Urban Landuse and Transportation Planning
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Lecture - 52
Urban Freight Planning: Demand Modelling

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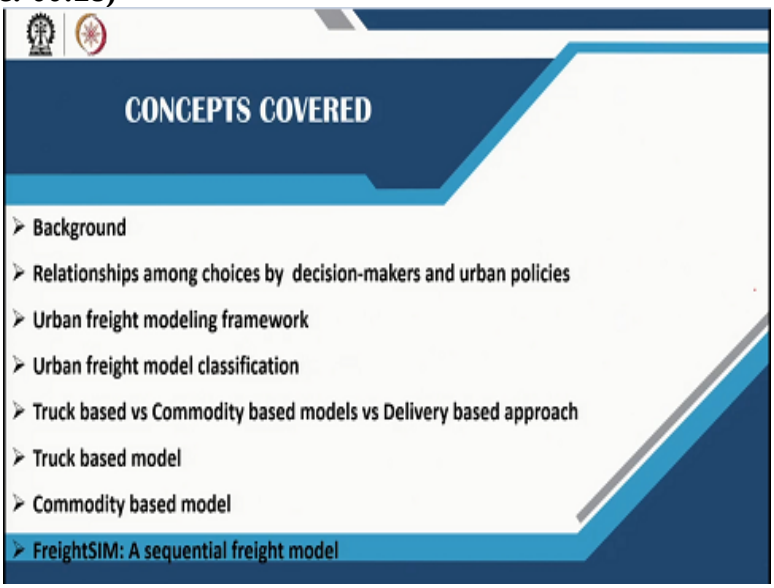

Lecture 52 will cover demand modeling for urban freight planning. The different concepts covered under demand modeling include the relationship among choices made by decision makers and different urban policies, urban freight modeling framework, and urban freight modeling classifications. The truck based approach, the commodity based approach, and the delivery based approach for developing urban freight models are also studied. FreightSIM, which is a sequential commodity based freight model, is studied in detail.

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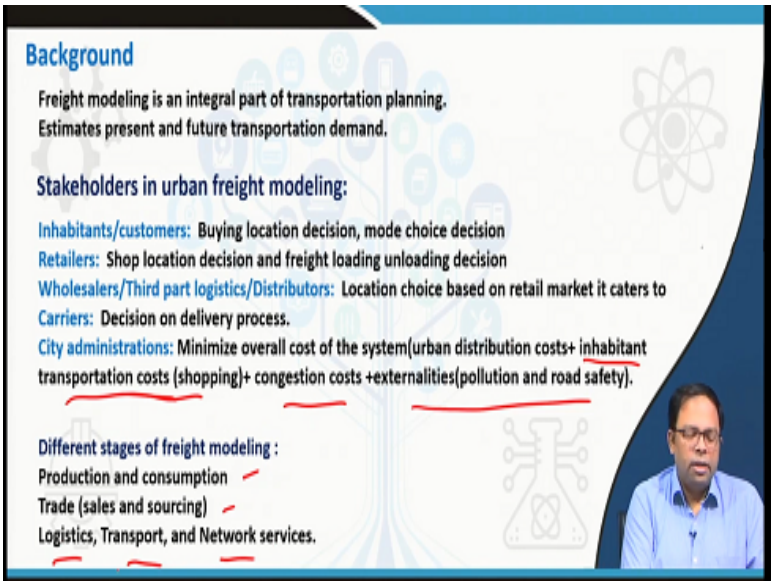

Background

Freight modeling involves different stakeholders. This section explores the different choices made by the various stakeholders. This is similar to the choice made by a household in a residential location choice, or mobility choice, or vehicle ownership choice or mode choice. The inhabitants or customers are the first set of stakeholders. Their buying location decision and mode choice decision sets the ball rolling. This determines the demand for a particular good in an urban area and to maintain that demand supply has to be made to those particular areas of certain goods and commodities. This is how freight is generated. This is followed by the retailers' shop location decision and freight loading unloading decision. Wholesalers/ third party logistics/ distributors cater to the demand based on the retailers' decision. The final freight flows get determined by the carrier's vehicle and route choices, determined by the restrictions laid out by the urban administration. Urban administrators are guided not only by notions of cost minimization, but also by the need to reduce negative externalities on urban areas.

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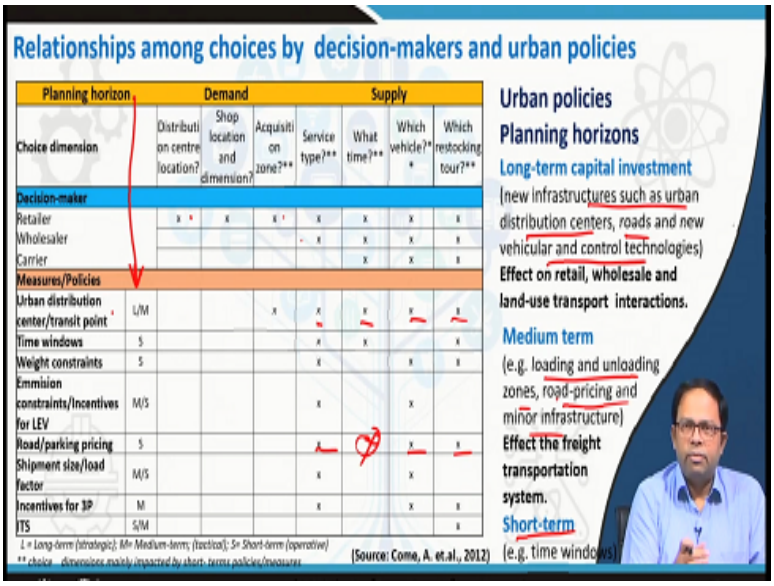

The above slide shows a table from a paper by Comi, A et. al, 2012. This table shows the different choice dimensions, the different decision makers as well as different policies that can be undertaken in an urban area. Policies like time windows, weight constraints, emission constraints, road parking, shipment size, and incentives, influence different stakeholders and they also have a planning horizon. In the long-term horizon, capital investment decisions like locating new infrastructures such as urban distribution centers, roads, and new vehicular and control technologies are made. Medium term decisions involve deciding on loading and unloading zones, road-pricing and minor infrastructure. And in the short-term horizon, decisions involve time windows for freight vehicles, weight constraints on freight vehicles, etc. The table is also a summary of the relationship between a policy and the different stakeholders involved. For example, as can be seen from the table, the shop location and its dimensions are the concern of the retailer, but the type of restocking tour concerns the retailer, the wholesaler as well as the carrier.

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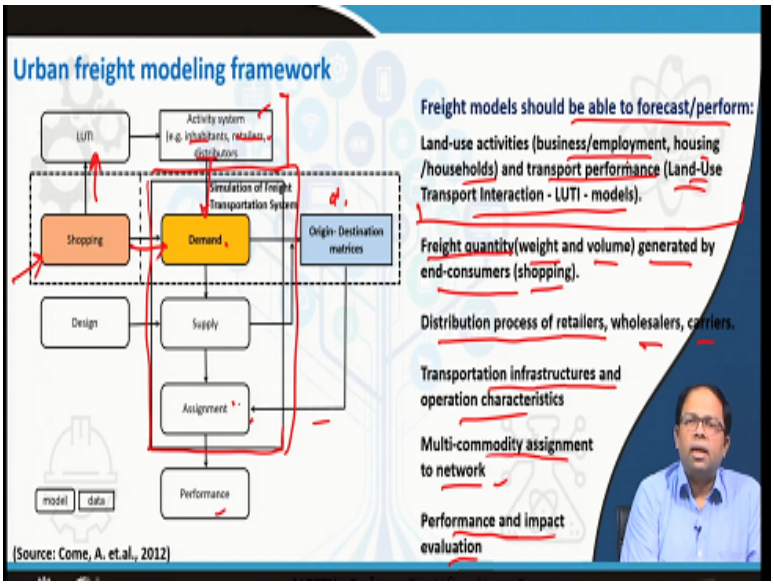

Urban freight modeling framework

A freight model should be able to forecast certain kinds of activities like landuse activities and transport performance. Landuse activities include location choice for business or households. In this way a freight model gets integrated with the land use transportation model. A freight model has to forecast the freight quantity, in terms of volume and weight, generated by the end-consumers through the shopping activities. The process of distribution of this freight volume, from wholesalers to retailers via the carriers, is the next part of the modeling process. This has to include the location choice of warehouses, the vehicle fleet to be used and the type of tour to be undertaken. Once, the process of distribution is determined, the freight model has to perform multi-commodity assignment to networks. This includes assigning freight vehicular flows to an urban road network and assessing how it affects the overall traffic movement, in terms of travel time, link load functions, etc. The final stage in this modeling framework is that of performance and impact evaluation of the plans generated through this process.

To sum up, residential and business location choices generate the demand for shopping. Once the supply is designed to satisfy the demand, origin-destination matrixes are drawn. The commodity flows are converted to vehicular flows and assigned to urban road networks. This is finally followed by evaluation of the plan performance.

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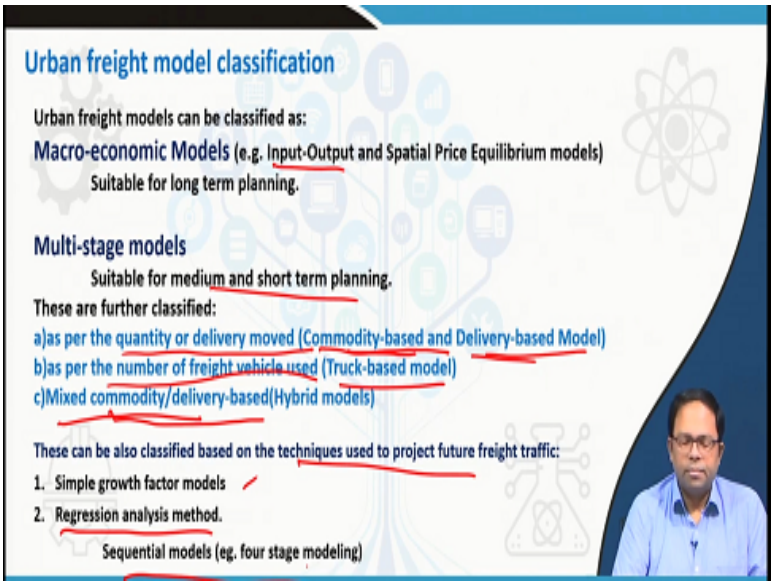

Types of Urban freight model

Urban freight models can be classified into macro-economic and multi-stage models. Macro-economic models are suitable for long-term planning horizons. Input-output model and Spatial price equilibrium model are two such examples. Input-output model determines the interdependence between various sectors of the economy in terms of intermediate and finished goods. This interdependence leads to the generation of freight flows at the regional and national level. As such this model is not suitable at the urban scale. This model is detailed out in the upcoming lectures.

Multi-stage models are another type of urban freight model, suitable for short and medium term planning. These are similar to the four stage models used in passenger transport. These can be further classified into commodity based, delivery based, truck based or hybrid models. Commodity based models predict commodity flows, whereas truck-based models predict freight flows in terms of the number and size of vehicles. Hybrid models combine commodity and truck based models. Freight models can also be classified based on the different techniques used for projecting future freight traffic. Simple growth factor and regression analysis are two such techniques. Growth factor models rely on time series data and as such have low data requirement. But otherwise, it is better to adopt regression analysis.

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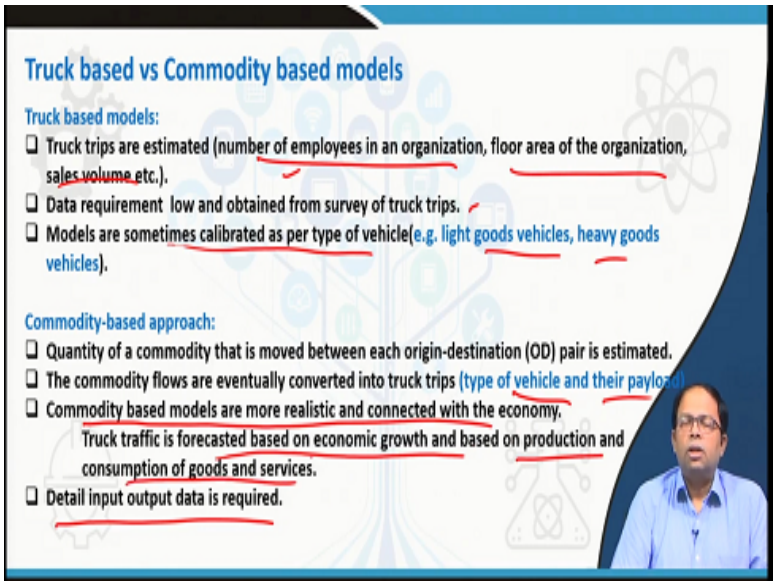

Truck based vs. Commodity based models

Truck based models use regression analysis to predict the number of truck trips generated. The prediction can be based on the number of employees in an organization, floor area of the organization, sales volume, etc. These data can be obtained from a survey of the existing truck trips. The distribution model then generates an origin-destination matrix between zones. The assignment process is then completed taking into account the different vehicle.

In a commodity based approach, the quantity of commodity that is moved between each origin and destination pair is estimated. The commodity flows are eventually converted into truck trips. These models predict the underlying supply and demand, which causes the generation of freight flows. Commodity based models are, therefore, more realistic and connected with the economy.

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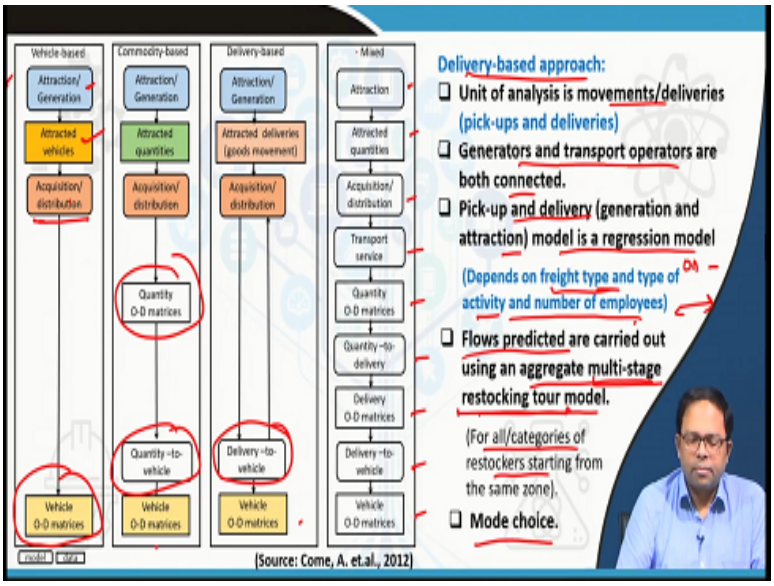

Delivery-based models

In a delivery based model, the unit of analysis is movement. Movements comprise of both pickup and delivery. The model combines a sequence of statistic and descriptive models. The pickup and delivery is predicted using a regression model based on the freight type, activity type and the number of employees in the establishment. These flows are segregated in terms of transport service and journey types, to obtain the vehicle O-D matrices. Flows that are predicted using this model are assigned using an aggregated multistage restocking tour model. Aggregation is done zone wise. The term multistage is a reference to the different kinds of vehicles that will be used for the restocking tour. The delivery based models give an accurate picture of the present scenario, but fail to forecast future demand in the event of policy changes.

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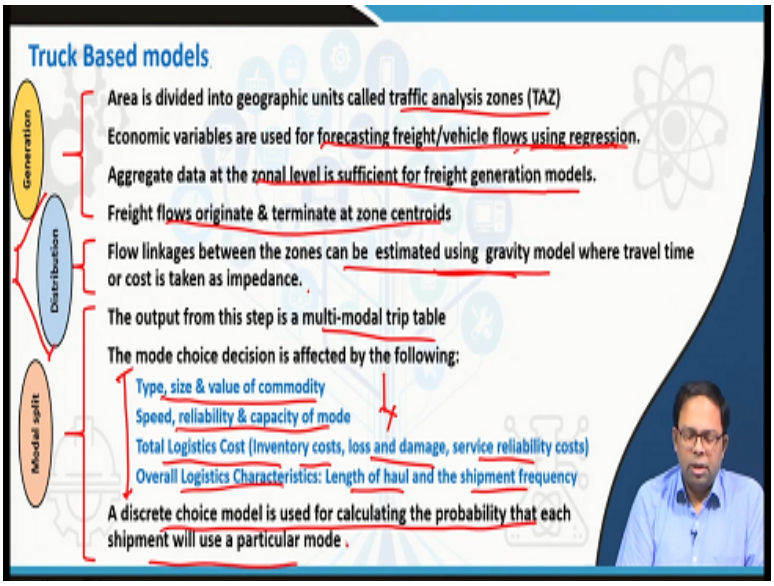

Truck based models

In this type of modeling, the freight vehicle trip is the reference unit. The first stage of the model involves trip generation, followed by trip distribution in the next stage. The area is divided first into geographic units called traffic analysis zones and then economic variables are used for forecasting freight vehicle flow using regression. The aggregate data at the zonal level is sufficient for freight generation models and freight flows originate and terminate at the zone centroids. The flow linkages between zones can be estimated using the gravity model where travel time or cost is taken as impedance. The next stage of the model is the modal split. A discrete choice model gives the probability of the shipment using a particular mode. This probability is determined by the:

- Type, size & value of commodity
- Speed, reliability & capacity of mode
- Total Logistics Cost (Inventory costs, loss and damage, service reliability costs) and
- Overall Logistics Characteristics: Length of haul and the shipment frequency

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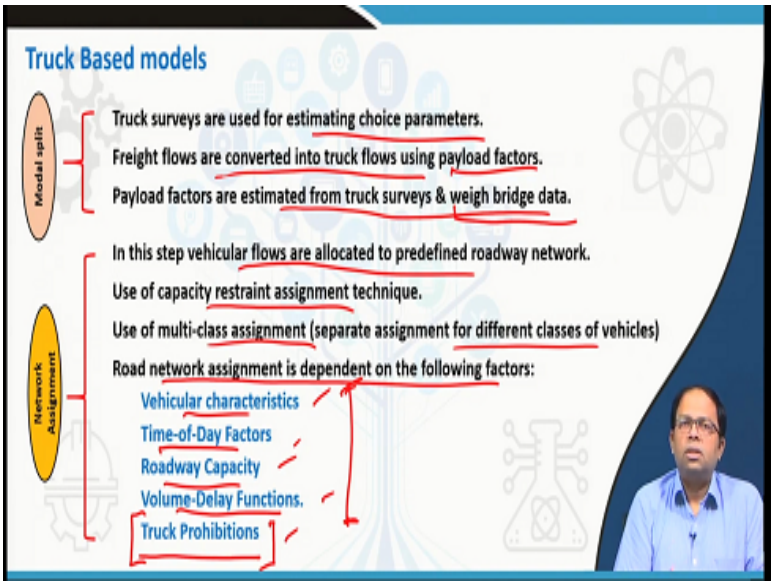

Truck surveys are used for estimating the choice parameters. Once the type and number of vehicles are determined the model proceeds to the stage of network assignment. In this stage, vehicular flows are allocated to predefined roadway network using capacity restraint and multi class assignment technique. These techniques take into consideration the following factors:

- Vehicular characteristics
- Time-of-Day Factors
- Roadway Capacity
- Volume-Delay Functions.
- Truck Prohibitions

Compared to a four stage model for passenger trips, truck prohibition is an added factor that needs to be considered. This is because most urban areas place restrictions on the entry of freight vehicles based on the time of the day, vehicle size, type of corridor, etc.

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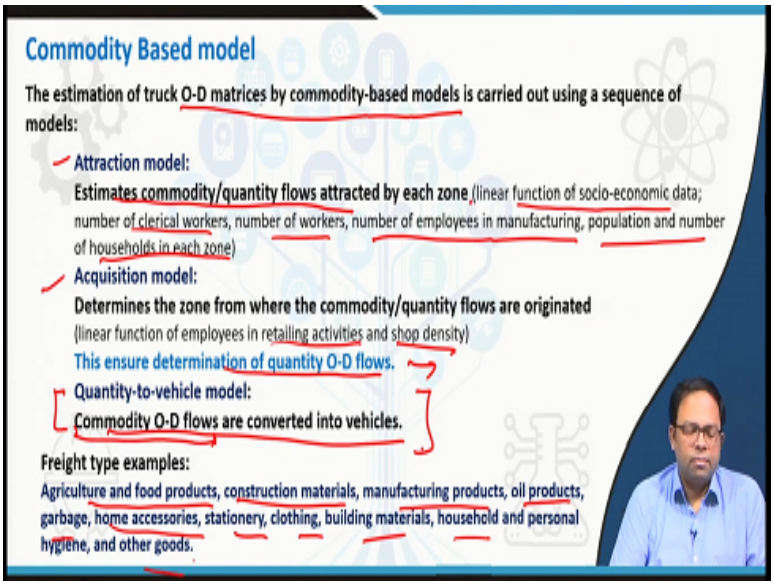

Commodity based modeling

Commodity based models are executed separately for different types of commodities like agro produce, construction materials, waste, etc. It is a sequence of sub-models that include attraction, acquisition and quantity-to-vehicle models. The attraction model estimates the commodity flows attracted by each zone using a linear function of socio-economic data. This can include the number of clerical workers for that zone, number of workers, the number of employees in manufacturing, population and the number of households in each zone. The acquisition model determines the zone from where the commodity flows originate. This is a linear function of employees in retailing activities and the shop density of the zone. The OD flows are determined either by a gravity model or by a destination choice model. Once OD flows are determined, the commodity flow is converted into vehicles flows.

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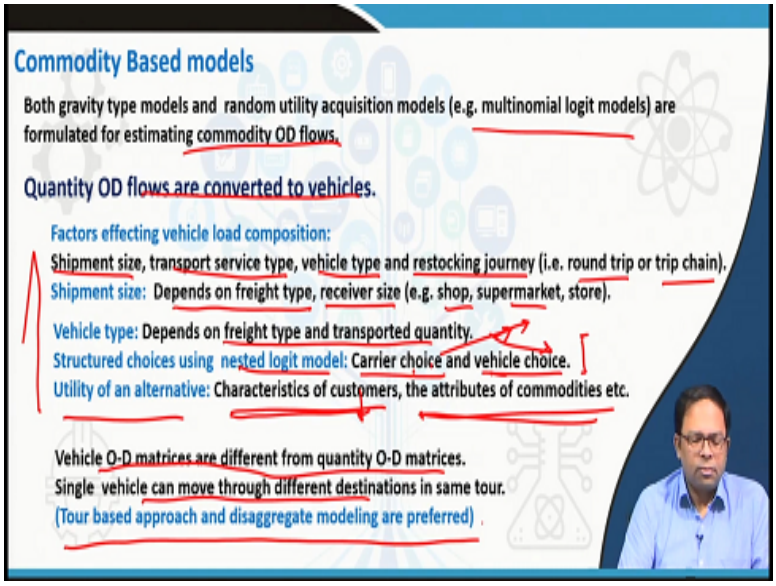

Various factors govern the conversion of commodity flows into vehicle flows. These are shipment size, transport service type and the tour type. Shipment size depends on the freight carrier and the receiver. Vehicle type depends on the quantity of goods to be transported. A nested logit model can also be used for jointly modeling carrier and vehicle choice. Carriers may include private carriers or third party logistics firm. The probability of a private carrier returning empty after a round trip is high compared to a third party logistics firm. Thus, the type of carrier will determine the vehicle tour, which can be a round trip or trip chain involving several trips.

Commodity OD matrices are not the same as the vehicle OD matrices because a vehicle can take a tour and can connect between different drop points in a single tour. So, because and we will add up the tour based approach and disaggregate modeling approaches are preferred in this kind of modeling process.

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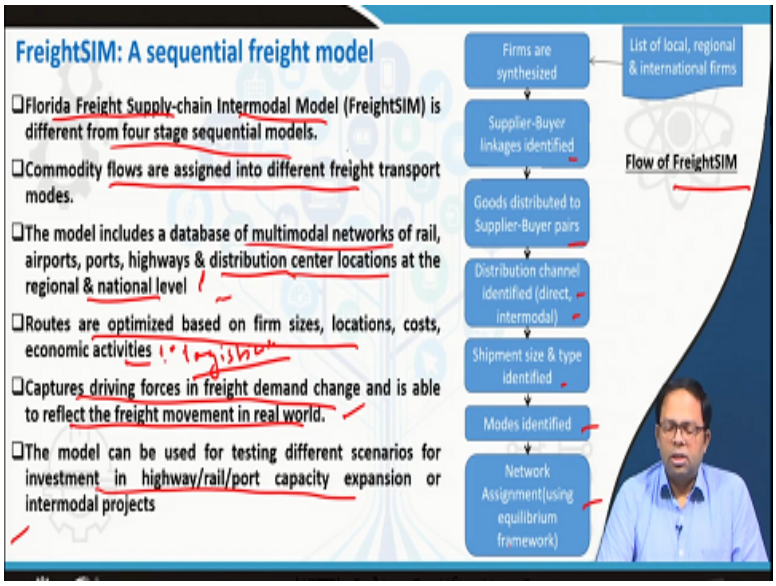

FreightSIM

FreightSIM is a sequential freight model developed for the city of Florida. It is an intermodal commodity based model. The model captures the forces driving freight demand and is able to reflect the freight movement in real world. The model can also be used for testing different scenarios for investment in highways, railways, and ports or for capacity expansion in other intermodal projects. The model is initialized using a database of local, regional and international firms, from which supplier and buyer linkages are identified. Goods distributed to supplier-buyer pairs are assigned to direct or intermodal distribution channels. For this the model includes a database of multimodal networks of rail, airports, ports, highways & distribution center locations at the regional & national level. Once the mode of shipment is identified, network assignment is carried out using the equilibrium framework.

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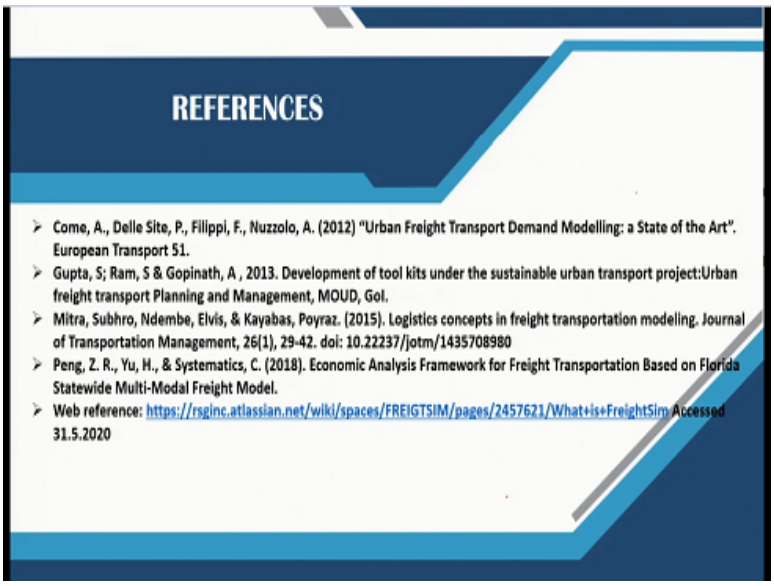

The above slide shows the references used.

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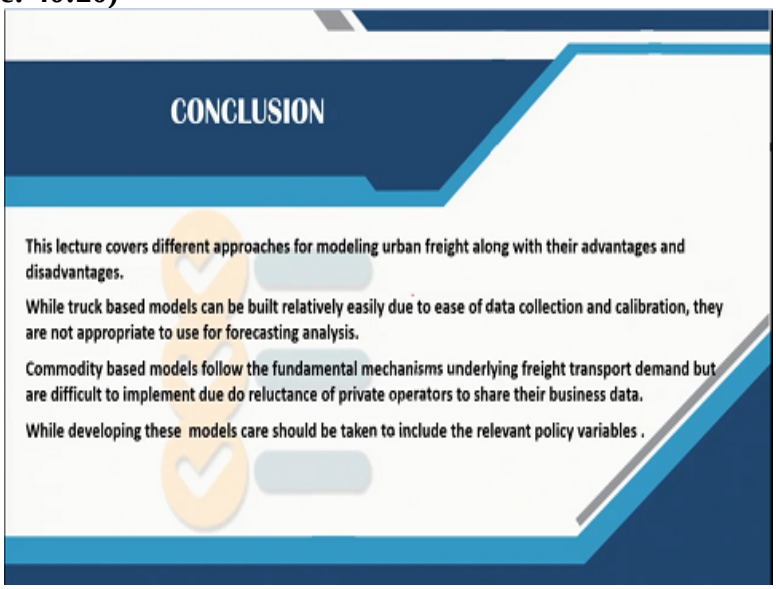

Conclusion

This lecture covered the different approaches for modeling urban freight along with their advantages and disadvantages. While truck these models can be built relatively easily due to ease of data collection and calibration, they are not appropriate to use for forecasting analysis. Commodity based models follow the fundamental mechanisms underlying freight transport demand, but is difficult to implement due to reluctance of private operators to share their business data. So, truck based models are appropriate in the absence of data. While developing these models, care should be taken to include relevant policy variables so that the effects of these policies on freight management are revealed.