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Technical Report Documentation Page

1. Report No. 4080-6	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Activity-Based Travel-Demand Modeling for Metropolitan Areas in Texas: Representation and Analysis Frameworks for Population Updating and Land-Use Forecasting		5. Report Date November, 2004
7. Author(s) Chandra R. Bhat, Jessica Y. Guo, Sivaramakrishnan Srinivasan, Aruna Sivakumar, Abdul Pinjari, and Naveen Eluru		6. Performing Organization Code 8. Performing Organization Report No. 0-4080-6
9. Performing Organization Name and Address Center for Transportation Research The University of Texas at Austin 3208 Red River, Suite 200 Austin, TX 78705-2650		10. Work Unit No. (TRAIS) 11. Contract or Grant No. 0-4080
12. Sponsoring Agency Name and Address Texas Department of Transportation Research and Technology Transfer Section/Construction Division P.O. Box 5080 Austin, TX 78763-5080		13. Type of Report and Period Covered Research Report (9/03-10/04) 14. Sponsoring Agency Code
15. Supplementary Notes Project conducted in cooperation with the Federal Highway Administration.		

16. Abstract

The focus of this report is on the Comprehensive Econometric Microsimulator for Socioeconomics, Land-use, and Transportation System (CEMSELTS), the constituent component of the Second Generation Comprehensive Econometric Microsimulator of Daily Activity-Travel Patterns—CEMDAP-II—that is responsible for updating the current population and urban environment for a future year. This report documents the representation framework and the analysis framework based on which the update of demographic and socioeconomic characteristics of the population will be implemented in CEMSELTS.

17. Key Words Activity-Based Analysis, Population Updating, Land-Use Forecasting, Representation Framework	18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

19. Security Classif. (of report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of pages 42	22. Price

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

ACTIVITY-BASED TRAVEL-DEMAND MODELING FOR METROPOLITAN AREAS IN TEXAS: REPRESENTATION AND ANALYSIS FRAMEWORKS FOR POPULATION UPDATING AND LAND-USE FORECASTING

Chandra R. Bhat
Jessica Y. Guo
Sivaramakrishnan Srinivasan
Aruna Sivakumar
Abdul Pinjari
Naveen Eluru

Research Report 4080-6

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Research Project 0-4080
"Activity-Based Travel-Demand Modeling for Metropolitan Areas in Texas"

Conducted for the

TEXAS DEPARTMENT OF TRANSPORTATION

in cooperation with the

U.S. DEPARTMENT OF TRANSPORTATION
Federal Highway Administration

by the

CENTER FOR TRANSPORTATION RESEARCH
THE UNIVERSITY OF TEXAS AT AUSTIN

November 2004

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Chandra R. Bhat
Research Supervisor

ACKNOWLEDGMENTS

Research performed in cooperation with the Texas Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration

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CHAPTER 1
INTRODUCTION

Conventional wisdom has long indicated that demographics, land use, and transportation are intimately linked (for example, Mitchell and Rapkin 1954; Jones et al. 1983; Jones 1990; Banister 1994; Hanson 1996). While demographics represent the characteristics of decision makers and land use represents the spatial pattern of urban development and activities, transportation serves as the mechanism for spatial interaction between geographically dispersed activity sites. Recognition of the linkages among demographics, land use, and transportation is important for realistic forecasts of travel demand. Conventional methods, however, use aggregate forecasts of socio-demographics and land use to feed into travel models and, consequently, cannot capture the multitude of interactions that arise over space and time among the different decision makers.

Considering the shortcomings of the conventional approach, there has been increasing realization to develop disaggregate, behavioral approaches that capture land-use and travel behavior in an integrated way while accommodating the moderating role of demographic characteristics (Waddell 2001). Development of such a comprehensive behavioral framework would require the integration of activity-based travel models with disaggregate models that capture the population demographic processes, the households' long-term choice behaviors, and the economic markets in which the households act. Specifically, such an integrated land-use transportation modeling system should address three important issues. First, over a long-range, multiyear, forecasting time frame, individuals go through different life-cycle stages and households change in composition. Such demographic processes need to be modeled endogenously (i.e., within the integrated land-use transportation model system) to ensure that the distribution of population attributes (personal and household) are representative at each point of time being modeled and are sufficiently detailed to support the behavioral decision models being used. Second, as the demographic process takes place, individuals may begin/finish schooling, move onto different life-cycle stages, enter/exit the labor market, or change jobs. Similarly, households may decide to own a house as opposed to rent, move to another location or acquire a vehicle. If these longer-term behavior choices concerning the housing and labor market are treated merely as exogenous inputs to the activity-based travel models, then the possibility that households can adjust with combinations of short- and long-term behavior is systematically ignored (Waddell et al. 2001). A significant increase in transport costs, for example, could influence a household to consider adapting with any combination of daily activity and travel patterns, job locations, or residential location. Thus, a framework accounting for this interdependency between short- and long-term behaviors is required to address combinations of land-use and transportation policies. Third, actions of individuals and households take place within the housing, labor, and transportation markets. Interactions between households and other decision makers (such as businesses, institutions, and real estate developers) in these markets ultimately shape the land-use patterns. If the behavior of households is to be captured properly, the behavior of these other actors in the markets must be modeled explicitly.

The overall focus of this research is to develop an activity-based, land-use transportation modeling system called CEMDAP-II (Second Generation Comprehensive Econometric Microsimulator of Daily Activity-Travel Patterns) (Figure 1.1) that addresses the shortcomings of the conventional approaches identified in the previous paragraphs. This comprehensive system takes as input the detailed individual and household socio-demographics and the activity-travel environment for the base year. In addition, the analyst can also specify different policy scenarios for future years. The data is first run through CEMDAP (the activity-travel microsimulator developed as the first part of this research; see Research Reports 4080-1 through 4080-5 for a complete description of this system) to obtain the detailed activity-travel characteristics for each individual. These then feed into a dynamic traffic assignment (DTA) scheme to determine the network link flows and speeds by time of day. The evolution of the population and the urban environment is modeled by the Comprehensive Econometric Microsimulator for Socioeconomics, Land-use, and Transportation System (CEMSELTS). Taking as input the current socio-demographics and activity-travel characteristics, prescribed policy actions, and level of service characteristics obtained from the network assignment component, CEMSELTS provides as output socio-demographic characteristics of the population and the attributes of the activity-travel environment for a time increment into the future (e.g., one year). This information feeds back into the activity-travel simulator to obtain the detailed activity-travel characteristics for the future year. The loop is executed until the link flows and speeds are obtained for the forecast year specified by the analyst. The effects of the prescribed policy actions can then be evaluated based on the simulated network flows and speeds for any year between the base year and the forecast year.

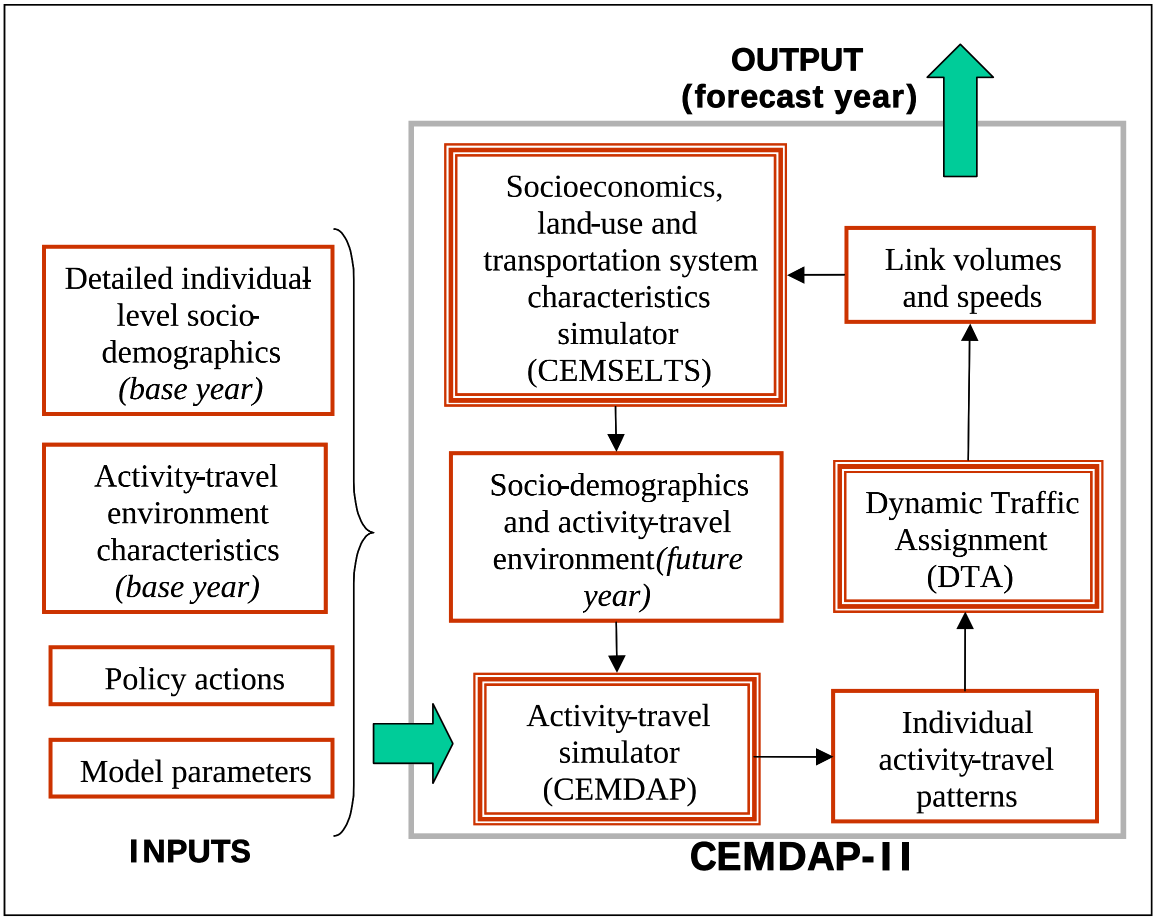

Figure 1.1 The structure of CEMDAP II

Within the overall focus of this research effort, the focus of this report is on CEMSELTS, the constituent component of CEMDAP-II that is responsible for updating the current population and urban environment for a future year. In particular, this report documents the representation framework and the analysis framework based on which the update of demographic and socioeconomic characteristics of the population will be implemented in CEMSELTS. The experience with such demographic and socioeconomic updating methods is relatively limited, at least within the travel-demand forecasting community (Miller 2003). A recent work focusing specifically on simulating demographic evolution for the purposes of travel forecasting is the DEMOS 2000 (Sundararajan and Goulias 2003). Other population updating systems that have been developed in the travel-demand forecasting community (and with varying levels of detail and sophistication) include the micro-analytic integrated demographic accounting system (MIDAS) (Goulias and Kitamura 1996), and micro-analytical simulation of transport employment and residences (MASTER) (Mackett 1990). Earlier land-use transportation modeling systems that focus on modeling certain aspects of the population evolution processes, such as residential relocations and automobile ownership, include TRANUS (de la Barra 1989), MEPLAN (Hunt 1993), URBANSIM (Waddell 2002), and ILUTE (Miller, Hunt, Abraham, and Salvini 2004).

The remainder of the report is organized as follows. Chapter 2 presents an overview of our representation framework and discusses the elementary units whose actions and interactions define the dynamics of the urban system at large. By first discussing the difficulty in modeling the evolution of all the elementary units identified in our representation framework, Chapter 3 identifies the constituent components of the urban environment whose characteristics are most relevant to the overall function of CEMDAP-II. The actions and events that drive the evolution of these urban components are described in detail. Chapter 4 presents the analysis framework we propose for CEMSELTS to model these actions and events. Chapter 5 presents the summary and conclusions.

CHAPTER 2

REPRESENTING THE URBAN ENVIRONMENT

In the traditional trip-based approach to travel-demand modeling, the interaction between travel demand and the urban environment (often referred to as land use) is typically addressed at an aggregate level through the concept of accessibility, which refers to the ease of movement between places. The level of accessibility within a given region is determined by the structure and capacity of the transportation system as well as the land-use pattern. A reduction in the cost of movement (in terms of either money or time) leads to increased accessibility to potential trip destinations and hence increased travel demand. As more interaction occurs, the land-use pattern changes because more trips are generated and relocated to places that become more accessible.

Since the activity-based approach to travel-demand analysis is behaviorally oriented and places the focus on the underlying decisions of individuals that manifest themselves in the aggregate travel patterns, a similar behavioral framework should be adopted to examine the land-use transportation relationship. That is, the demand for activity and travel needs to be integrated with a broader view of the individuals, households, firms, real estate developers, and institutions whose decisions, life events, and interactions with each other drive the evolution of an urban region.

Figure 2.1 depicts our behaviorally oriented representation of the urban environment for the purpose of developing CEMSELTS. As shown in the middle of the diagram, we consider the urban environment as encompassing four interrelated markets:[1] service and amenity, job, housing, and transportation. The actors in these markets are labeled on the two ends of the diagram and include the individuals, households, institutions, firms, and real estate developers.[2] Through their actions and life events (labeled in italics in Figure 2.1), the actors evolve over time and so do the markets that they interact with.

[1] The term "market" is used to represent an action space within which transactions are conducted between consumers and suppliers.
[2] The categorization of the actors is based on their role in the markets and is not mutually exclusive. For example, real estate developers can also be considered as firms, but form a separate category because of their specific role in the housing market

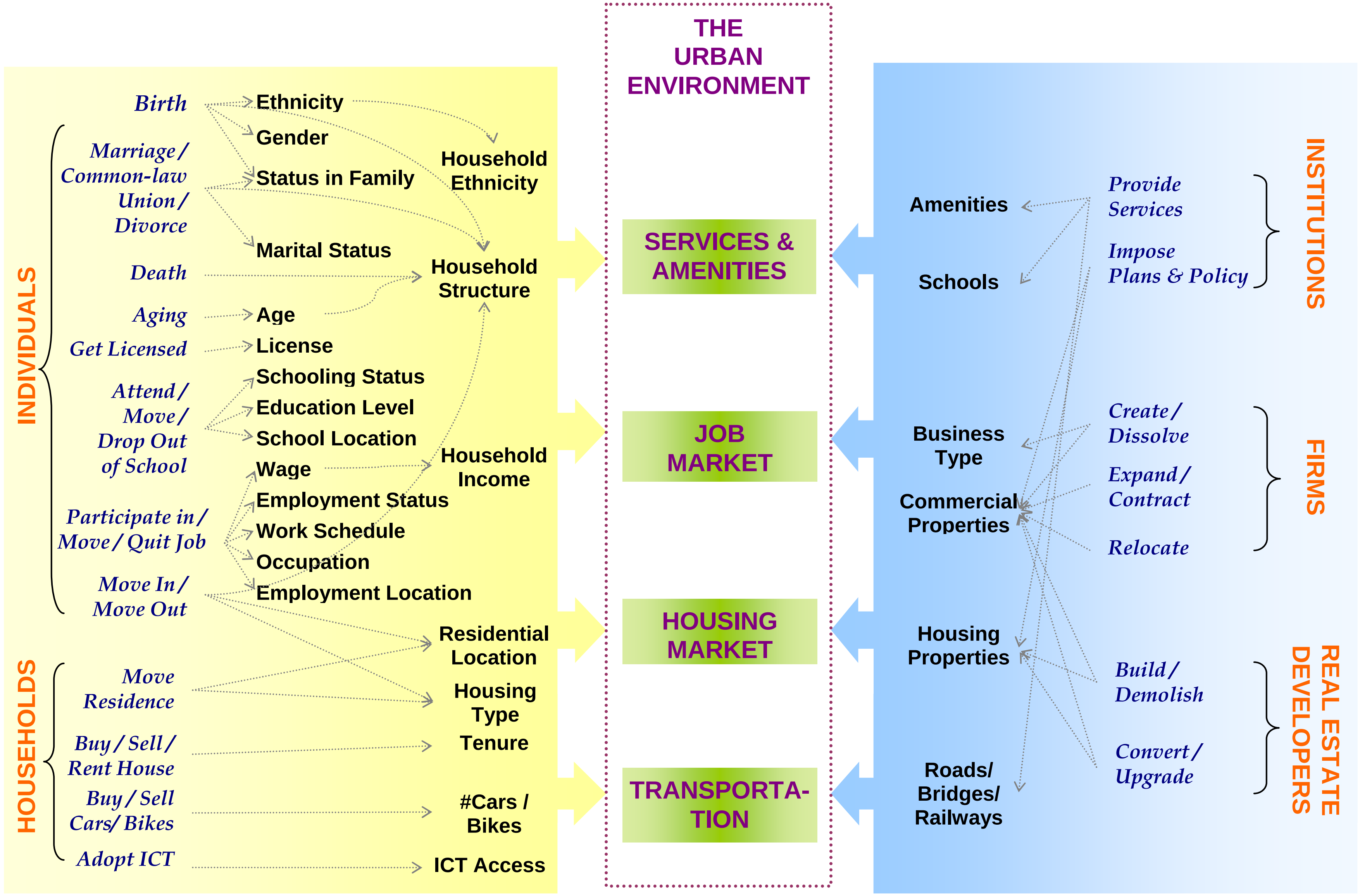

Figure 2.1 The actors shape the urban environment through their actions, life events, and interactions with each other in the markets

The inhabitants of the urban system comprise the first group of actors. The actions or life events of the inhabitants can be broadly classified into individual-level events and household-level events. At the individual level, each person's demographic and socioeconomic characteristics change as she or he undergoes various processes, such as birth, marriage, schooling, and working, and makes various decisions, such as how much education to get or what kind of occupation to be in. As a result of some of these processes and decisions, households are created and/or dissolved. Households are characterized by the aggregate attributes of their constituting members (such as ethnicity composition, family structure, and household income). The state of a household also evolves through household-level events such as residential move or buying a car. Clearly, the individuals and households act as consumers in the real estate, amenity and services, and transportation markets. They also act as suppliers of labor and consumers of jobs.

The second group of actors is real estate developers. Through building, demolishing, converting, and upgrading residential properties, the real estate developers largely determine the housing market supply. They also supply commercial properties for housing businesses and firms, which form the third category of actors. As firms evolve through their creation, dissolution, expansion, contraction, and relocation, their locations and trade types change. This in turn changes the spatial distribution of the job market. It also changes the distribution of sites of non-employment–related activities such as shopping and socializing.

The fourth category of actors that we consider is government institutions. These institutions often play the major role in providing urban infrastructure such as the transportation system and social amenities and services. They also shape the real estate and job markets through interventions in the form of transportation infrastructure investments and urban development policy.

In addition to the interactions among the four groups of actors described in the preceding paragraphs, an urban region may also change because of external factors and forces acting at the higher level. For example, the sustenance of existing jobs and the creation of new jobs depend on not only the supply and demand within an urban area but also the regional and global economy. The population size of an urban area changes not only as birth and death take place, but also as a result of regional migration. These external factors need to be accounted for in any successful urban simulation exercise.

CHAPTER 3

URBAN SIMULATION FOR ACTIVITY-TRAVEL ANALYSIS

Ideally, we would like to consider all the actors identified in Figure 2.1 at the elemental level and explicitly model their actions, events, and interactions with each other. However, the empirical modeling of urban evolution at such a level of detail would not be necessary for the purpose of providing input data to the activity simulator, which only requires data about the land-use and transportation network at the aggregate (zonal) level. Furthermore, to simulate the market behavior at the elemental level would require much detailed data, such as that of the firm and real estate developers, which are typically unavailable in practice. Given these considerations, the implementation of CEMSELTS will focus on the detailed modeling of events and actions—hereafter referred to as processes—of the individuals and households in the system. The processes relating to other groups of actors, namely the institutions, businesses, and real estate developers, will not be modeled explicitly. Rather, the *aggregate* impact of these processes on the amenity and services, job, housing, and transportation markets are either modeled endogenously or considered as exogenous.

Simulating the processes that the population undergoes over time requires taking into consideration the factors contributing to the occurrence of these processes. The occurrence of a process may also trigger the occurrence of a subsequent process. For example, a household buying and relocating to a new home may also trigger the children to move to a different school or the parents to change to a job that is closer to the new home. Below, we describe each of the processes that will be simulated in CEMSELTS and discuss the factors and processes that may increase or decrease the likelihood of a process occurring. Individual-level processes are described in Section 3.1 and household-level processes are described in Section 3.2

3.1. Individual-Level Processes

3.1.1. Birth, aging, and death

Birth, aging, and death are three very fundamental, biologically regulated evolution processes. Birth is one of two processes that increases the population of an urban system (the other process is immigration). Birth is the result of a decision made by a woman and typically depends on her marital status, age, educational attainment, and the number and ages of children in the family. For most women, such decisions are delayed until schooling is completed. Women in common-law unions might be less likely to give birth compared to their married counterparts. Determined at birth are the newborn's gender and ethnicity. These characteristics remain the same throughout the individual's life cycle. When simulating these characteristics for the newborns, we need to consider the aggregate birth rates of the region by gender over time. The birth rates may also differ by ethnicity. This is because people of different ethnicities tend to differ in their exposure to education, level of employment, beliefs relating to marriage and family planning—which are factors influencing birth rates.

All individuals in the urban system undergo the natural and deterministic process of aging. A person's age significantly impacts his or her marital status, childbearing decisions, education, employment status, and choice of residential location. Hence, the aging process can be expected to trigger several individual- and household-level processes.

Death is one of two processes that decreases the population of an urban system (the other process is emigration). Modeling deaths involves consideration of regional mortality rates, which in turn vary by age, gender, race, locality, and public health care practices.

3.1.2. Marriage, common-law union, and divorce

Marriage and common-law union (i.e., cohabiting arrangements) are the processes that are largely responsible for the formation of new family-type households. On the other hand, divorce (the term divorce is used here generically to also include the termination of the common-law union or cohabiting arrangements) is a process that leads to the dissolution of existing family-type households.

For single-persons, common-law unions and marriage are competing events—either one may occur. When simulating the occurrence of such events, we need to take into account the earliest age, as specified by law, at which an individual can enter a common-law union or marriage. Other factors that influence the timing for common-law unions and marriage include gender, ethnicity, pregnancy, employment status, and education. The formation of a new family unit, through marriage or common-law union, has considerable influence on other events. It not only has an impact on such obvious demographic events as childbirth, but also has an important role in migration and labor market events. There is also a possibility of simultaneity in the decisions pertaining to marital status and education/employment status.

For the married and cohabiting couples, the divorce process signals the end of the existence of a family unit. Choices relating to divorce may be impacted by factors such as ethnicity, employment/education levels of the couple, and presence of children. In the event of a divorce, a household unit splits into two units with very different characteristics from the original one. Consequently, divorce could trigger other processes such as residential moves and other housing choices.

3.1.3. Move-in and move-out

Move-in and move-out of adults represent two major processes that result in a change to the structure of existing households and can also lead to the formation of new households. These processes can occur in both family and non-family type households. Specifically, the move-ins can occur in predominantly two types of settings: (1) move in of a new roommate, and (2) the return back home of a young adult. Similarly, move-outs also occur predominantly in two types of settings: (1) move out of a roommate, and (2) move out of an adult from the parental home. Schooling and employment decisions can be expected to be very significant determinants of triggering the move-in and move-out processes.

3.1.4. Get licensed

Owning a driver's license is an important explanatory variable in modeling one's activity-travel pattern. The possession of a driver's license by an individual depends upon age, presence of vehicles in the household, and his or her ability to drive. It is generally the case that almost all eligible persons in the age group 16 to 65 years tend to have driving licenses. Children and persons below 16 years of age do not possess drivers' licenses, while elderly and disabled persons may or may not possess drivers' licenses depending on their disability level, health status, and age.

3.1.5. Schooling

For most children, schooling begins at the age of six. Upon entering a school, an individual does not leave until one of the following competing events occurs: graduation, dropout, or move to a different school because of residential relocation. The occurrence of one of these events may be impacted by factors such as age, gender, ethnicity, residential location, etc. The schooling-related decisions of adults can be expected to be significantly different from those of children. Upon graduation (from high school or other higher-degree programs), adults may consider further education either immediately or after a period of wait time. The probabilities of these events depend on the gender, age, location of residence, and educational history of the individual. Further, adults can also be expected to make schooling decisions simultaneously with the employment decisions.

3.1.6. Employment

The participation of household members in the labor market is important in the context of urban environment evolution for two reasons. First, individuals supply their time and skills in the labor market in exchange for wages, which form the major source of income used to pay for housing and other goods and services. Second, work represents the most frequent destination of travel other than home and, therefore, plays an important role in determining an individual's daily activity and travel pattern.

One could view employment status as a choice among not working, full-time work, part-time work, self-employment, or flexible forms of contract labor. The decision depends on the set of employment opportunities, which are influenced by the individual's education, training, skills, experience, and choice of occupation. Certain occupations are more generic and low wage but lead to more opportunities and lower risk of unemployment; other occupations are more specialized and high paying but involve limited opportunities and location choices. Individuals make labor supply decisions by comparing potential wages against job-related costs such as commute costs, day care costs, opportunity costs such as lost welfare benefits, and the value of leisure time. The potential wages of adults is in turn impacted by factors such as education, employment, tenure of job, location, and occupation category.

There are several dimensions to the timing of one's job in the market, including length (the number of hours that a job demands), structure (the part of the day and week in which the individual works), and flexibility (the degree of employee control over variation in his or her work hours). These key dimensions affect not only a firm's profitability but also the amount and ordering of employees' time for domestic and personal activities. The variation between individuals' weekly work hours is primarily attributed to the status of their employment, that is, part-time or full time. Race is one of the most significant determining factors of workers' actual and preferred work hours. Job and family characteristics are determining factors of work hour structure. Race and usual length of a workweek are significant factor in influencing flexibility in work schedule.

The choice of work location is closely related to the choice of residential location. Efficient commuting, resulting from working closer to home, is an important factor. However, workers whose work is more specialized have a lower number of suitable jobs in a given geographical area and tend to adopt a wider job search pattern. Furthermore, gender, wage maximization, race, and skill level are also contributing factors.

3.2. Household-level Processes

3.2.1. Residential move

Residential relocation is one of the most important decisions that a household makes during the course of its lifetime and also has a very profound impact on all members of the household. The move can be intra-urban or regional (i.e., immigration and emigration).

Having a child, marriage, and divorce are triggers of residential relocation. In addition to the stage of the life cycle, other factors that are expected to influence the mobility choice include household income, number of full-time workers, and number of years each worker has held his or her current job. Older or low-income households are less likely to move. The presence of children might stimulate or inhibit a move, depending on whether the current residential neighborhood is suitable for children. The presence of multiple workers in a household may affect mobility in either way. On the one hand, more workers in a household implies a higher likelihood that one of them will change jobs, resulting in a higher probability of relocation. On the other hand, because of the ripple effects of relocation on all workers, one could argue that a multiworker household will have a lower propensity to relocate. While the workplace of the primary worker imposes the dominant locational constraint, the secondary worker's place of employment and labor force attachment constitute additional constraints. The length of employment represents the other link between work and residence. The longer the employment, the less likely a household is to move. The effect of employment may differ for males and females.

Almost simultaneously with the event of residential move, a household needs to decide the tenure, the dwelling type, and the location.

Housing tenure choice depends largely on the relative costs of rental and owner-occupied housing, particularly the effect of the tax system on relative costs and housing demand. People who want better-quality housing are more likely to own. Thus, wealthier households can afford to buy housing and become homeowners more easily than can low-income households. Once the decision to rent is made, either on the basis of preference or of necessity, renters have fewer choices and less flexibility with regard to location and housing quality compared to homeowners. Family background also has an important influence on tenure choice. People whose parents are homeowners are more likely to become homeowners themselves, reflecting either the transfer of resources from parents to their adult children or the influence of the parents' attitudes toward home ownership. Demographic factors such as marital status, presence of children and age of household head are also positively related to home ownership.

Dwelling considerations include size and quality. Size can be measured in terms of floor plan, number of rooms, number of bathrooms, etc. Quality can be measured by number of units in the building (house versus apartment), age of building, architectural style, and facilities available (e.g., swimming pool). The preference for dwellings is expected to differ for different households and is determined by household taste and needs.

The decision of residential location plays a significant role in the modeling of activity-travel patterns of individuals. The location of a household depends on factors like the job of the main breadwinner, school locations of children, perceived quality of life in the locality, etc. Households with young children would prefer to stay in sprawling houses away from the city. But small households with one to two members might prefer to stay close to the city downtown for social contact. The location choice depends on the price of housing, the distance to the workplace, socioeconomic status, stage of life cycle, ethnicity, quality of nearby schools, and proximity of parks. Other hard to quantify factors that also affect location choice include ethnic preferences, racial biases, family loyalty to specific neighborhoods, and preferences for architectural styles. Social status also has a significant role in the households' decision-making process, especially in societies with a strong stratified structure.

3.2.2. Automobile/ bicycle holdings

Car and bike ownership is a critical intermediate link between household location choices and subsequent activity-travel decisions. For instance, households who choose to live and/or work in low-density suburban areas will of necessity (if not also preference) be "auto oriented," tend to have a high auto ownership level, and make most, if not all, trips of any significant distance by auto. Households living in pedestrian-friendly areas are more likely to own and travel on a bike.

In deciding how many autos or bikes to own, the household has a choice of zero, one, two, and so on. The level of ownership changes through selling, buying or trading-in existing vehicles. The decision is generally based on the affordability (reflected by cost and income) and the usefulness to the household of having vehicles (as reflected by household size, number of workers, or availability of alternative mode). In deciding the type of autos to own, the choice is among all the available makes, models, and vintages of automobiles. In this case, the decision is influenced by factors such as the purchase price, fuel economy, and capacity for passengers, as well as luggage.

3.2.3. ICT adoption

The household's decisions relating to the adoption of information and communication technologies (ICT) relate to ownership of phones, cell phones, computers, and Internet connectivity. These choices are increasingly becoming important determinants of daily activity- and travel behavior. The adoption of these in-home ICTs can be impacted by factors such as household structure, education and employment levels, and automobile ownership.

CHAPTER 4
THE ANALYSIS FRAMEWORK

This chapter describes the analysis framework developed for the modeling of the individual- and household-level processes (all these processes are collectively referred to as the "population updating" process). The important processes or events relevant in this context have been identified and discussed in detail in the previous chapters. This chapter describes our approach to integrate the modeling of all these different processes into a comprehensive analysis framework. Prior to describing our analysis framework, we would like to point out that the detailed empirical modeling of such a population updating process is complicated by at least two major factors: first, there is a relative lack of theory to comprehensively describe these complex and interdependent processes. Second, the availability of data is limited, and when available, data is often at aggregate levels and not at the detailed household level as is warranted by microsimulation-based modeling approaches. Given these major issues, the analysis framework presented here seeks to systematically and comprehensively model the population updating process to the greatest detail possible.

4.1. Overview of the Analysis Framework

The analysis framework developed for the modeling of the individual- and household-level processes comprises two major model systems (Figure 4.1): (1) the migration model system, and (2) the demographic evolution and long term choices model system. The **migration model system** comprises models that describe the movement of existing households out of the study region (i.e., emigration) and the movement of new households and individuals into the study region (i.e., immigration). This strategic positioning of the migration models at the highest level is motivated by possible implementation benefits. Specifically, identification of households moving out of the study region as the first step during implementation could help achieve savings in processing time and resources, as it is not necessary to determine further any other changes to the characteristics of this population. The migration model system is discussed in more detail in Section 4.3. The **demographic evolution and the long-term choices model system** focus on describing the changes to the population that continue to remain in the study area. This model system in turn comprises three major components: (1) individual-level evolution and choices models (modeling births, deaths, schooling, employment, etc.) (2) household formation models (modeling marriage, divorce, move-ins, and move-outs), and (3) household-level long-term choices models (modeling residential moves, automobile ownership, etc.). These are discussed in more detail in Section 4.4 Given the detailed (disaggregate) characteristics of the base-year population, together these two model systems completely determine the future-year population characteristics by modeling the changes to all relevant attributes of the households and individuals.

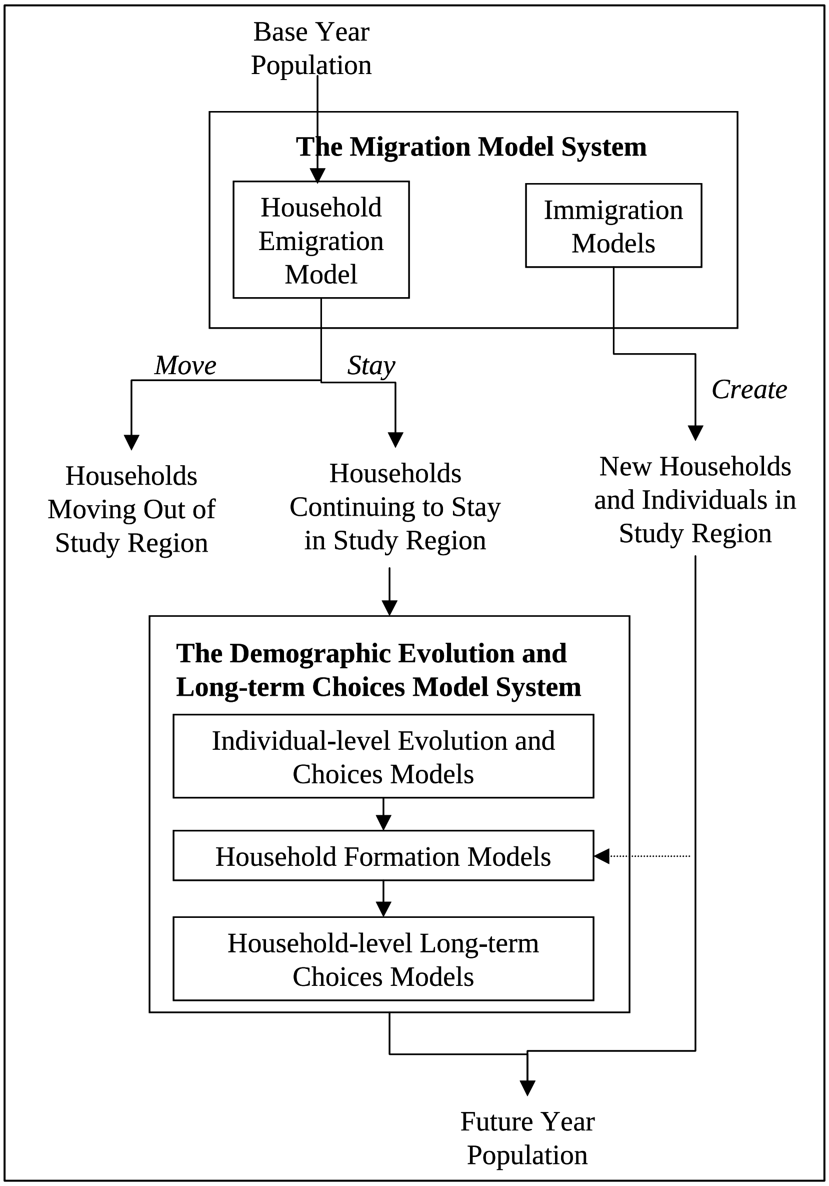

Figure 4.1 Overview of the analysis framework

4.2. The Migration Model System

As described in the previous section, the migration model system includes models for both emigration and immigration (Figure 4.1). The household emigration model determines the likelihood that a household will move out of the study region as against continuing to stay in the same region. Note that this model is focused on modeling the move of the entire household. In addition, it is also possible that one or more individuals of the household will move out alone and the others remain. The household formation models capture such transitions (see Section 4.4.2 for a discussion on household formation models).

Unlike emigration, modeling immigration comprises several models to determine the characteristics of the population moving into the study region. These models determine the different aggregate characteristics (such as age, gender, ethnicity, household composition, education level, automobile ownership) of the incoming population. During implementation, these models are used to synthesize "new" individuals and households to be added to the study area. Thus, all the characteristics of the immigrant population for the forecast year are completely determined and hence this population is not subjected to the demographic evolution and the long-term choices model system (see Figure 4.1**)**. However, the immigrant population, in addition to the existing population, can also serve as candidates for new household formations via marriage and move-ins (household formation models are discussed in Section 4.4.2). Hence, while modeling immigration, it is useful to distinguish between immigration of entire households versus immigration of individuals into existing households in the study region (for example, by marriage or as roommates). This distinction determines the extent of disaggregate, household-level interactions of this immigrant population with the existing population of the study area and these interactions become important considerations during implementation of the models in forecasting. The ability to distinguish between migrations of individuals versus entire households into the area would be determined based on the availability of data to model the immigration process.

4.3. The Demographic Evolution and Long-Term Choices Model System

The demographic evolution and the long-term choices model system determine disaggregate, individual- and household-level changes to the population that continue to stay in the study area. As already identified in Figure 4.1, this model system is further broken down into three main components. Each of these components is discussed in Sections 4.4.1, 4.4.2, and 4.4.3 below. It is important to note here that the sequencing of the modeling of the different processes is intended as a systematic approach to make the modeling of a large number of potentially interrelated processes analytically tractable.

4.3.1. Individual-Level Evolution and Choices Models

This component of the analysis framework (Figure 4.2) comprises a suite of models for describing individual-level evolution processes such as aging, deaths, and births; the personal mobility-related choice of obtaining a driver's license; and long-term choices relating to schooling and employment.

The first demographic evolution process modeled is aging. Aging, unlike all other processes discussed in this chapter, is a deterministic process. Hence, a simple counter (rather than a probabilistic choice model) is adequate to implement the aging process. In addition to the physical aging of the individuals, it is also essential to track other aging processes such as length of stay in a housing unit, length of stay in marital status, length of stay in school or employment.

Mortality is the next individual-level evolution process modeled within our analysis framework. This model determines the likelihood of the death of an individual. In addition, the model also prescribes an upper-limit cutoff point on the age beyond which individuals are assumed not to live. During implementation, an individual predicted to die, based on this model, is removed from the system and is subjected to no further processing. It is possible that the death of one or more individuals in a household may result in a household composed only of children (individuals 15 years and younger are classified as children and the rest as adults). A secondary model will be developed to transfer the children to other households with one or more adults.

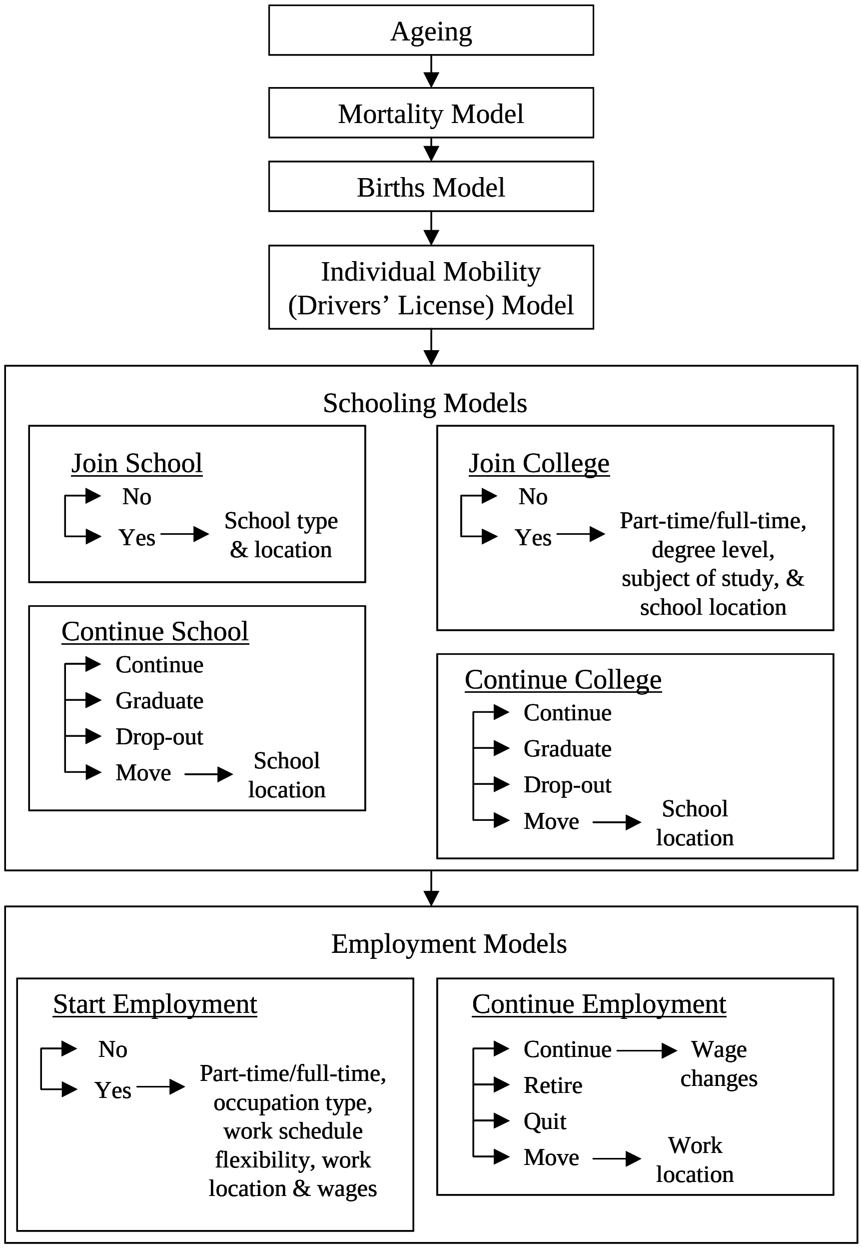

Figure 4.2 Individual-level evolution and choices models

Birth is the final individual-level evolution process modeled and is applicable for adult women who are married or cohabiting. (In our analysis, we classify the marital status of adults to be either single, cohabiting, married, or widowed.) This model determines the number of children born by gender. During implementation for forecasting, this model determines the number of new individuals to be synthesized and added to the household.

The next three model-systems focus on long-term choices made by individuals about mobility, schooling, and employment. The individual-level choice about mobility relates to obtaining and maintaining a valid driver's license. (Note that automobile purchase decisions also relate to mobility, but these are viewed as household decisions and are discussed in Section 4.4.3.) Correspondingly, the following two models capture the individual mobility decisions: (1) model for the decision to obtain a driver's license (this model is particularly focused on children turning sixteen), and (2) model for the decision to maintain a valid driver's license. In the absence of data to empirically estimate the second model, it might be safely assumed that, once obtained, all adults maintain a valid license.

Separate models for schooling-related choices are estimated for children and adults, considering that the primary and secondary schooling-related choices of children could be very different from the postsecondary or college-level schooling choices of adults. The schooling decisions of children are determined using two models. The **join school** model determines the likelihood of nonstudents starting to attend school. For those choosing to attend school, the model also determines the school type (i.e., primary school, middle school, or high school) and the school location. The choice of school type might be largely dictated by age of the child, and in-turn determines the normal length of stay at the school and candidate school locations. The **continue-school** model is applicable for children who currently are students and adults who are in high school. This model determines whether the student continues at the same school or not. Termination of attendance at a school may be a result of graduation, dropout, or move to another school. Hence, the continue-school model determines the likelihood of the occurrence of one of the four possible outcomes identified above. This model will also include an upper-end cutoff to terminate school attendance.

Analogous to the models for children, schooling models for adults (who are high school graduates) also comprise two main components: the **join-college** model for nonstudents and the **continue-college** model for current students. The first model for nonstudents determines whether or not an adult chooses to pursue postsecondary education. For those choosing to undertake higher-level studies, the model determines (1) whether the schooling is to be part-time or full time; (2) the degree level (bachelors, masters, or doctoral); (3) the subject of study (such as engineering, medicine, arts, sciences, law, etc.); and (4) the school location. The first three choices could determine the length of stay at school, candidate school locations, and subsequently, also influence the employment-related choices. In modeling the choice of school location, adults can choose to attend schools outside the study area (unlike in the case of school location choice of children). The second model (i.e., the continue-college model) is analogous to the continue-school model for the children. This model determines one of four possible outcomes for persons already in college: continue attendance, graduate, dropout, or move to another school. This model will also include an upper-end cutoff to terminate school attendance.

The final individual-level, long-term choices models focus on the employment-related choices of the adults (children cannot be employed). As in the case of schooling models, modeling employment-related choices also requires that we distinguish the choices of unemployed persons from the choices of those who are employed. Correspondingly, we identify the following two major model systems: the **start-employment** model and the **continue-employment** model. The start-employment model determines whether or not a currently unemployed adult starts working during the year. For those choosing to work, the model determines (1) whether the work is to be part-time or full time; (2) the occupation type (for example, basic industry, retail industry, or service industry); (3) work schedule flexibility; (4) work location; and (5) wages. The second major employment-related model system (i.e., the continue-employment model) determines the continuation or termination of work of the employed person in his or her current employment location. The termination of employment at the current location may be a consequence of one of the following: retirement, quitting job, or switching jobs. Thus, the continue-employment model determines one of four possible outcomes (i.e., continue, retire, quit, or move) for employed persons. Subsequent to modeling these choices, secondary models determine the changes to work characteristics (especially wages) for persons continuing to work and the new employment characteristics for persons choosing to switch jobs. As in the case of schooling models, the continue-employment model will also include an upper-end cutoff to terminate the employment. A very important facet to be addressed by the models focusing on employment-related choices are the interdependencies in these decisions across household members. Based on further analysis, we will prescribe an appropriate sequence for modeling the employment-related choices when multiple adults are present in the household.

4.3.2. Household Formation Models

The next major component in the overall analysis framework comprises models for household formation (Figure 4.2). We identify four processes that lead to formation of new households: (1) marriage/cohabitation; (2) divorce; (3) move-ins; and (4) move-outs. Each of these is discussed subsequently in detail.

The marriage/cohabitation models describe the decision of single adults to marry or enter a cohabiting arrangement (i.e., common-law union) with another single adult and consequently form a new household. These decisions are modeled using a set of three models. The first model, the **marital-choice** model, determines the choice of single individuals to stay single as opposed to marrying or entering a cohabiting arrangement. The second model, the **spousal/partner characteristics** model, determines the characteristics of the spouse/partner that an individual wishes to marry/cohabit with. Finally, the third model, the **new family residence** model, determines whether the individual continues to live at the same residence after marriage, moves to the spouse's residence, or moves to a completely new residential unit. During implementation of these models for forecasting, the marital-choice model is run for all single adults in the population to identify the individuals who are likely to marry or choose to cohabit. Subsequently, the spousal characteristics models are used to match these individuals (i.e., those who choose to marry or cohabit) with their spouses and partners and the new family residence models are used to locate these newly formed families appropriately.

The divorce models describe the dissolution of existing households as a consequence of a divorce between married couples (or because of the termination of cohabiting arrangements) and the subsequent formation of newer households. These decisions are modeled using four models. First, the **marriage dissolution** model determines the likelihood that a marriage will end in divorce or a cohabiting arrangement will terminate. The next three models describe the subsequent formation of the new households as a consequence of a divorce (or termination of cohabitation). The **child custody** model determines which of the parents gets custody of the child(ren). The **resource allocation** model determines how the collective resources of the family (house, wealth, automobiles, etc.) are distributed between the couple, and finally, the **individual residence** model determines the new residential choices of the two separating adults (one of the adults may remain in the original household whereas the other moves out, or both can move out from the original home).

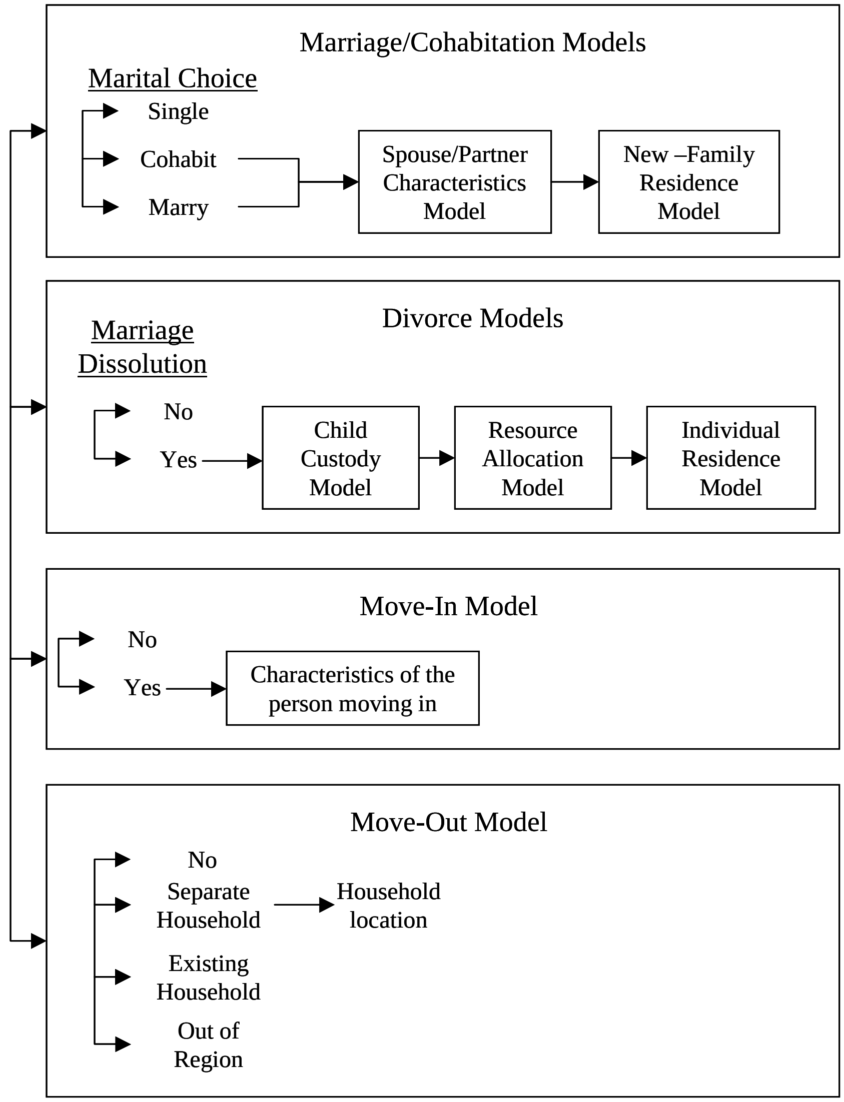

Figure 4.3 Household formation models

Move-in and move-out of adults represent the two other major processes, which can result in the formation of new households. However, these processes do not change the marital status of the individuals (as does the marriage/cohabitation and divorce models). The move-ins can occur predominantly in two types of settings: move in of a new roommate and the return back home of a young adult. In each case, the move-in model determines the characteristics of the adult who is to move into the household conditional on an adult being predicted to move into the said household. As in the case of move-ins, the move-outs also occur predominantly in two types of settings: move out of a roommate and move out of an adult from the parental home. For the appropriate types of households, the move-out model determines the likelihood that an adult will move out and his or her new household location is conditional on choosing to move out. A person moving out can form a new independent household within the study region, join an existing household in the study region, or move out of the study area. During implementation, the move-in and move-out models will be applied to the appropriate subpopulation and based on the predicted choices of moves; the individuals will be transferred from one household to another, thereby creating new households.

4.3.3. Household-Level Choices Models

The final set of models in our overall analysis framework model are the long-term decisions of households. Specifically, we identify four major decisions (Figure 4.3): residential moves; automobile ownership; ICT (information and communication technologies) adoption; and bicycle ownership. These four processes are modeled sequentially and each of the four is discussed subsequently in more detail.

The residential move models focus on the decision of a household to remain in its current residential unit as opposed to moving to a new house. Conditional on choosing to relocate, households face three major decisions: the new household location; housing (dwelling unit) type (single detached unit, apartment, etc.); and the tenure (rent or own). Thus, the residential move model system comprises four interdependent models to completely determine the choice of a household to relocate and the subsequent choices relating to the new household.

The second major household-level, long-term choice model relates to automobile ownership. The two main decisions in this regard are the number of vehicles to own (modeled in terms of the household’s decision to buy, sell, or trade vehicles) and the vehicle type (passenger car, SUV, etc.) Explicit determination of the type of automobiles owned by the household is beneficial from the standpoint of modeling emissions and air quality.

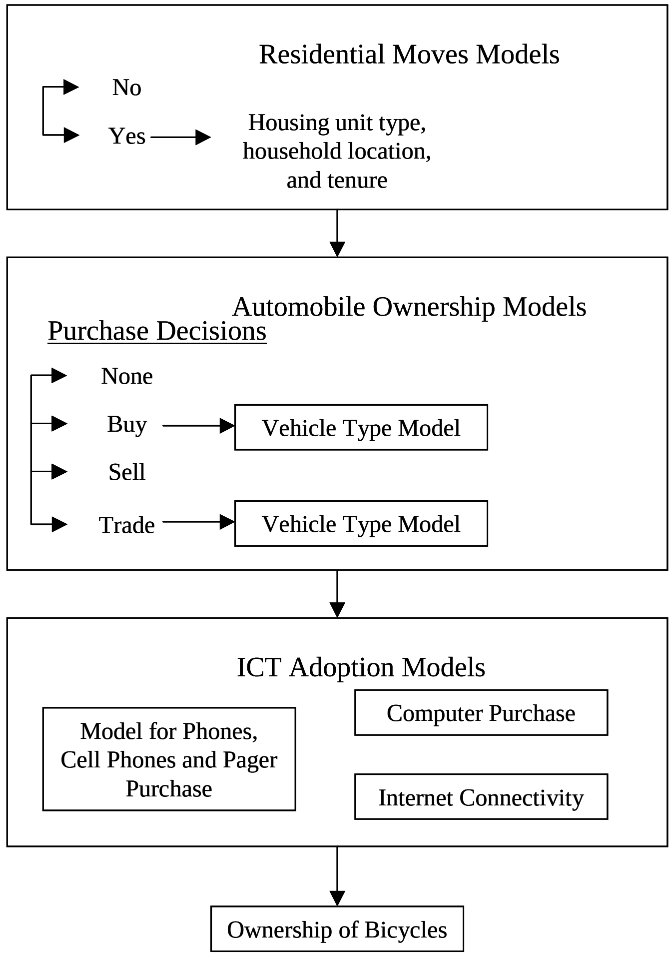

Figure 4.4 Long-term household choices models

The third long-term, household-level choice models determine the ICT adoption choices of the households. Specifically, these models determine the choice of household relating to the ownership of (1) phones/mobile phones/pagers; (2) computers; and (3) Internet connectivity. The number of bicycles owned is the final household-level choice determined.

CHAPTER 5
SUMMARY

Realistic forecasting of travel demand and the evaluation of the impact of policy actions requires the underlying models to capture the behavioral linkages among demographics, land use, and transportation systems. Conventional methods, however, use aggregate forecasts of socio-demographics and land use to feed into travel models, and consequently, cannot capture the multitude of interactions that arise over space and time among the different decision makers.

The overall objective of this research project is to develop an activity-based, land-use transportation modeling system that endogenously models the population demographic evolution processes and the household long-term choices—in addition to the short-term, activity-travel behavior. This comprehensive microsimulation modeling system, called CEMDAP-II, comprises three major components: (1) CEMDAP, the activity-travel simulator; (2) the comprehensive econometric microsimulator for socioeconomics, land use, and transportation system (CEMSELTS); and (3) a dynamic traffic assignment scheme.

The focus of this research report is on CEMSELTS. In particular, this report presents our representation of the urban environment. We consider the urban environment as encompassing four interrelated markets: service and amenity; job; housing; and transportation—with individuals, households, institutions, firms, and real estate developers as the actors in these markets. The actions and life events of the actors are first identified. Although the most comprehensive modeling approach would explicitly consider the actions of all of these actors and the interdependencies among these actions, for the purposes of developing CEMSELTS, we chose to focus our efforts primarily on the detailed modeling of the actions of households and individuals (the overall impacts of the actions of the other actors are captured at an aggregate level). The decision to adopt such a strategy is motivated by issues of data availability and the specific needs of the activity-travel simulator. The actions of the households and individuals (which are to be modeled in detail in this research) are then further described. Subsequently, the fourth chapter of this report describes our approach to integrating the modeling of all these different processes into a comprehensive analysis framework. The proposed sequencing of the modeling of the different processes in this analysis framework is intended as a systematic approach to make the modeling of a large number of potentially inter-related processes analytically tractable.

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