study or to model the same. In addition to that, there is a lack of land transactions and appraisals data, since they are either lost or in private hands. If the data on appraisals is available, then these data are location-specific and time-specific.

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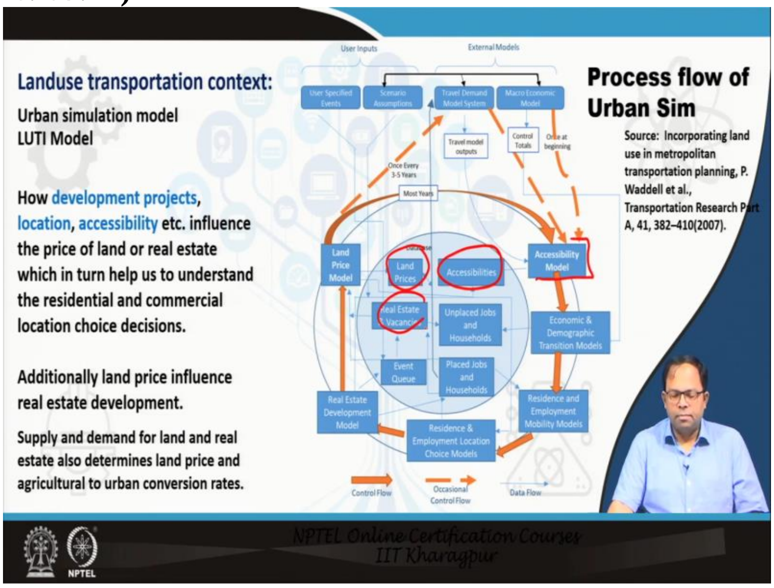

Land use and transportation context

The land price model is a sub-model of a large urban simulation model or an integrated land use and transportation model. Urban simulation models simulate the different urban process, to predict the changes in the urban system or urban area. For example, UrbanSim model constitutes different sub-models or subsystems like the accessibility model, travel demand model, employment transition model, and so on. Travel demand model systems influences the accessibility. Accessibility influences economic and demographic transition models, residence and employment mobility and location choices, real estate development model etc. Next, real estate development can influence the land price. Land price again influences accessibility. All these things are interrelated. So, there is a feedback loop in all these different components.Thus, while one component influences other components, and changes the overall urban area, these new changes will eventually influence the components that one started with.

It is important to understand, how development projects, location accessibility, etc., influence the price of land or real estate since it helps us to understand the residential and commercial location choice decisions. Additionally, land price influences real estate development. For example, real estate developers will buy land when land is cheap, or buy at a place where they can speculate that the land price will appreciate with the introduction of certain infrastructure. These kinds of decisions are influenced by land prices or real estate development.

The supply and demand for land and real estate determines the land price and agricultural to urban conversion rates. For example, the number of people coming into the city will want to stay in certain areas which constitutes the demand. Based on this demand, real estate developers will start building houses that enter into supply. There is always a gap between supply and demand. This gap determines the land prices. If there is less supply and high demand then land prices will appreciate and vice versa. Additionally, if the demand for land or real estate is high, then the demand for the conversion of agricultural land to urban land is also high. So, these two processes go on simultaneously.

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Supply and Demand

In economic models, when supply and demand are considered, the need to understand the concept of equilibrium and disequilibrium is important. In the land use and transportation model, equilibrium can be assumed for a particular time period, whereas disequilibrium is assumed by considering small timeframes like for every year.

In economic models, equilibrium refers to a hypothetical long-term market steady-state condition where supply, demand, and prices are perfectly balanced. At the end of the time period, demand and price are balanced based on the supply. Also, buyers and sellers have full information about the price and the benefits of the choices, and accordingly, they will choose a certain location, buy a certain house, or build on a certain area. Whereas in disequilibrium, supply and demand are not perfectly balanced, and the responsiveness of agents may also vary. It means housing demand for housing may outpace or lag housing supply causing the disequilibrium which results in boom-and-bust cycles.

Considering the figure given in the above slide, where magenta and grey represent supply and demand respectively. Initially, the demand is high and supply is less, then supply catches up and increases. Since the supply is more, the price falls. Later, the demand curve again gradually catches up and prices increase. So, when supply is more, real estate construction reduces and number of people involved in construction reduces, whereas, when demand picks up, then the real estate construction also starts. The bust cycle is where supply is more than the demand, and the boom cycle is where demand is more than supply. This cycle can last for a certain period. For example, in the figure the bust cycle is seen to be for 3 years.

There may be also substantive departure from equilibrium i.e., the gap in demand and supply is large. So, the knowledge of the market value of specific attributes comprising a housing unit is necessary to prioritize or to address the demand. For example, when there is less demand in the housing market, a real estate developer will try to build considering the attributes that people want because everything cannot be provided. It helps the real estate developer to understand what features/attributes to be targeted to generate more price in the market. It is because, land is a heterogeneous good and similarly, housing can also be broken into many components. So, everything is not demanded by the people, only certain components would have higher demand. People are also willing to pay more for these components/attributes.

If the market is in equilibrium, this would be equal to the supply price of adding an increment of that particular attribute i.e., if a real estate developer is developing or providing certain characteristics/attributes to a certain housing, he can charge some extra price for it and this price becomes the supply price or the price of that particular attribute. Whereas, in disequilibrium, there is an uncertainty in knowing what people want, so adding a certain charecteristics/price may not be appreciated in the market. Therefore, it is important to understand the prices of each component of either housing or land.

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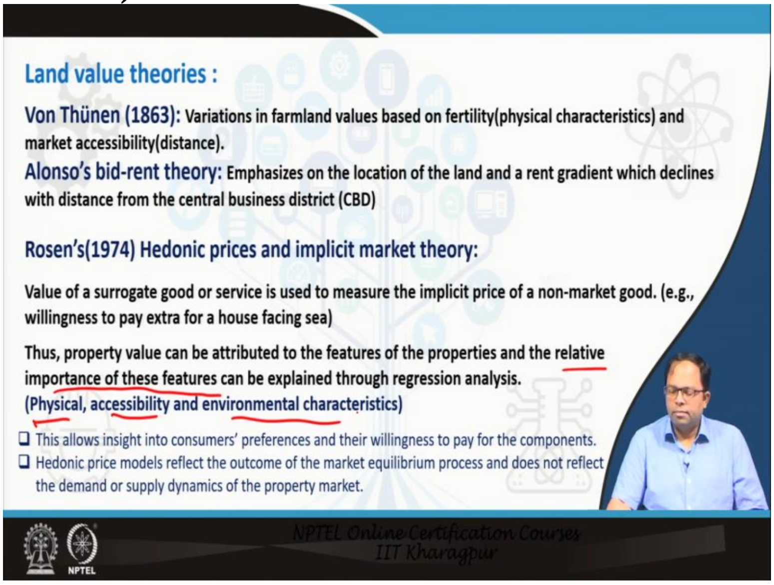

Land value theories

Land value theories have been developed by many researchers since the 1860s. Von Thunen has said variation in the price of land or farmland values are based on fertility, which is a physical characteristic, and market accessibility, which is a distance-based characteristics. So, land value depends on its characteristics as well as its accessibility. Alonso emphasized on the location of the land on its distance from the central business district (CBD). He stated that, a rent gradient declines with the distance from the central business district. It means that, more is the distance from the CBD lesser will be the rent that is to be paid for a certain kind of land use. These two theories were the starting point, but there are a lot of limitations to these theories.

In 1974, Rosen proposed the hedonic prices and implicit market theory, which states that, the value of a surrogate good or service is used to measure the implicit price of a non-market good. For example, the willingness to pay extra for a house facing the sea. If the house is facing the sea, it is very difficult to measure this particular feature. But, the amount of money people are willing to pay for this feature, can help in determining the price of this non-market good. This concept started the hedonic pricing models, or hedonic regression theory.

The property values can be attributed to the features of the properties, and the relative importance of these features can be explained through regression analysis. Since the amount of price a person is willing to pay for each nonmarket good is known, so a regression model can be developed for different components of the properties. Also, the relative importance of feature can be determined by understanding which feature people are willing to pay more. These features can be related to physical characteristics, accessibility, and environmental characteristics of that particular property. Additionally, it allows insight into consumer's preference for the components.

Hedonic price models reflect the outcome of the market equilibrium process and do not reflect the demand or supply dynamics of the property market. So, hedonic regression models can help in determining the components for which people are willing to pay, but it does not explain if it will increase the supply or what effect it will have on demand. So, these kinds of dynamics are not determined using hedonic models.

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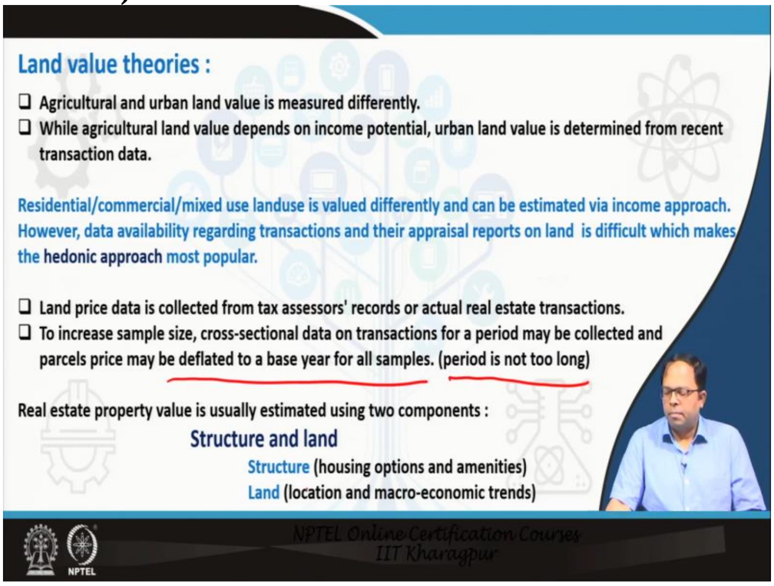

It is also important to understand that, agricultural and urban land is measured differently. Agricultural land depends on the income potential i.e. what kind of crops will grow in that particular land or what kind of earnings could be gathered in the future. But in urban land value determination, this is difficult, and usually, the land value is determined from the transaction data. Transaction data like what kind of price was determined for a particular land parcel in recent years when it changed hands. This data forms the base of understanding urban land values.

The value of residential buildings, or a commercial project, or a mixed land use can be determined based on an income-based approach like that for agricultural land. This is however, difficult to model or determine due to the non-availability of transaction data or appraisal data. Therefore, the hedonic approach is more popular, where land prices can be assessed by determining the components contributing to that particular land price, and the prices people are willing to pay for these components. This forms the basis of land value theories in urban areas.

Land price data is collected from tax assessors' records or actual real estate transactions. Sometimes, the number of transactions is not high in a particular area. So, to increase the sample size, cross-sectional data on transactions for a period may be collected. Since the land price changes over a time period and there may be a significant change in land price from year A to year B. Therefore, all the prices are to be brought to a common platform. So, the parcel/land prices may be deflated to a base year for all samples. Generally, very long periods of data are not considered, because even if the data is brought to a baseline, there will be a significant change in other characteristics that influenced land price. Thus, while considering every other variable to more or less remain same, price inflation or price increase is determined.

Real estate property value is usually estimated using two components, i.e. structure and land. Thus, real estate is not only the structure but also the land price. Structure means housing options and the features that are being provided. Land means the location and the macroeconomic trends that are in play in that particular area. Similarly, the model can be broken into 2 parts. For example, in housing price models, both components for land and components for the structure of the building can be included.

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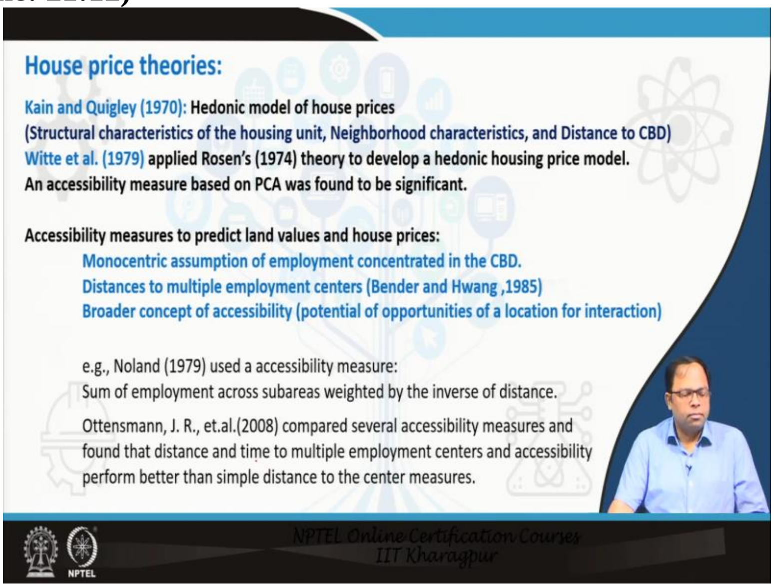

House price theories

House price theories were first initiated by Kain and Quigley. They proposed a hedonic model of house prices in the 1970s. This model included the structural characteristics of the housing unit, neighborhood characteristics, and the distance to the CBD. Witte et al (1979) primarily applied Rosen’s (1974) theory to develop a hedonic housing price model. He introduced an accessibility based measure in the model. He used principal component analysis to determine the factors influencing the land price, and an accessibility based measure was found to be significant in his study.

House price includes the price of structure and land both, whereas land price includes the price of the land only. These prices are guided by its location and could be determined by the accessibility value for that particular location. So, accessibility measures to predict land values and house prices refer to the location characteristics of that particular land parcel.

Many researchers have considered different kinds of assumptions to determine accessibility measures. The first is the monocentric assumption of employment concentration in CBD. So, the city has only one CBD and people go to this CBD for the jobs. The next assumption is of polycentric developments which states that a city does not have a single CBD rather it has multiple employment centers. The distance to multiple employment centers has been also measured in accessibility. Additionally, broader concepts of accessibility (discussed in the previous lecture) are used by many researchers where they consider potential opportunities of a location for interaction. For example, in 1979 Noland used accessibility measures, where the sum of employment across subareas weighted by the inverse of the distance was used. Then Ottensmann compared several accessibility measures and found that distance and time to multiple employment centers and accessibility perform better than simple distance to center measures. So, instead of using one parameter like distance to CBD from a particular plot/house, distance to multiple employment centers would give us better estimates.

Accessibility is the most important part of the land price model.

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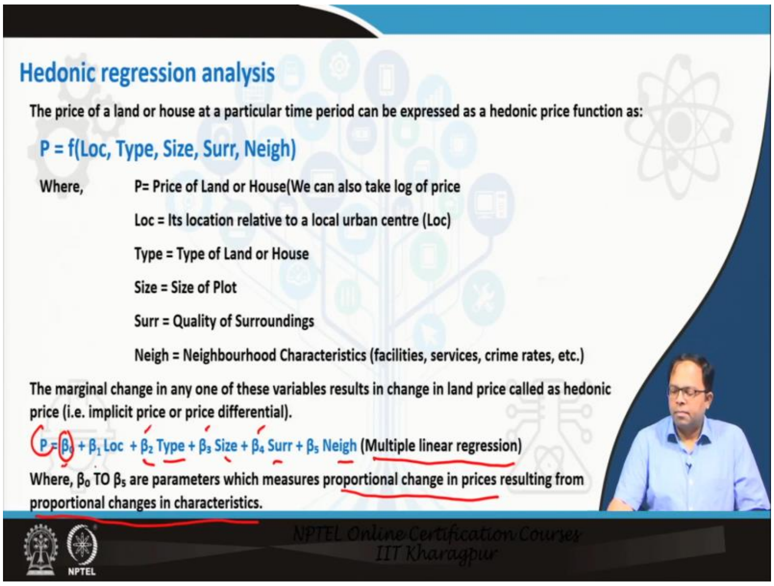

Hedonic regression analysis

Hedonic regression analysis is written in form of Equation 1(eq 1) where, the price of land or a house at a particular time period can be expressed as a hedonic price function.

$$P = f(location, type, size, surrounding, neighborhood) \qquad \ldots..eq\ 1$$

Where, P (the price of land/house) is a function of location (relative to the urban center), type of land or house, size of plot, quality of surroundings, and neighborhood characteristics such as crime rates, facilities etc. The marginal change in any one of these variables results in a change in land price called hedonic price, which is the implicit price or price differential. So, if anyone of these factors is changed, there would be a change in the price of land/house.

The hedonic function can be in linear or nonlinear form. If this function is in linear form as given in eq.2, then multiple linear regression (a statistical technique) is used to estimate the value of coefficients/parameters (β_0, β_1, β_2, β_3,….) corresponding to each variable.

$$P = \beta_0 + \beta_1 * location + \beta_2 * type + \beta_3 * size + \beta_4 * surr + \beta_5 * neigh \qquad \ldots.eq\ 2$$

So, β_0, β_1, β_2, β_3, β_4, and β_5 are all coefficients. These coefficients measure the proportional change in prices resulting from a proportional change in the corresponding known variable. For example, if the value of size changes, then based on the value of β_3, the total price will change. β_0 is the coefficient that takes care of all the variables which are not there in the equation and are unknown to the modeler or unknown to the people who are assessing this. The value of these coefficients is estimated by calibrating this particular model using data that is collected using services like transaction prices for that particular area.

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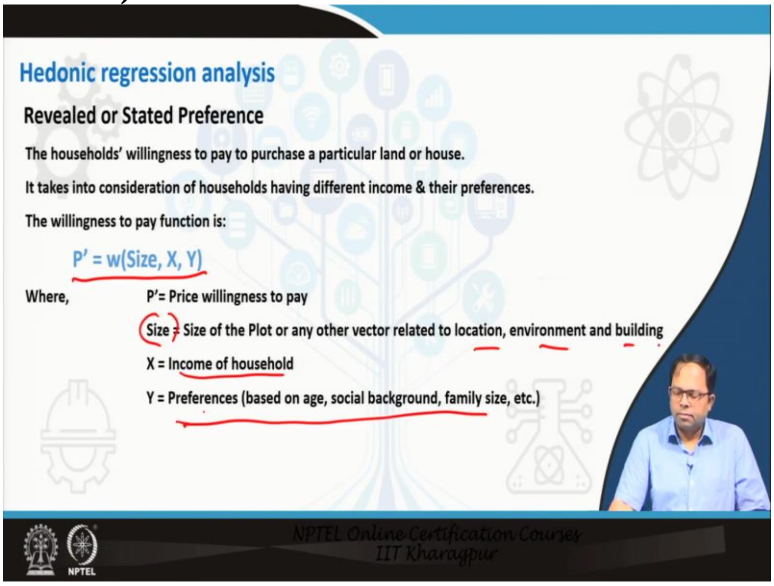

Hedonic models can be developed using revealed or stated preference data. Revealed preference data is related to actual choice. For example, the transaction prices, since the transaction has already taken place. The data related to the price of land/building, the characteristic of that particular location/ building, and so on, are all revealed preference data.

In stated preference kind of model, hypothetical scenarios are considered. People are asked about what kind of prices they are willing to pay for a particular land or a particular building. Even though they have not paid, options are given to them to assess their willingness to buy that land. So, it is a hypothetical measure. When hypothetical measures are considered, there are a lot of options/choices to give, therefore the estimation becomes more robust.

In the stated preference model, the willingness to pay based questionnaire is prepared. The household characteristics like income and preference are also taken into consideration. The willingness to pay functions can be written as;

$$P' = w(size, X, Y) \qquad \text{....eq.3}$$

where P' is the price household belonging to a particular socio-demographic or economic group willing to pay. It is a function of the size of that particular plot/house/location, environment, and the building and can also depend on the income of the household and their preferences based on age, social background and family size. Even though the size is included in the function, this actually incorporates all the properties of that land and building.

This model generally analyzes the kind of effect these parameters have on the house price, or the willingness to pay of individuals.

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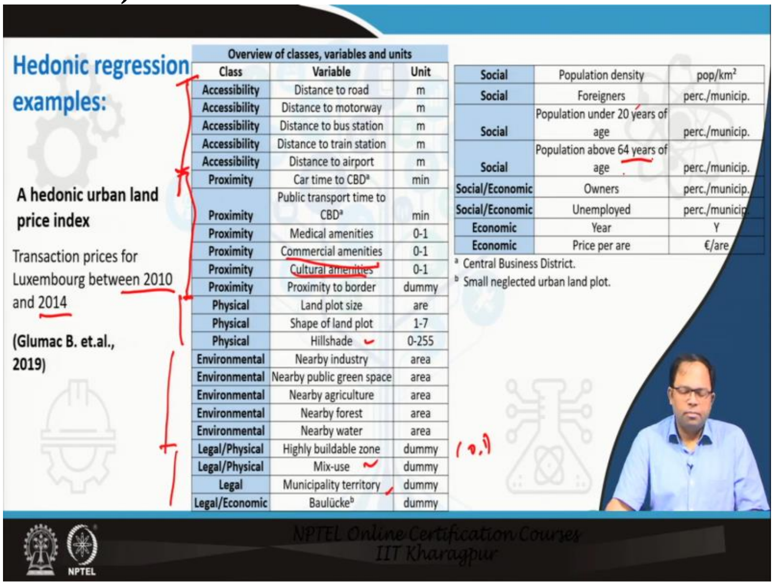

Hedonic regression examples

Glumac et. al. developed a hedonic urban land price index. It is based on transaction prices for Luxembourg between 2010 and 2014. The different parameters used in the model include several accessibility parameters such as distance to road, distance to motorway, distance to bus station, distance to the train station. So, these are different forms of accessibility. Several proximity variables are also included in the model such as car travel time to CBD, public transport travel time to CBD, proximity to cultural activity, and so on. These are monocentric measures. Even though they have used the term proximity, these are different forms of accessibility. The model also considered physical characteristics (e.g. land plot size, shape of the land), and environmental characteristics (e.g. nearby industry, nearby green space, nearby agriculture). In addition to these, legal/physical, legal/economic variables are also included such as, if the land is in a highly buildable zone, if the fare in that particular area is high, if mixed-use is allowed, if the land is within the municipal area or not, and so on. These variables are dummy coded which means that the variable will have only 0 and 1 value, so 0 translates to the absence of a variable, and 1 means the presence of a variable. For example, if it is not a mixed use then it is 0, and if it is mixed use then 1.

Social characteristics of that particular area like population density, number of percentage of foreigners, percentage of people under 20 years, or under 60 years are also introduced in the model. Thus many parameters are used to determine the price of a particular piece of land in an urban area.

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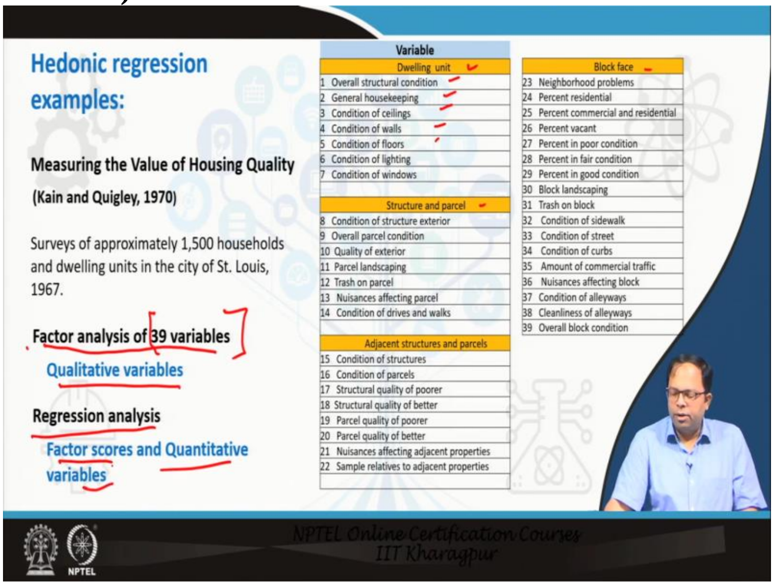

In 1970, Kain and Quigley also measured the value of housing quality. Approximately 1500 households and dwelling units in the city of St. Louis during the year 1967 were surveyed. They included both qualitative variables and quantitative variables in the model. They started with 39 variables and then narrowed these variables into smaller dimensions using factor analysis. It means that they have grouped those variables into factors.

The qualitative parameters like overall structural condition, general housekeeping, condition of ceilings, condition of walls, etc., related to the dwelling unit, then parameters related to the land parcel such as nuisances affecting the parcel, trash on parcel, parcel landscaping, quality of exteriors were considered. The variables like condition of adjacent structures, structural quality of the poorer parcels, nuisances affecting adjacent properties, etc., are related to adjacent structures and parcel. Then another group of parameters called block face includes neighborhood problems, the percentage of residential land use, percentage of commercial and residential, land use, and percentage of vacant plots.

So, parameters like cleanliness, nuisance, or condition of structure etc. are all qualitative parameters. These variables are measured in form of satisfaction ratings and the users are asked to rate these variables on a suitable scale (1-5 or 1-7). Next, these variables were combined into smaller groups using factor analysis. So, each factor (block face, or dwelling unit) was given a particular score, which is a combined score coming out of all these parameters, which is actually used in the regression model. In regression analysis, the scores for each factor were used in addition to the other quantitative variables.

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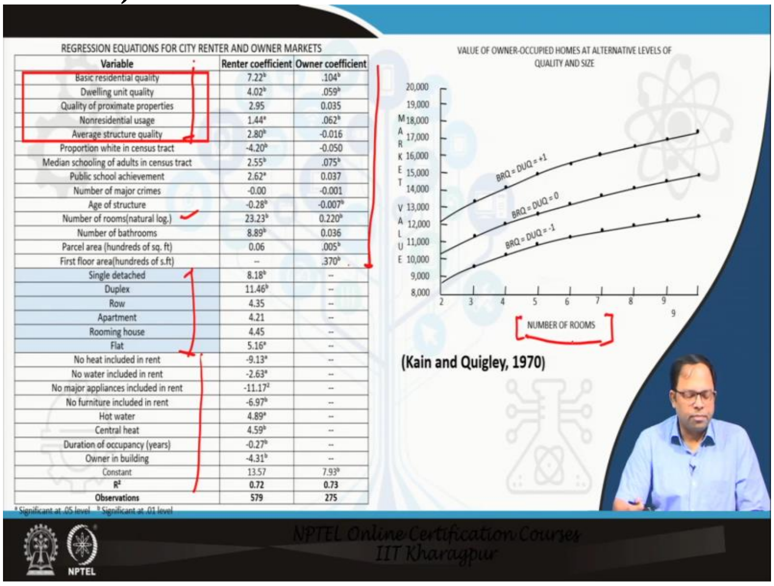

The above slide presents the list of variables, with the factors scores. Basic residential quality, dwelling unit quality, quality of proximate properties, non-residential usage, average structural quality, were the broad factors. The variables like the proportion of white people in that particular census tract, median schooling of adults, education level, public school achievement, school quality, age of structure; are the quantitative factors. The dummy variables are the kind of housing, like single detached (1 or 0), duplex (1 or 0), row (1 or 0), etc.

Separate hedonic regression models were developed for rental prices, as well as for buying prices for the houses in that particular area. The coefficient values are estimated for both the models and are given in the table illustrated in the above slide. Since the beta values (coefficient values) are estimated, the graph could be plotted for the price against one of the variables. These graphs are created to understand the change in the price of land/house against change in the value of a particular variable. For example, the graph (in the slide) is plotted for price and number of rooms. It presents how the increase in the number of rooms, changes the price.

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Hedonic regression limitations

There are certain limitations to the hedonic regression model. These models assume that, all the individuals have perfect knowledge in regards to purchasing a land or house i.e., they have all the information about all houses, all prices and that is why they have chosen that particular house. Data quality is also often an issue in land price models. Since the quality of available data determines the quality of the model.

Existing market conditions may result in a person choosing the next best alternative. For example, the property that an individual wants is not available. So, due to urgency, he may choose the next best alternative. So, regression analysis may give wrong results. Multicollinearity of explanatory variables is also an issue. Since some of the variables introduced in the model may be related to each other. The final limitation is that the model assumes immediate market price adjustment to change in a variable parameter.

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Some of the references are listed in the above image.

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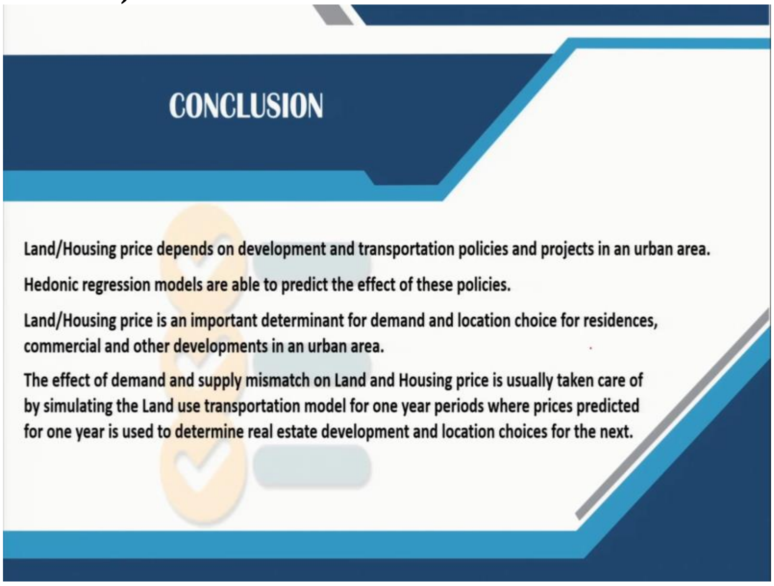

Conclusion

Land price or housing price depends on development and transportation policies and projects in an urban area. Hedonic regression models can predict the effect of these policies. Land/housing price is an important determinant for demand and location choice for residences, commercial and other developments in an urban area. Also, the effect of demand and supply mismatch on land and housing price is usually taken care of by simulating the land use transportation model for 1 year periods where prices predicted for 1 year is used to determine real estate development and location choices for the next. Instead of assuming the equilibrium state for a long term like 5 or 10 years, the land use transportation model is developed by assuming the equilibrium state for a year and then the land prices are determined every year based on the condition and then take it as an input for the location choice and the real estate development model in the next time period. This helps to achieve or simulate the disequilibrium conditions to a certain extent.