

**INTEGRATED LAND-USE AND
TRANSPORTATION MODELS:
BEHAVIOURAL FOUNDATIONS**

Related Books

HENSHER & BUTTON (Eds.)
Handbooks in Transport 6-Volume Set

AXHAUSEN (Ed.)
Travel Behaviour Research

GÄRLING et al (Eds.)
Theoretical Foundations of Travel Choice Modeling

HENSHER (Ed.)
Travel Behaviour Research: The Leading Edge

MAHMASSANI (Ed.)
Travel Behavior Research Opportunities and Applications Challenges

TIMMERMANS (Ed.)
Progress in Activity-Based Analysis

Related Journals

Land Use Policy
Editor: A. Mather

Transportation Research Part A: Policy and Practice
Editor: Phil Goodwin

Transportation Research Part B: Methodological
Editor: Fred Mannering

Transport Policy
Editors: Moshe Ben-Akiva, Yoshitsugu Hayashi & John Preston

For a full list of Elsevier transportation research publications visit:
www.elsevier.com/transportation

INTEGRATED LAND-USE AND TRANSPORTATION MODELS: BEHAVIOURAL FOUNDATIONS

Edited by

MARTIN E.H. LEE-GOSSELIN

Université Laval, Québec, Canada

SEAN T. DOHERTY

Wilfrid Laurier University, Waterloo, Canada



United Kingdom – North America – Japan –
India – Malaysia – China

Emerald Group Publishing Limited
Howard House, Wagon Lane, Bingley BD16 1WA, UK

First edition 2005.

Copyright © 2016 Emerald Group Publishing Limited

Reprints and permission service

Contact: books@emeraldinsight.com

No part of this book may be reproduced, stored in a retrieval system, transmitted in any form or by any means electronic, mechanical, photocopying, recording or otherwise without either the prior written permission of the publisher or a licence permitting restricted copying issued in the UK by The Copyright Licensing Agency and in the USA by The Copyright Clearance Center. No responsibility is accepted for the accuracy of information contained in the text, illustrations or advertisements. The opinions expressed in these chapters are not necessarily those of the Editor or the publisher.

British Library Cataloguing in Publication Data

A catalogue record for this book is available from the British Library

ISBN: 978-1-786-35952-0

Printed and bound in Great Britain by
CPI Antony Rowe, Chippenham and Eastbourne



Awarded in recognition of
Emerald's production
department's adherence to
quality systems and processes
when preparing scholarly
journals for print



LIST OF FIGURES

Figure 1.1:	Western European productivity and population growth rates since 1000	3
Figure 1.2:	Access to motorised travel in Switzerland by age	4
Figure 1.3:	France: Estimated daily personal travel [km/day]	4
Figure 1.4:	USA: Development of daily commute	5
Figure 1.5:	Switzerland: Shift in household consumption patterns	6
Figure 1.6:	Example for the change in the generalised cost of travel: Zürich – New York	9
Figure 1.7:	Local activity spaces of two persons by type of day (Measured as 95% confidence intervals of all locations visited during a six-week diary)	10
Figure 1.8:	Variation of the size of the activity space by home location, car and public transport season ticket ownership	11
Figure 2.1:	Hierarchy of Decision - Making & Scheduling	36
Figure 3.1:	Object Oriented Class Structure	65
Figure 3.2:	Project Types	65
Figure 3.3:	Inserting Activity Episodes into Project Agendas	72
Figure 3.4:	Inserting an Activity into a Person Schedule with Travel	73
Figure 3.5:	Example of Cleaning a Schedule that has a Short Work Episode	74
Figure 3.6:	CHASE Main Scheduling Interface, Showing Add/Modify Dialog Box Used to Capture Attributes of Activities	76
Figure 4.1:	Conceptual Framework for Spatio-Temporal Behaviour	95
Figure 5.1:	Detail of OPFAST paper instruments, completed and faxed daily by respondents	120
Figure 7.1:	Mobile Phone Ownership by Age in the USA	162
Figure 7.2:	Mobile Phone Ownership by Age and Gender in Japan	163
Figure 7.3:	Mobile Phone Possession in Car by Age and Gender in Australia	163
Figure 7.4:	Mobile Phone Switched-On in Car by Age and Gender in Australia	164
Figure 7.5:	Overall Proportions with Mobile Phone Switched-On in Car	165
Figure 7.6:	Mobile Phone Usage in Japan	165
Figure 7.7:	Mobile Phone Heavy Users by Age and Gender in Japan	166
Figure 7.8:	% Calls to Friends by Age and Gender in Japan	167
Figure 7.9:	% Calls to Family Members by Age and Gender in Japan	167
Figure 7.10:	% Business Calls by Age and Gender in Japan	168
Figure 7.11:	Place of Making or Taking a Call by Gender in Japan	168
Figure 7.12:	Place of Making or Taking a Call by Age in Japan	169

Figure 7.13:	Mobile Phone Availability in Car by Trip Purpose in Australia	170
Figure 7.14:	Mobile Phone Availability in Car by Time of Trip in Australia	170
Figure 7.15:	Frequency Distribution of Trips per Person per Day	172
Figure 7.16:	Frequency Distribution of Phone Calls per Day	172
Figure 7.17:	The Relationship between Trips per Day and Phone Calls per Day	173
Figure 7.18:	Percent of Trips by Age and Gender	173
Figure 7.19:	Percent of Phone Calls by Age and Gender	174
Figure 7.20:	Trips and Phone Calls per Person per Hour	174
Figure 7.21:	Percent of Trips and Phone Calls by Hour of Day	175
Figure 7.22:	Average Duration of Trips and Phone Calls by Hour of Day	175
Figure 7.23:	Cumulative Distributions of Duration of Trips and Phone Calls	176
Figure 7.24:	Trips and Phone Calls by Hour of Day by Males under 30	177
Figure 7.25:	Trips and Phone Calls by Hour of Day by Females under 30	177
Figure 7.26:	Trips and Phone Calls by Hour of Day by Males aged 30 to 60	178
Figure 7.27:	Trips and Phone Calls by Hour of Day by Females aged 30 to 60	178
Figure 7.28:	Trips and Phone Calls by Hour of Day by Males aged over 60	179
Figure 7.29:	Trips and Phone Calls by Hour of Day by Females aged over 60	179
Figure 8.1:	Trip Length Frequency Distribution (Adjusted) for Home-Based Work Trips	204
Figure 8.2:	Trip Length Frequency Distribution (Adjusted) for Home-Based Other Trips	204
Figure 9.1:	IMULATE	216
Figure 9.2:	Development Environment and Modular Products	216
Figure 9.3:	User Interface	220
Figure 9.4:	Retrieving Information from a MapLayer	221
Figure 9.5:	Visualising Links	221
Figure 9.6:	Simulation Control	222
Figure 9.7:	Household Level Activity Participation in Space-Time	224
Figure 10.1:	Modelling principles	235
Figure 10.2:	Hierarchical model	236
Figure 10.3:	People life cycle	237
Figure 10.4:	Path between halls	238
Figure 10.5:	Simulation principles	239
Figure 10.6:	Atlas - Airport simulation interface	240
Figure 10.7:	Scenario 1 - hall A behaviour	242
Figure 10.8:	Scenario 1 - hall B behaviour	242

Figure 10.9: Scenario 1 - hall C behaviour	243
Figure 10.10: Scenario 1 - hall D behaviour	243
Figure 10.11: Scenario 1 - halls performance	244
Figure 10.12: Scenario 2 - halls performance	245
Figure 10.13: Scenario 3 - halls performance	246
Figure 10.14: Passengers' distribution and flow	247
Figure 11.1: Interactions among modules simulating temporal dynamics	255
Figure 11.2: Buying and selling allocations giving rise to commodity flows from production zone to consumption zone via exchange location	256
Figure 11.3: Summary of categories of activities and commodities in make and use tables	258
Figure 11.4: Space categories and allowable transitions	269
Figure 12.1: Hybrid Choice Model	278

LIST OF TABLES

Table 2.1:	Suggested List of “Primary” Projects	39
Table 2.2:	Suggested List of "Universal" Activities	50
Table 3.1:	Classifications for Activity Episode Generation	67
Table 3.2:	Behavioural Assumption Summary and Assessment	77
Table 4.1:	Proposed classification of activities by their degree of spatial and temporal spontaneity	97
Table 7.1:	Mobile Phone Ownership by Region	161
Table 7.2:	Place of Phone Call by Age and Gender	180
Table 8.1:	Summary Statistics from the Household Travel Surveys	193
Table 8.2:	Comparison of Statistics of the HTS and Simulation Samples	194
Table 8.3:	Comparisons of HTS and Simulated Person Trip Rates per Household	194
Table 8.4:	Comparisons of HTS and Simulated Person Trip Rates per Mobile Household	194
Table 8.5:	Comparisons of Simulated Person Trip Rates per Household across Data Sets	196
Table 8.6:	Comparison of Total Trips By Purpose	196
Table 8.7:	Comparisons of Simulated Data by Mode and Purpose	198
Table 8.8:	Mode by Purpose for the Simulation and Adjusted Simulation versus the AHTS	199
Table 8.9:	Comparisons of HTS and Simulated Departure Times by Trip Purpose	200
Table 8.10:	Time of Day by Purpose for Simulation and the AHTS	201
Table 8.11:	Comparison of HTS and Simulated Vehicle Trip Lengths (minutes)	202
Table 8.12:	Trip Length By Purpose from the AHTS and both Simulations	203
Table 9.1:	Sample Household 2-Day Activity Summary	223
Table 11.1:	Potential activity categories for activity allocation module	258

ACKNOWLEDGEMENTS

This book was a product of the PROCESSUS network research programme, funded by the Social Sciences and Humanities Research Council of Canada (SSHRC), the Network of Centres of Excellence in geomatics (GEOIDE), and the Quebec Ministry of Transport (for more details, please see the Introduction).

The editors undertook the preparation of this volume with the much appreciated assistance of an Editorial Board consisting of Pavlos Kanaroglou, Eric Miller and Paul Villeneuve. Between us, we persuaded a large number of colleagues to perform independent reviews: we wish to thank these anonymous people for their many suggestions, which in some cases guided substantial revisions of the draft papers.

We also much benefited from the thoughtful guidance of Chris Pringle and Zoë Youd of Elsevier Limited, Oxford, throughout this undertaking.

The editors would like to thank each of the contributing authors for their careful collaboration during the multiple stages of review, correction and/or modification, as applicable.

The preparation of camera-ready copy requires the fastidious attention of someone with infinite patience, and the ability to talk politely to the more esoteric functions of word-processing software, something the editors did not always succeed in doing. That indispensable colleague was Manouane Théberge of the Groupe de recherche interdisciplinaire mobilité, environnement et sécurité (GRIMES), Université Laval. We offer our sincerest thanks for her impeccable work and good humour throughout the preparation period.

The costs of technical services for this book were shared between the SSHRC grant and the GRIMES.

Balancing family and work is never easy, and this book could only increase this tension, especially as the editors were often on different continents. Our heartfelt thanks to our spouses and children, and to our employers, l'École Supérieure d'Aménagement du territoire et de Développement régional of Université Laval, and the Department of Geography and Environmental Studies, Wilfrid Laurier University, for their generous understanding.

INTRODUCTION

It may seem odd to see a book with the words “behavioural foundations” come from a group of authors that includes scarcely anyone with a traditional behavioural background. If anything, we would like this to serve as an invitation to set us straight – we believe something isn’t quite right with the behavioural assumptions going into the gamut of land-use and transport models, and we’d like to get the ball rolling on some innovative and creative new solutions.

In this vein, we brought an international group of modellers, data-designers, geomatics experts policy analysts, and some behavioural scientists, to Quebec City in 2002. We asked them to unplug their computers and share ideas under the broad topic of “The Behavioural Foundations of Integrated Land-Use And Transportation Models: Assumptions and New Conceptual Frameworks”. This Colloquium was a landmark event in a major research programme on those behavioural foundations that had been underway since 1999 in a network of six (later eight) Canadian universities, with the collaboration of eight (later ten) institutions in six other countries¹. Known as the PROCESSUS² Network, it overlapped and built upon the work of the ILUTE³ Consortium, founded by Eric Miller of the University of Toronto in 1994 to pursue collaborative research on major simulation models for urban areas.

The behavioural research programme, consisting of 20 linked projects, was made possible by unprecedented funding for this class of urban problems through a Major Collaborative Research Initiative grant from the Social Sciences and Humanities Research Council of Canada, by an important synergy with the spatial sciences through project funding from the GEOIDE network (Geomatics for Informed Decisions), supported by the Network of Centers of Excellence Programme of the Canadian federal research councils, and by additional financial support from the Ministère des Transports du Québec for PROCESSUS’ empirical and database work in the Quebec City region.

It was at the Québec Colloquium that most of the chapters of this book were presented in a preliminary form. They were selected for the book with a view to establishing an open forum to share our experiences and to plot our course. Our overriding objective for both the research programme and the book was to question the behavioural foundations of ILUTE-type models, and to determine how such decision-support tools could help Canadian cities plan a future in

¹ The Canadian members were Université Laval (network host), the University of Toronto, the University of Calgary, Université de Québec/INRS-Urbanisation, Culture et Société, Wilfrid Laurier University, McMaster University, McGill University and St.Mary’s University. The international collaborating institutions were Imperial College, London (UK), the University of Westminster (UK), Göteborg University (Sweden), L’École Navale de Brest (France), IVT-ETH, Zurich (Switzerland), Massachusetts Institute of Technology (USA), Boston University (USA), Georgia Institute of Technology (USA), the University of Sydney (Australia) and The Urban Transport Institute (Australia).

² PROCESSUS Network: PROCesses of behaviour underlying Equity and Sustainability in Systems of Urban access and their Simulation. Réseau PROCESSUS : PROcessus Comportementaux Essentiels aux Systèmes d’accès Urbain durables et équitables et à leur Simulation

³ ILUTE: Integrated Land-Use, Transportation and Environment, a framework for modelling.

which the access that they offer to activities and services is environmentally sustainable, healthy and equitable. By behavioural foundations, we mean any framework or set of assumptions concerning the mechanisms and processes of human behaviour and decision-making over time, space and across multiple actors. As shown throughout the papers in this book, these may be adopted from a variety of disciplines, such as from: economics (e.g. random utility maximization), geography (e.g. space-time prisms), psychology (e.g. decision-making processes/rules), sociology (e.g. social networks, family dynamics), and others.

The behavioural foundations are explored in the context of land-use and transportation decision-making in built environments – by individuals, households, and businesses. These range in scale from daily decisions of households concerning what to do, where and when to do it, and by what travel mode, to longer term decisions concerning residential choice, vehicle holdings or land consumption by business entities. For it is the summation of all these individual micro-level decisions that culminates in the aggregate flows of traffic and urban growth, and has important implications for the environment, equity and sustainability.

Why are the behavioural foundations so important? Put simply, this class of model is only as good as the behavioural assumptions upon which it is based. One of the major uses of integrated urban models is to forecast human behavioural changes in response to emerging policy, technologies, and growth scenarios. Many of these, such as travel demand management policies or growth in telecommunications, inherently invoke changes at a micro decision-making level: if the behavioural mechanisms for these changes are not incorporated in the model, how much faith can you put in their output?

This book contributes in three key thematic areas, covered with varying degrees of overlap by all the authors: (I) conceptual issues and approaches; (II) key behavioural components and related data needs; and (III) operational modelling issues and advances.

Much of the material comprising the conceptual theme resulted from a challenge to those who normally focus on operationalising models through mathematical formulation and computer simulation: they were asked to clearly identify and communicate the underlying bases and assumptions of their models and approaches. We felt it was critical to establish the open forum with researchers who can offer new concepts, theories, frameworks, and data collection methods that could potentially enhance or question these bases. Surely, if we are to solve the emerging problems in our field, we need to make it accessible and understandable to a wide range of disciplines, and encourage intense collaboration.

Many of the papers in this volume explore new data collection tools that offer the potential to address past assumptions about the key behavioural components more empirically, and provide a basis for fundamentally new model types. For example, computerized surveys have emerged that can interactively prompt and track aspects of behaviour that are difficult to capture on paper, such as the sequence of data entries. At the same time, in-depth household interview methods have been extended, for example to engage respondents in interpreting the room for manoeuvre that they perceived to have been present when organising themselves and others in time and space during a recently observed week of activities. Stated preference/adaptation

surveys and retrospective recall have evolved to more thoroughly explore future and past response scenarios. Other tools, such as Global Positioning Systems (GPS) and 3-D visualization, are being used to reduce respondent burden and to potentially provide an opportunity for more in-depth exploration of other issues. In all, a shift in focus from observed outcomes alone (e.g. trip patterns, aggregate goods flows) to the inclusion of underlying decision processes is accruing.

The operational model development issues stemming from these behavioural foundations touch on a longstanding criticism of behaviourally rich disaggregated modelling approaches: the challenge of accounting for all the behavioural mechanisms and causal effects that are present. Rather than recoil at the apparent complexity, this book demonstrates how we can embrace the challenge, conceptualize the issues, and offer new solutions. Some of these capitalize on recent technologies such as Geographic Information Systems (GIS), agent-based simulation, and distributed computing, while others extend and integrate the established and the new, such as “hybrid” models and the proposed interdependence of sub-models within an ILUTE “suite”.

In all, this book was intended as an opportunity for the authors to openly expand their ideas, without a requirement for empirical support at this stage (although this is often provided where available), thus allowing many questions to emerge and creative approaches to be suggested. This serves both to stimulate and challenge other researchers, and provide an important basis for students and younger researchers to launch new projects – something that we feel is critical to forming a basis for substantive growth in the field.

The *conceptual issues and approaches* theme opens with contributions from two leaders in the field (Axhausen and Miller) who provide their latest perspectives on emerging approaches to understanding travel behaviour. In particular, Axhausen provides both a general introduction to travel behaviour issues and their historical evolution, highlights the most prominent issues and conceptual approaches (activity generation, activity spaces, scheduling, projects, etc.), and introduces several new focal areas for future research (e.g. social networks). Eric Miller, a recognized leader in the development of urban simulation models, takes a much more applied approach, providing a detailed sketch of how such concepts could be translated into analytical modelling advances and the challenges involved. The presentation is particularly comprehensive as travel decision making is treated as derived from the wider notions of activities, projects, schedules, and resources/budgets, all within a household multi-day context.

Roorda *et al.* take up the challenge posed by Axhausen and Miller with respect to activity scheduling behaviour, and take a specific look at the many assumptions that are often made when it comes time to model, and what new types of data could be used to address, expand and/or avoid such assumptions. For example, when activities and trips are inserted into an existing schedule, assumptions are made concerning how various activities may be modified as a result, and suggestions for exploring the validity of these assumptions using empirical data made.

Ramadier *et al.* complete the conceptual theme with a review of social psychological theories of the dynamic relationship between an individual in her social setting and the built

environment. They present a conceptual framework intended to guide survey methods that can observe the rules and heuristics with which agent-based models could more realistically represent the decisions that underlie spatio-temporal behaviour. A key implication for data collection is that rules can best be observed functioning in a two-stage “negotiation” cognitive process that is upstream from activity and travel patterns, a notion that fits well with the interplay of household, person and project “scheduler” roles proposed in the Miller chapter. They also argue for new efforts to simultaneously measure spatial and temporal flexibility, both as it is perceived, and as it may be inferred from executed activities.

The four chapters in the section on *behavioural components and data needs* expand on many of the key issues related to the representation of activity/travel decision-making that are put forth in the first chapters. McCray *et al.* focus on the adequacy of data collection methods to capture the articulation between what people do in time and space and what else they might do – and especially in the case of disadvantaged groups, those desired activities for which access is too costly or personally disquieting. In their wide-ranging chapter, they examine the implications of the evolution of activity patterns (including their extension into cyberspace), and the challenges of making surveys inclusive of all groups, including those that are hard to reach, such as the urban poor. To keep up with the phenomenological changes, and to overcome the selection biases that may accompany some types of survey methods, they conclude that flexible multi-instrument packages are often indispensable, especially at the specification stage of new model development. They give three case examples of such methods, two of which were guided by the conceptual approach in the Ramadier *et al.* chapter.

The Jotisankasa and Polak chapter gives a thorough review of recent efforts to incorporate in travel behaviour models a dimension that is often absent: the mechanisms of traveller learning. They develop in-depth the example of the cognition of travel time (including the effects of departure time) and route choice. They compare modelling approaches with and without updating mechanisms for perceptions of network attributes, and examine other aspects of learning. The chapter identifies six modelling issue areas in which research is needed to more fully incorporate learning mechanisms into integrated land-use and transport models: the learning component, choice modelling, habitual choice, choice set formation, data collection methods, and the evolution and convergence of the systems.

One of the key components that is changing the dynamics of activity scheduling is the rapid diffusion of mobile telephony. Richardson and Seethaler present a portrait of this phenomenon from several countries, including some characteristics of users and uses. They describe their efforts to find data on the interaction between mobile phone use and travel, which is too recent a development to have been covered, for example, by national travel surveys. As an interim measure, they used an Australian national time-use survey to compare a number of characteristics of the use of land-line phones and of tripmaking, including durations and temporal profiles of both for different population groups. This provides some leads for future analysis and some principles for new types of data collection.

To conclude the data discussion theme, Stopher describes a number of experiments to simulate household travel data. These methods start from suitable demographic data sources, and

employ parameter distributions from travel surveys that are carried out in other geographic areas, but which support comparable demographic definitions. Such simulations are attractive cost-savers. He presents statistical evidence that, with some cautions, useful datasets can be developed, and through the microsimulation of households, the datasets can be projected into the future, assuming that underlying distributions of travel characteristics remain stable. Research into a number of enhancements are suggested, including the introduction of random components to make the variance of characteristics of expanded households more realistic, the simulation of trip tours rather than trips, and the Bayesian updating of the simulations.

The chapter by Buliung *et al.* opens the set of four papers on *modelling issues and advances*. It moves the focus more directly on to integrated land-use and transportation models, including a thorough historical review, tying in how emerging travel behaviour approaches (dealt with in previous chapters) and geocomputing technologies are being incorporated into such models and their expansion. They pay particular attention to the need for interfaces that can be readily understood by model users who are not GIS experts. Ray and Claramunt subsequently demonstrate how a distributed computing environment offers a new avenue for the simulation of dynamic systems, and the exploration of the underlying properties and behaviour of large real-world systems. Despite remarkable recent increases in computing power, they illustrate from an example of passenger flows in an airport that multi-agent simulations can easily push the limits of memory and processing of a single computer. Distributed computing platforms seem well suited to future extensions of such simulations, especially those incorporating the complexity of collaboration between agents.

Hunt and Abraham follow with a chapter devoted more exclusively to the structure of land-use models, emphasizing how the many system elements (businesses, households, etc.) behave and interact. Their approach to simulating markets for goods, services, labour and space involves allocating flows between zones using nested logit models, according to exchange prices and transport (dis)utilities. It has been applied not only to urban regions, which are the main preoccupation of ILUTE frameworks, but also to larger geographies, namely the American states of Oregon and Ohio.

The book ends with a chapter by Bolduc *et al.* that explores recent extensions of econometrics to represent idiosyncratic aspects of choice processes, and to allow for apparently irrational decisions. They describe the development of Hybrid Choice Models (HCM) that build on basic Random Utility Theory, but include key elements of the cognitive processes believed to underlie choice, including aspects of history and context, the formation of perceptions, heterogeneity and unobserved constraints. Until recently, HCM methods have been demonstrated only on small-scale models with two or three alternatives: their chapter explores the application of HCM to large scale models with numerous dimensions and flexible formulations of the choice process, such as would be needed for urban simulations.

In an ideal world, all disciplines would truly collaborate together, surveys would have 100% response rates, all data would be shared, all models would be open source, and behavioural assumptions would not be needed (since the models would capture all aspects of them!). But questions remain. How will we know if we are on the right track? How far off are models that

that would reasonably satisfy the behavioural standards/frameworks outlined in this book? How will we know we got there? We encourage everyone to keep asking these questions, and look forward to future stages of the work, including the second International Colloquium to be held in Toronto in 2005.

Sean T. Doherty

Martin E.H. Lee-Gosselin

1

A DYNAMIC UNDERSTANDING OF TRAVEL DEMAND: A SKETCH

K.W. Axhausen, IVT, ETH Hönggerberg (HIL), Zürich, CH

ABSTRACT

This paper highlights two under-researched areas in transport planning: a) the structure of travellers' social networks in connection with their basic mobility choices; and b) the day-to-day dynamics of activity generation. This discussion is set against the background of overall economic changes during the last 50 years, which have funded the behavioural changes observed.

The discussion is conceptual, as there is not enough empirical evidence available to conclusively demonstrate the trends identified. The paper argues that the spatial dispersion of the social networks in combination with the residential location choices were, and will be, the main factor in the observed increases in miles travelled. The conceptual framework for the day-to-day dynamics is based on the rhythmic patterns of need accumulation and their satisfaction through activities and long-term projects.

AVERAGES AND DYNAMICS

Transport planning claims to understand the dynamics of the systems it analyses: transport infrastructures and travel behaviour. A closer look reveals that certain dynamics are well understood, others less so, some not at all. The reasons for these partial understandings are the previous and current professional tasks of the discipline and the preferred modelling tools.

2 *Integrated Land-Use and Transportation Models: Behavioural Foundations*

Understanding the systems as being in equilibrium is not a motivation to search for change (See also Manski, Forthcoming). No one doubts the usefulness of the mathematical tools provided by the equilibrium concept, but the differences between two different equilibria do not necessarily tell the analyst anything about the path of the implied system and behavioural changes.

In this paper, we cannot set out a theory for everything; we cannot even provide a description of every substantial dynamic process in the transport system. We want to highlight two specific areas against the background of the overall economic change of the last 100 years. The paper is speculative, despite of using graphs to illustrate its argument at various stages. It has to be speculative, as there is little empirical base on which to draw for the two main issues it wants to address: a) changes in the spatial distributions of social networks and b) intrapersonal dynamics of daily travel behaviour.

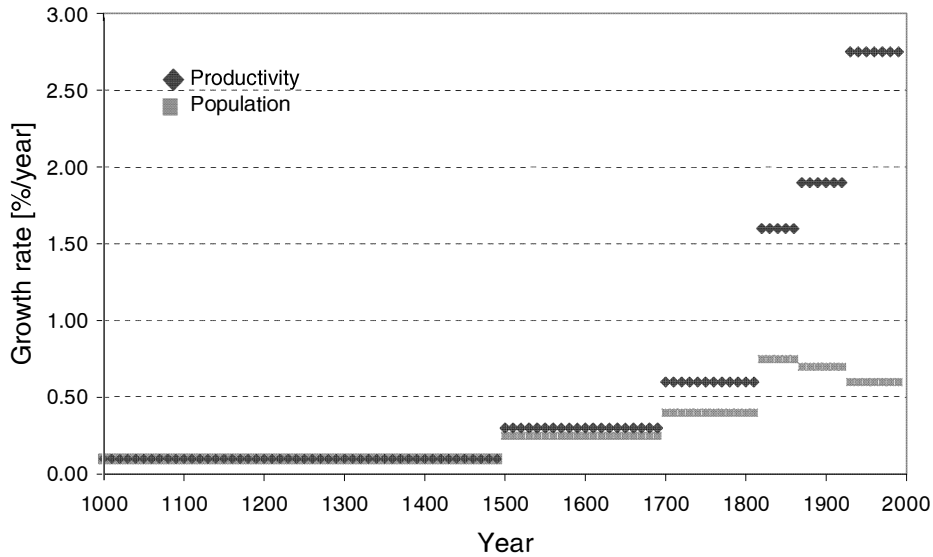
Transport planning describes behaviour during particular times and in specific locations. It uses the parameters estimated from it to forecast changes, which may occur with new structures of generalised costs, new population levels and distributions, and activity opportunities. Notions of constant time budgets and money budgets, as well as constant tastes, help to justify this approach (Zahavi, 1979; Becker, 1976). While constant interpersonal time budgets have been reported in the literature, money budget shares have not been constant over the last 50 or 100 years (see below), which raises doubts about the approach. In addition, even 25 years after Zahavi's work, no credible mechanism has been suggested to explain the observed stabilities in average travel times over the years. These stabilities are surprising given the overall change in social and economic conditions.

In the first part of the paper, we will inform readers about the scale of those changes mentioned above by highlighting a small number of key developments. In the second part, we will discuss likely impacts of the anticipated further changes on the physical distribution of travellers' social networks. Finally, in the third part, we will outline a framework for the daily dynamics of travel behaviour which translate these bigger changes into daily practise.

A BRIEF LOOK BACK

The key development of the last 100 years is the translation of the accumulated differences between productivity and population growth (See Figure 1.1) into mass consumption. Key sectors in this process were housing and travel demand. In housing, the trend to smaller households combined with the use of cheaper suburban land made, for example, about 50m² available for each Swiss by 2000¹; an increase of 66% since 1950 (Rumley, 1984).

¹ The numbers for Germany are substantially lower: 41 m²/person in 1998 (Statistisches Bundesamt, 2000) and substantially higher for US metropolitan areas: 59 m²/person for blacks and 73 m²/person for whites (Kahn, 2001).



Source: adopted from Galor and Weil (2000)

Figure 1.1 Western European productivity and population growth rates since 1000

In terms of travel demand, the Swiss, like most other populations of the OECD area, have achieved almost complete motorisation, defined here as (almost) universal licence ownership and (almost) universal car availability of licence holders. Figure 1.2 shows that women raised during and directly after World War II will be the last group to be excluded from this. A share of non-licence holders will remain, but very few out of a reasoned voluntary stance. The licence has become too much of a badge of adulthood to be ignored. Car availability among licence holders is impressive for all age groups. It is clear that certain younger age segments (to some extent) do not have the resources, which delays the universality of access². Virtually everyone has access to a parallel technology, telephony. Its process of adoption started earlier than that of the car, ran parallel with it for most of the post-war period and is now in a new phase, during which households are slowly starting to replace the joint household land-line access with mobile phones for each member.

The access has been translated into use, and the associated speed gains translated – in the main - into longer distances (Figure 1.3 and Figure 1.4). The discussion about the translation rate is still inconclusive, but the majority opinion suggests a value of 1.0, i.e. a constant travel time budget (e.g. Schäfer, 2000). The pattern is consistent with the on-going process of residential dispersion visible in all OECD countries.

² The population of licence holders without access would be an interesting subject of in-depth study.