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New Communication Technologies and Travel

Draft Introduction

This Introduction starts by explaining in Section 1 the general issues to be addressed. Section 2 defines the scope of the study. Section 3 describes and justifies the approach to be followed and Section 4 outlines the structure of the thesis.

1. The Issues

When a new mode of communication is introduced, it is generally expected to reduce the demand for travel: why travel to speak to someone if you can call them on the phone for example? But looking back in history, this does not appear to have happened. Rather, communication and travel have grown together. In economists' language, communications and travel appear to be complements rather than substitutes. Imagine the DNA double-helix, with one strand being communication and the other travel, growing together, with the cross links – representing new modes of communication or transport – appearing to boost the spiral on upwards. Now economists say, glibly, that this is obviously due to economic growth. While economic growth provides the means, it does not explain why people choose to spend their rising real incomes on communication and travel. For example, when the Post Office was opposing Rowland-Hill's penny post proposal in the late 1830s, they asked 'why should people want to send letters just because it's cheap to do so?' (Daunton, 1985: 22). By 1953/4, transport accounted for 7 percent of household expenditure: now it accounts for about 16 percent (Root, 2000: 450, ONS, 2007: 62). The aim of this thesis is to unpack this phenomenon, because correlation does not, of course, imply causality.

Transport and communications were once synonymous, collectively known as "communications" (Root, 2000: 437). Until telegraphy arrived, "the speed of transport was also the speed of communication" (Ling & Yttri, 2002). This is graphically illustrated by the fact that following the arrival of the telegraph, the British Government had to stop its practice of releasing details of the departure of troops to the Crimean War in 1854 because the information that had previously taken the same time as the troops to arrive could now be telegraphed to the enemies (Standage, 1999: 145). (Some 150 years on, the military authorities continue to grapple with the problems of information release created by new communications technology: military personnel using blogs, podcasts, and mobile devices (Ministry of Defence, 2007: para 15).)

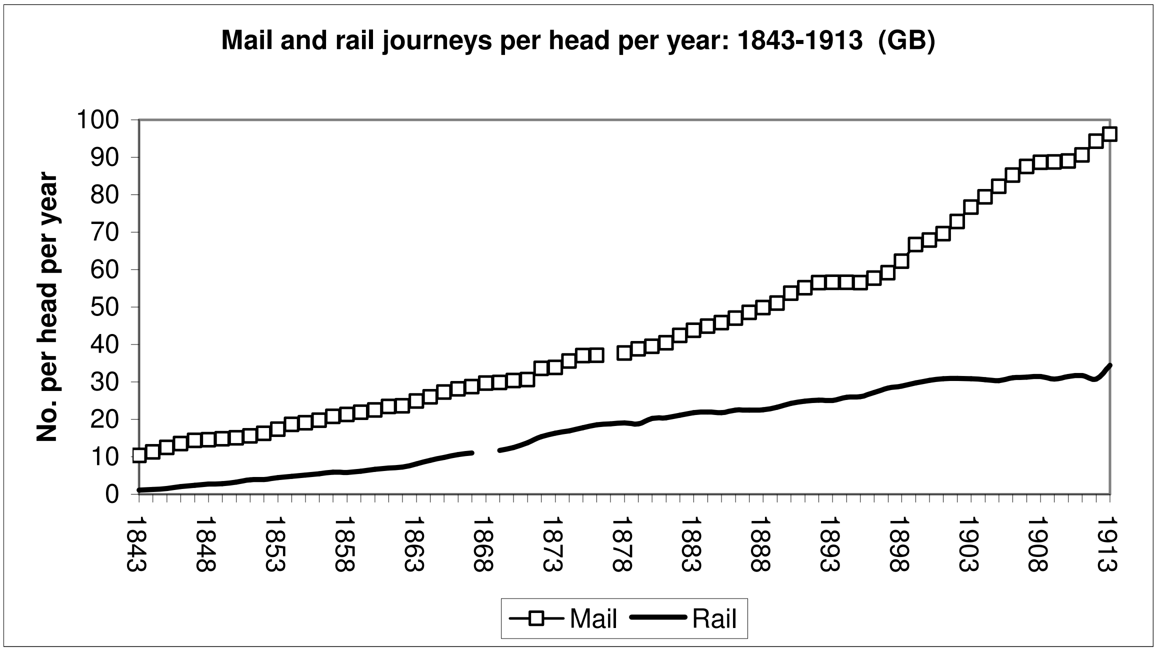
More important for ordinary people than the telegraph was the introduction of the penny post in 1840: this meant travel was no longer necessary in order for ordinary people to communicate. Although the postal service had become increasingly efficient during the last part of the eighteenth century and the first part of the nineteenth, with better roads and carriages, speed and capacity were limited and the prices were high (see for example Bagwell, 1974; Jackman, 1962). Thus it was not until the introduction of the penny post in 1840 that "for the first time in the history of man" "the poor" were able "to communicate with the loved ones from whom they were separated" (Trevelyan, 1937/1962: 278). This affordable postal service was of course facilitated by the arrival of the railways, which revolutionised transport, making personal travel available to an extent never before seen: in particular the 1844 Railway Act, which introduced the "Parliamentary train" with fares set at one (old) penny a mile. As a result of these innovations:

- the number of items sent by post rose from four per head a year in 1839 to almost 100 in 1913
- passenger journeys grew from one per head a year in 1843 to nearly 35 in 1913.

(Details in Fig. 1.) The relationship between mail and rail is addressed in Chapter 6.

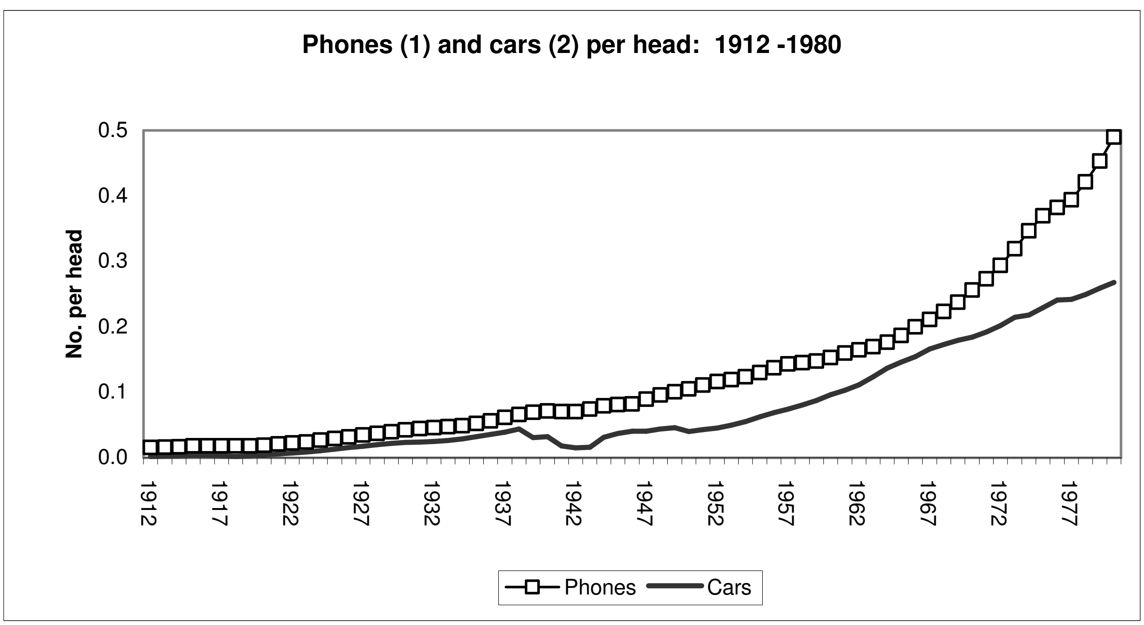
In 1879, fixed line telephones arrived in the UK but the spread was slow, not reaching even 1 in 5 households until around 1960 (BT Archives, 2007: CSO, 1994). And although the 1903 Motor Car Act marked the start of car era, again, their spread was at first slow and “they remained a luxury until the 1960s” (Root, 2000: 442 & 448). It was 1980 before there was a phone for every two people and a car for one in four. (Details in Fig. 2.) Phones and cars are discussed in Chapter 7.

Fig. 1: Mail and rail



Source: Mitchell (1988)

Fig. 2: Phones and cars



Source: Mitchell (1988)

(1) "Stations": i.e. phones, not connections (which are lower) and includes business phones. Includes southern Ireland before 1923.

(2) GB.

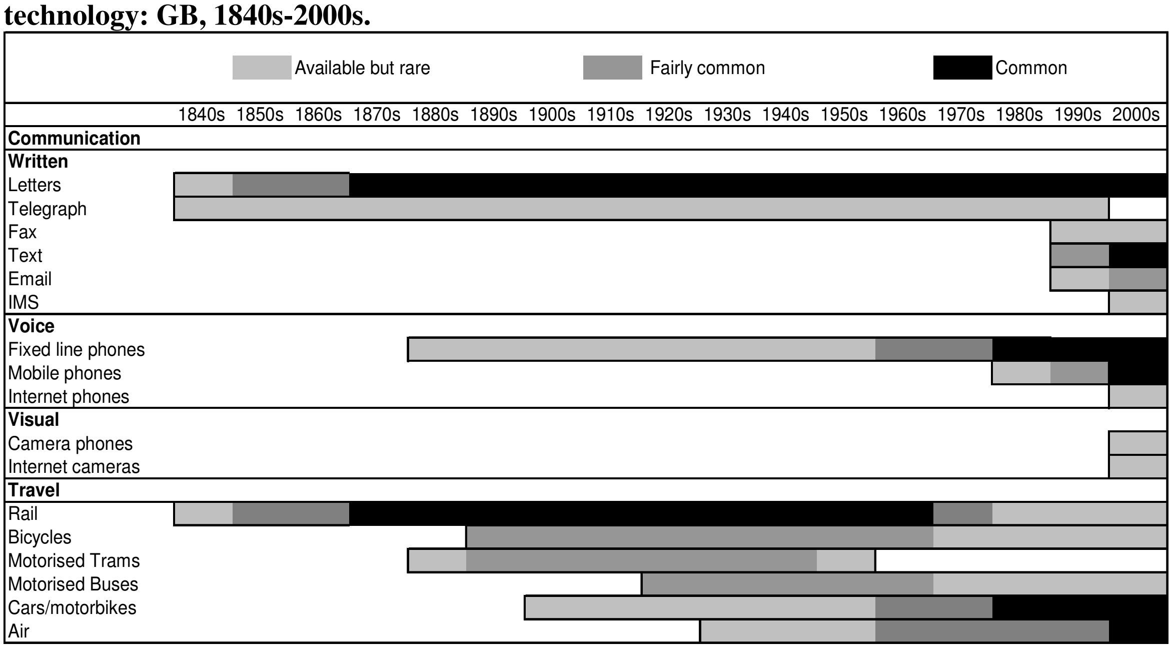
The revolution in transport technology has resulted in 'time-space convergence' as illustrated by Giddens' example of the time taken to travel from the East Coast to the West Coast of the United States:

> "On foot the journey would take more than two years; on horseback, eight months; by stagecoach or wagon, four months; by rail in 1910, four days; by regular air service today, five hours; by the fastest jet transport, just over two hours". (1984: 114)

And noted by geographer, Janelle (1991) who points out that the 210 mile journey from Boston to New York took 4,700 minutes in 1800 and 300 minutes by car in 1965, implying a "convergence" of 27 minutes a year on average.

Now we are experiencing another communications revolution, the digital revolution, with mobile phones and the internet. As Root (2000: 452) points out, these new communication technologies are in their infancy and "predicting the impact is like trying to forecast the effects of mass car ownership in 1908 when the first Ford model T cars were made". But, I suggest, a better understanding of what happened in the past may increase our understanding of the present and the future. The technological innovations in both communications and travel since the 1840s and their popularity are summarised in Fig. 3.

Fig. 3: Indicative timeline of the availability of personal communications and travel technology: GB, 1840s-2000s.



The relationship between new communication technologies and travel is of interest within academia and to policy makers because, firstly, and obviously, it is relevant to the general current concern about the economic and the environmental impact of travel, and secondly, it is relevant to the long-running debate about the impact of technology on society, in particular on social solidarity. This rest of this Section provides a brief overview of these two themes.

Economic and Environmental Costs of Travel

The future development of travel and transport networks is controversial and in 2006 three major official reports appeared:

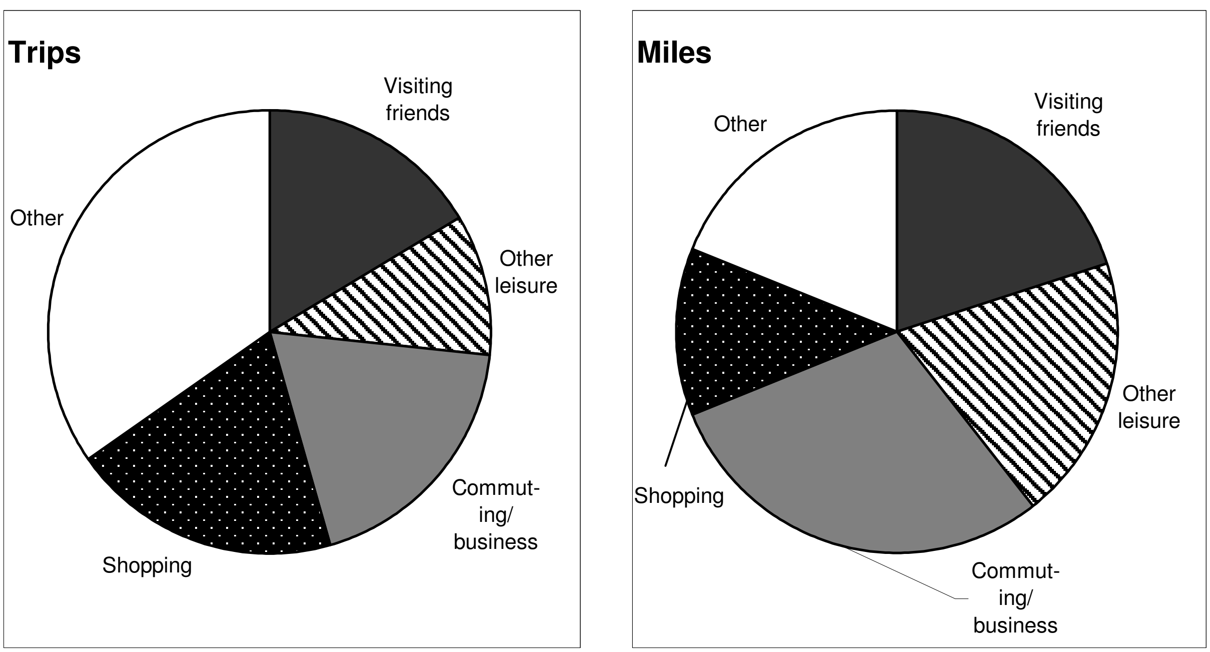
- The Office of Science and Technology's (OST) Foresight *Intelligent Infrastructure Report* which looked at how science and technology could be used over the next 50 years to create "robust, sustainable and safe transport, and its alternatives" (Foresight, 2006a: 16, 18);
- The *Eddington Transport Study*, commissioned by the Treasury and the Department for Transport (DfT) which looked at transport's "long-term impact on the UK's economic growth, productivity and stability, within a sustainable development context" (Eddington, 2006);
- The *Stern Review Report on the Economics of Climate Change*, "an independent Review" commissioned by the Chancellor of the Exchequer (Stern, 2006).

The UK's roads are the most congested in Europe (Root, 2000: 451; Foresight, 2006a: 16). The cost of congestion is measured in terms of time wasted by business and freight traffic, and on this basis congestion is estimated to cost the UK economy some £7-8 billion per annum in 2005 prices (Eddington, 2006, Vol 1: 12). This is about the same as is currently spent each year to "maintain and develop transport infrastructure" (Foresight, 2006a: 2).

"An average resident of Great Britain makes over 1,000 trips a year, travelling over 7,000 miles" (Eddington, 2006, Vol 2: para 1.1). This is about double the mileage travelled forty years ago (Root, 2000: 463), largely due to more trips. While faster travel means longer distances are covered, "the time spent each day on regular travel activity has remained constant at an average of 1½ hours" (Foresight, 2006b: 21).

Schipper & Meyers (1992: 117) noted that in OECD countries "a major source of growth in travel has been leisure and vacation-related". In the UK the miles travelled each year to visit friends and for other leisure activities increased by 6% between 1995/7 and 2005, compared to an increase of only 2% for other activities (DfT, 2006). By 2005, leisure travel – to visit friends, go to entertainments, take part in sports and so on – accounted for a quarter of these 1,000 annual trips and 4 out of 10 of the miles travelled (Fig. 4): furthermore 80% of this travel was by car.

Fig. 4: Purpose of travel by trips and miles, GB, 2005



Source: DfT, National Travel Survey (2006)

Eddington (2006: Vol 2: para 1.53) claims that while "leisure and other trips dominate the demand for travel after standard working hours on weekdays", because there are "lower levels of demand for commuting and business trips, the impact on other travellers is minimal". Those who have been stuck in traffic jams on a Saturday, or even a Sunday, may query this claim. Furthermore, the congestion costs quoted above do not take account of the effect on leisure travel. Even when leisure time is taken into account in the DfT's economic appraisals, it is valued significantly less than work time: at around £5 an hour for non-working time compared to £20 to £45 an hour for work time in 2002 prices (DfT, 2007). This relatively low valuation of leisure time – about the same as the minimum wage – is apparently based on people's willingness-to-pay (ibid). While this seems to be at odds with the often-expressed view that we live in a time-poor money-rich society, the picture is really rather more complicated (see Gershuny, 2000: 46-75): time use is discussed in Chapter 2.

However, the DfT's position underlines Larsen et al's (2006: 153) point that "policy discussion of leisure travel has often adopted a language which questions the necessity of such travel". Larsen et al argue that rather than being unnecessary, this travel "is essential for the social capital structure of a given society", and if the importance of this were recognised, it would have implications for, the provision of public transport at weekends for example (ibid: 158).

The Government's policy, set out in *The Future of Transport White Paper* in 2004, is to "manage the growing demand for transport" rather than "simply providing ever more capacity on our roads and railways, ports and airports" because "the damage to our environment, landscape, towns and cities and our quality of life would be unacceptable" (DfT, 2004: para 8). Both the Eddington (2006) and Foresight reports (2000a: 9, 28) reiterate that the answer is more efficient management of the existing infrastructure by the clever use of technology. There is little new here. In its first annual report, published in 1991, the then Department of Transport (DTp) said that it sought "to make the most effective use of existing roads", going on to describe ways in which new, albeit less sophisticated, technology could be used (DTp, 1991: 14).

The Foresight report (2006a: 9) also notes that there might be a role for "virtual communications" to reduce the demand for transport and that intelligent systems may make society "less centred around a transport system" based on nineteenth century technology, namely railways and cars. There is, however, little support for this substitution hypothesis. For example, Adams (1999) argues that societies' use of the phone and the internet is highly correlated with physical mobility and that:

> "The hope that extensive use of telecommunications will obviate the need for travel and the movement of goods, rests upon a decoupling of the trends of electronic and physical mobility for which there is no precedent".

And Adams adds that the argument that communication and travel are substitutes:

> "presumes that people will be content with lives of increasing incongruity of experience - that they will not want to meet and shake hands with the new friends that they meet on the Internet, that they will not seek first-hand experience of the different cultures that they can experience vicariously electronically, and that they will not wish to have real coffee breaks with their fellow workers. It presumes much for which there is, as yet, little encouraging evidence."

Root (2000: 452) notes that "many claims have been made that new information technologies will limit the need for travel but these have not been upheld". And Woolgar asserts that "virtual technologies supplement rather than substitute for real activities" and "the more virtual, the more real": the introduction and use of new 'virtual' technologies can actually stimulate more of the corresponding 'real' activity" (Woolgar, 2002: 16-19). More recently Larsen et al (2006: 74) told the DfT that:

> "so far there are good reasons to believe that physical travel will continue its growing significance in relationship not only to business and professional travel, but also in relationship to teleworking, family life and emerging forms of friendship."

Despite this pressure to travel more, we are told that the UK must reduce its carbon emissions from transport to 'save the planet' (see for example Köhler, 2005). Now according to the Department for the Environment, Food and Rural Affairs (DEFRA), the UK accounts for about 2 percent of carbon dioxide emissions – the main greenhouse gas – and in 2005 road transport accounted for about a quarter of that 2 percent (DEFRA, 2007) i.e. UK road transport is responsible for about ½ percent of global carbon dioxide emissions. Thus halving the carbon dioxide emissions from the UK's road transport would reduce global emissions by just ¼ percent. There is, therefore, a question to be debated: are the economic and social costs of halving the UK's emissions from road transport worth paying for a ¼ percent reduction in global carbon emissions? As the Stern Report (2006: Annex 7.c) notes, "the welfare costs of reducing demand for travel are high". This study may help to inform this debate.

Social Solidarity

The cohesion of society is a central concern of sociology and since the nineteenth century sociologists have considered the impact of new technology on society. For example, Marx and Durkheim both looked, in different ways, at the impact of the industrial revolution on social cohesion. It is also of interest to policy makers: the Foresight report discussed above talks about the need for strategies to "enhance social cohesion" (2006a: 11).

> "Few ideas saturate Western thought as does the conviction that modern life has destroyed 'communities'. …Community has disintegrated into a mass of atomistic and alienated individuals." (Fischer, 1982: 1)

Tönnies (1887/1957) introduced the idea that there has been a change from "gemeinshaft" – the pre-industrial world of villages, with close, face-to-face ties, where people are fixed geographically and socially in a homogeneous and regulated community – to "gesellshaft" – the urban, industrial world, in which people are mobile in heterogeneous and impersonal communities. Whether the world was ever as described by gemeinshaft or that the modern world is accurately described by gesellshaft is debatable. Even more debatable is the underlying value judgement that gemeinshaft is good and gesellshaft, bad.

Yet now concern about the impact of the new digital communications is expressed in terms of gemeinshaft-gesellshaft. For example, geographer Adams (2001) has distinguished between hypomobile, gemeinshaft societies – geographically based "small scale" societies in which "everyone knows everyone" – and hypermobile, gesellshaft societies – "aspatial communities of interest" in which time is spent "physically, in the midst of strangers".

Based on wide-ranging research that documented the negative effects of watching television, there was concern in the early and mid 1990s that the internet might have similar negative effects. Kraut et al (1998) reported that greater use of the internet was associated with less social involvement and more loneliness due to weak ties being substituted for stronger ones. Follow-up work suggested less negative impact but some remained: stress, possibly due to the time spent online, and a decline in commitment to the local area (Kraut et al, 2002). In particular, online relationships were found to be "weaker on average than those formed and maintained off-line" and internet use is associated with positive outcomes for extraverts, but negative ones for introverts.

Mobile phones have also been attacked. For example, while they may allow people to keep in closer contact with their 'nearest and dearest', they may also result in an unwelcome blurring of the work-home boundary. Myerson (2001:64-5) even fears that mobile communications will replace "meanings with messages, consensus with instructions and insight with information". In effect he is arguing that communication is undertaken to obtain results rather than to communicate desires (ibid: 25-27); more prosaically, he suggests conversations will be replaced by credit card transactions (ibid: 65). Furthermore, there is a hint that mobiles may be bringing about a reduction in self-reliance, the development of what could be called a 'phone-a-friend culture': a mountain rescue organisation complained of the rising number of calls for help, saying that people "don't take responsibility for themselves because they think they have the ultimate safety blanket in their coat pocket – their mobile" (The Times, 28 Jan 2005). As Clark (2003: 27) says, the mobile is "a prime, if entry level, cyborg technology" that may "turn out to mark a crucial transition point" to "dynamic biotechnological unions".

Castells (2000: 506) has a rather different view on the gemeinshaft-gesellshaft theme. Information technology, he argues, has "disconnected" "the social relations of production" by creating a new networked society in which capital is global and operates in the "instant time of computerized networks" but labour is local and runs on the "clock time of everyday life".

Not all, however, take this pessimistic view of technological change. Harper (2003) posed the question "*Are mobiles good for society?*", which he answered in the affirmative on the basis that "society is not less cohesive than it has been in the recent past" but that "the ways in which solidarity are achieved are different", and that rather than society being altered by technology – technological determinism – society is shaping technology. Harper & Hamill (2005) noted that "*Kids Will be Kids*", suggesting that teenagers' use of mobile phones now is perhaps beneath the surface not so very different from teenagers' rituals 40 years ago.

Yet Kranzberg's First Law says that "Technology is neither good nor bad, nor is it neutral", because of long-term unforeseen consequences or its use in different contexts, often arising as a result of widespread use (Kranzberg, 1986). For example, Kraut et al (2002) report that television illustrated how "enjoyable uses of new technology may be harmful in the long run". Root (2000: 463) comments that more communication and travel have created "opportunities and pleasures" while "causing environmental damage and reducing quality of life in ways that we have not sought". Technology brings about changes, for the better for some people, at least some of the time, but maybe not for others. How to weigh the benefits to some against the costs to others is the basic problem of welfare economics: the extreme view, defined by Pareto, is that a change can only be said to be for the better if no-one is made worse off (*Oxford Dictionary of Philosophy*, 1996: 277). Such changes are, I suspect, rare.

Whether any given technological development is good or bad for an individual or for society is a matter of judgement, but in order to make such a judgement, the effects must first be identified and quantified. Castells (2000: 357) says:

> "Fortunately while there is technological discontinuity there is in history a great deal of social continuity that allows analysis of tendencies on the basis of the observation of trends that have prepared the formation of the new system over the past two decades".

While I agree with Castells' basic idea that technological discontinuities are imposed on social continuity, I will argue later that 'social continuity' should be looked at over many decades, if not centuries. But the point here is that this project may be able to contribute to a better understanding of those processes and their effects.

2. The Scope

What the Project Covers

Communication and travel are very wide topics. To make the project manageable, I focus on person-to-person social communication that is mediated through a communications network (such as the postal service or email) or involves a journey, which could be regarded as mediated through the transport network. By social communication, I mean interaction with friends and family; something close to Habermas's concept of 'lifeworld'. Habermas's lifeworld and related concepts are discussed in Chapter 3. A key determinant of an individual's demand for social communication and travel will therefore be the number and strength of links with other people: in other words, their social network (Foresight 2006a: 21; Larsen et al, 2006). Thus this project is about the relationship between social, communication and transport networks.

Mathematicians' interest in networks can be traced back to Euler in the eighteenth century (Calderelli, 2005: 17-20) and they have generated all kinds of measures to analyse networks. For example, Scott's (1994/1991: 1) *Social Network Analysis: A Handbook* provides nearly 200 pages on "the key concepts used in assessing network structure – density, centrality and cliques and so on" (ibid: 1). Based on the interpretation of their structural features Watts (2004) distinguishes between 'symbolic' networks, which can be thought of as "network representations of abstract relations between discrete entities, such as the World Wide Web, and 'interactive' networks, whose links describe tangible interactions that are capable of transmitting information, influence or material" such as advice networks, the Internet, and the power transmission grid. Drawing on this idea, I prefer to distinguish between 'intangible' and 'tangible' networks.

A social network is intangible. There are no physical links other than those provided by the communications and transport networks. Indeed, Urry (2004) asks "surely there are no social networks, only material systems that realize communications, movements and the 'occasional encounters' that characterise networks"? A social network is a representation of relationships between people, but there are of course many different types of relationships. The concept of a social network is not straightforward and is examined in Chapter 1.

Some transport networks, such as road and rail, are clearly tangible in that there are physical links: it is meaningful to talk about the length of the network, measured in miles. However, an airline network is measured in terms of cities served – 'nodes' in network theory – rather than length. Furthermore, transport networks exist independently of the use made of them, in the short run at least; and to that extent they can be regarded in this context as exogenous.

Communication networks are even less straightforward. The postal service is an organisation that enables communication using physical transport networks. The fixed-line phone network comprises physical links but, like an airline network, the size of the network is measured in terms of nodes, in this case the number of subscribers, and thus could be described as endogenous. Similarly, subscribers create wireless communication networks, in which the physical links are also provided by nodes – base stations – rather than lines.

Thus while transport and communication networks can both be regarded as tangible in comparison with social networks, transport networks tend to be exogenous while communication networks tend to be endogenous. While all three are networks, they have different characteristics and thus the relationship between the social, communication and transport networks is therefore by no means simple.

What the Project does Not Cover

Narrowing the topic means that certain areas of communication and travel will not be covered, in particular:

- confining the project to person-to-person communication excludes broadcasting, sending information from one to many. This clearly rules out television and radio as well as those RSS feeds that access databases. Thus travel generated by seeing places on TV or on the internet is not covered. But internet blogs are included because, while they can be regarded as broadcasts, they are also used for personal communications (see for example Nardi et al, 2004; Hodkinson 2006 & 2007), as are social networking sites such as *Facebook* (www.facebook.com).

- confining the project to social communication excludes business communications. The determinants of business communication are different to those of social communication: business communication depends on the type of organisation and management practices rather than on personal preferences and social networks. This means this study does not explicitly cover home-working versus commuting, which arises from decisions on labour supply and the impact of the industrial structure and so on. Similarly, it does not cover the choice between internet shopping and physical shopping. However, the lessons for these activities from the social communication model will be discussed in Chapter 8.

3. The Approach

This is a multi-disciplinary project, primarily based on sociology and economics, but also drawing from time to time on other disciplines. The methodology to be used is social simulation modelling and in particular, agent-based modelling, which brings together micro and macro observations, qualitative and quantitative studies. This Section starts by discussing what is meant by a model and what models can achieve in sociology and economics; it introduces social simulation and agent-based modelling, and discusses their relationship to other sociological methods.

Modelling

A model is an analogue, usually a simplification, of the process being modelled. The use of models in sociology can be traced back to Weber's "ideal type". Boudon (1987: 53, 55) defines a model as:

> "a deductive system resting upon highly simplifying assumptions. Relevant actors are defined, generally small in number. The actors are provided with motivations. In the same way, the structure of the situation of action is characterized by a few features".

"Simplification seems to be part of all understanding" (Phelps Brown, 1972) but how simple can a model be? What is appropriate depends on the purpose of the model and the nature of the process being modelled. Think of a map: if you are walking to the next village, the sort of map that will be useful is quite different to the one you need if you are planning a tour of Europe.

Two basic classes of models are relevant here: statistical models and simulation models (Gilbert & Troitzsch, 2005: 16). Statistical models focus on correlations between variables at one point in time or over time. They may comprise sets of equations: maybe just a few, maybe many hundred. Macro-economic models are a classic example. Typically, these statistical models are used for forecasting. However, a model that predicts well may not add much to our understanding. Quite accurate short term economic forecasts may sometimes be made by looking at the time trend of the variable in question and extending it a little way ahead, with no understanding of what is underlying the forecast changes. Indeed, Coleman (1994: 4) observes that:

> "macroeconomic predictions based on leading indicators having known statistical association with subsequent system performance may give better predictions than will economic models based on interactions among parts of the system".

The issue of forecasting will be discussed further in Chapter 9.

While forecasting is an important activity, especially to support policy makers, academics are generally more interested in gaining a better understanding of the processes at work in the world. Simulation models are a tool that can be used to investigate dynamic social processes (Gilbert & Troitzsch, 2005: 18; Monge & Contractor, 2003: 100) and are therefore used in this thesis. As with statistical models, simulation models can vary in size and scope from the very simple model of phone adoption to be presented in Chapter 3 to the 'world models' developed in the 1970s (see for example Gilbert & Troitzsch, 2005: Ch 3).

In social science, model building starts with the identification of the phenomenon to be 'explained': the 'observed phenomenon' or Gilbert & Troitzsch's 'target' (2005: 15). The phenomenon is observed through data, which could come from sources ranging from ethnographic studies to national surveys and administrative data. There are, of course, always problems with data: it may not directly measure the process of interest, there may be problems in the way it is collected and so on. Great care is always needed in interpretation.

From whatever data is available, a theory is proposed i.e. a possible, testable explanation is proposed drawing on concepts developed in the discipline. For example: an economist may have a theory about the market behaviour under monopoly conditions which builds on the concepts of demand, supply and monopoly; or a sociologist may draw on the concept of alienation to 'explain' a failure to vote in elections. The theory must then be translated from a verbal description to a mathematical or computer model. Macy & Willer (2002) suggest that "computer simulation is more tractable (but less generalizable) than mathematical modeling and more rigorous (but less nuanced) than natural language". As van der Leeuw (2005) puts it:

> "models enable researchers to economically describe a wide range of relationships with a degree of precision usually not attained by the only other tools we have to describe them: natural languages".

The translation process may expose implicit assumptions that might not otherwise have been appreciated, identify variables that had not been considered, raise questions of definition or about the form and dynamics of the relationship. Thus the act of model building itself helps researchers to think about a problem and is particularly helpful in multi-disciplinary work as "they act as a kind of mirror that reflects the implications of different conceptual models in a neutral way" (van der Leeuw, 2005).

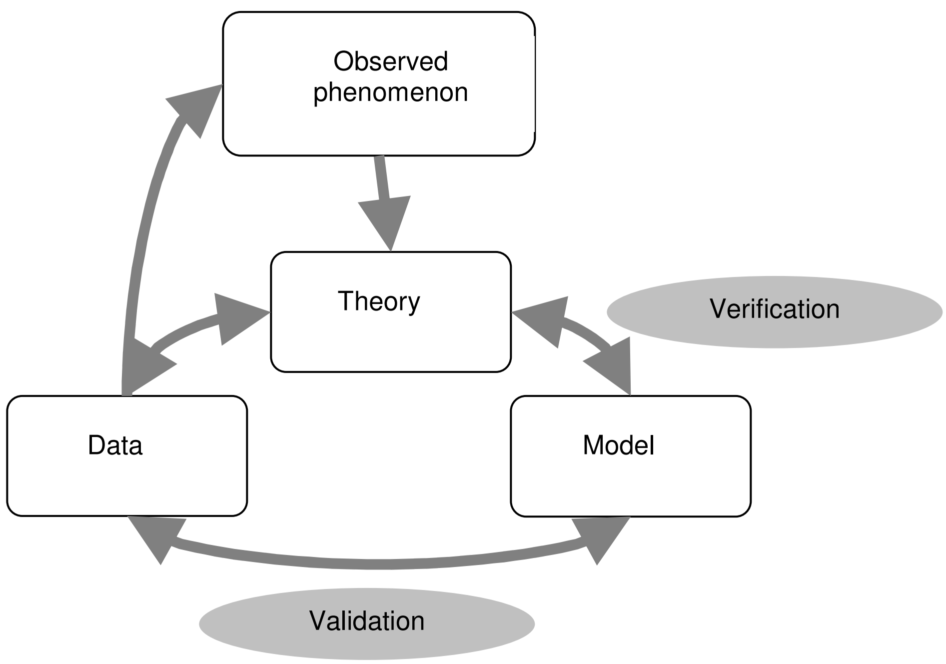
Having been built, the model must be verified, checking whether the program is working as desired. Finally, it is validated, checking that the output is consistent with the observed data. A good match between the output of the model and the observed data is a necessary but not sufficient requirement for the model to be judged as good: if the model does not remotely fit the data then it cannot be a good model. Nevertheless "factual evidence can never 'prove' a hypothesis, it can only fail to disprove it" (Friedman, 1953: 8-9).

To sum up: a phenomenon is observed, a theory developed about that phenomenon, a model built, verified and validated. While this sounds like a linear process, it is not: it is iterative. The model should contribute to the further development of the theory, and maybe suggest new data collection and more modelling: it should be “fruitful” in Friedman’s terms (1953: 10). He argues that the process of “constructing hypotheses and testing their validity” “never begins from scratch; the so called ‘initial stage’ always involves comparison” with previous work (ibid: 13). Or as economist Leontief (1971) put it:

> “True advance can be achieved only through an iterative process in which improved theoretical formulation raises new empirical questions and the answers to these questions, in their turn, lead to new theoretical insights.”

This iterative process is illustrated in Fig. 5.

Fig. 5: The process of modelling



Thus a model is a tool to assist constructive thinking about a question. It does this in two ways. First, the act of modelling encourages the clarification of both the concepts and the theory and helps to formulate questions. Second, the outputs of the modelling process may provide some answers or at least help to formulate further questions and data requirements.

Social simulation modelling

The development of computational social simulation modelling started in the early 1960s (Gilbert & Troitzsch, 2005: 6) and initially was based on systems dynamics, a macro, top-down approach using equations. Next came microsimulation, which takes a set of data about a population – of people, households or firms – and applies rules to reflect changes, enabling the modeller to look at the overall impact (ibid: 8). Unlike the systems dynamics approach which focuses on changes to distributions at the population level, microsimulation models permit changes to each element of the population distribution (Macy & Willer, 2002). Such an approach is particularly useful for modelling policy changes, to see who is made better or worse off by tax changes for example.

However, although allowing for differences between individuals, microsimulation does not allow interaction between them (Macy & Willer, 2002). For that, agent-based simulation is required. Macy & Willer (2002) summarise the situation thus:

> "Computational sociology has traditionally used simulation to forecast social trajectories based on statistical associations, using models that are highly realistic, empirically grounded, and holistic. In contrast, agent-based models use simulation to search for causal mechanisms that may underlie statistical associations, using models that are highly abstract and microsocial."

While both system dynamics and agent-based models are used in this thesis, the emphasis is on agent-based modelling.

Agent-based simulation arrived "with advent of the personal computer" in the 1980s/ early 1990s, "imported from the study of nonlinear dynamics and from artificial intelligence research" (Macy & Willer, 2002; Gilbert & Troitzsch, 2005: 6). Macy & Willer (2002) claim that "sociology has lagged behind other social sciences in appreciating this new methodology": and the Foresight report, referred to above (2006a: 26), describes it as an "exciting area of development". In their introduction to the special issue of the *American Journal of Sociology* devoted to agent-based modelling, Gilbert & Abbott (2005) argued that:

> "the most important changes in social science computation have come in the use of computers to 'think through' the implications of human actions within given social structures–action in networks. Such 'agent-based modeling' has been applied to everything from the diffusion of norms and innovations to voting."

This newness means that the techniques are still under development. Indeed, this project goes into areas that are still regarded as 'difficult' (Gilbert, 2006): innovation, culture, networks and history. These, and other difficulties, are discussed in the technical Chapter 5.

An agent-based model is a computer program that creates a world of heterogeneous agents in which each agent interacts with other agents and with the environment. These simple, local interactions can generate complex, emergent behaviour, global patterns that can be compared with macro phenomena such as diffusion of information or technology (Gilbert & Troitzsch, 2005: 11-12; Macy & Willer, 2002). In a sense, this is a micro, bottom-up approach, yet it is more than that for it establishes a link between the individual and the group, between the local and the global, between the micro and the macro. In other words, it generates emergent properties. This is discussed in Chapter 3.

This new computational sociology should not be seen as an alternative to the traditional sociological methods of observation, interview and survey. The qualitative and quantitative approaches provide different types of information, both of which contribute to the building and validation of these models. Without these, such modelling would be impossible and indeed better data collection procedures are needed (Boero & Squazzoni, 2005: Moss & Edmonds, 2005). Put the other way, the modelling is a way of building on and consolidating the data that is available, bringing together the qualitative and the quantitative. In this study, this new modelling technique brings together data from many different studies undertaken about communication and travel, distilling the information in a new way in order to gain greater insights into the sociological and economic processes.

But a word of warning from ethnographer and modeller Agar (2003: 5.2):

> "Models can't represent an ethnographic account in a virtual reality. …What models can do is clarify an idea, one that a researcher has concluded is central and key in understanding a particular phenomenon, an idea that is 'post-ethnographic.' An agent-based model can't do the ethnography. It can't represent it, either. What it can do is test a critical piece of the structure/agency puzzle after you're done."

The models can be used to obtain an idea of the relative importance of the factors suggested by the observations and theory. Of course precise quantification is rarely if ever possible in social sciences, but it is possible to produce indicators of orders of magnitude, likely ranges and 'best estimates'. Two examples illustrate the importance of quantification in the context of this study:

- To understand the importance of an innovation, it is essential to know how many people have access to it. The impact of cheap postage depends on how many people can write, as will be discussed in Chapter 6. The impact of the telephone depends on how many people can connect to the network, as discussed in Chapter 7.
- Quantification permits the identification of the impact of constraints, such as time: given that there are only 24 hours in the day and all the biological and other calls on our time, how much time is left to communicate? Time (and financial) budgets will be discussed in Chapter 2.

Thus by quantifying, modelling adds to the understanding of society provided by other sociological methodologies.

Modelling also facilitates experimentation. The difficulty of experimentation has proved a major stumbling block in the development of social science as experimentation on people is almost impossible for practical and ethical reasons: only in very special and limited circumstances is it acceptable to apply some "treatment" to one group and not to another and observe the differences (Gilbert, forthcoming: 10-11). However, agent-based models are particularly well-suited to use for experimentation and can to an extent fulfil this role (Macy & Willer, 2002; Cederman, 2005; Moss & Edmonds, 2005). In agent-based models, both the structure of the world and the types of interaction can be varied and the different outcomes compared. A model can be used to ask "what if?" For example, if there is no data available on social networks in the nineteenth century, a model could be used to explore the impact of reasonable assumptions. Models can be used to show that under certain circumstances, some particular event could not happen, suggesting a hypothesis might be false.

Another major problem with the 'traditional' qualitative and quantitative sociological studies is that they are essentially static: they show a snapshot at one point in time. Longitudinal studies, by which I mean studies lasting over several years, are rare although the British Household Panel Survey is an example. Some long-running studies repeat a few questions at regular intervals over many years (such as the Government's Family Spending and the General Household Surveys) but these surveys only cover the relatively recent past.

But neither of these approaches can overcome the fundamental problem that it is not possible to do good before-and-after studies with new technology. New technology presents a special problem. By the time the technology has been widely adopted and the need for a study is recognised, it is too late to examine the 'before' state. For example, it is difficult to obtain information from people today about life before mobile phones even though they have been widely available for only a few years; and only the middle-aged and older are able to recollect life before fixed-line phones were ubiquitous. It is therefore very difficult to obtain information about the process of change, the dynamics.

But modelling can help. To quote anthropologist Barth (from Cederman, 2005):

> "Explanation is not achieved by a description of the patterns of regularity, no matter how meticulous and adequate, nor by replacing this description by other abstractions congruent with it, but by exhibiting what makes the pattern, i.e., certain processes. To study social forms, it is certainly necessary but hardly sufficient to be able to describe them. To give an explanation of social forms, it is sufficient to describe the processes that generate the form".

This new computational sociology:

- provides a means by which data from numerous qualitative micro studies can be tested to see the extent to which they may 'explain' the macro phenomena
- provides ways of examining processes rather than taking static snapshots
- facilitates quantification and experimentation.

Merton (1949, quoted in Boero & Squazzoni, 2005) provides a nice summary:

> "the challenge of social science within range is neither to produce big, broad and general theories of everything, nor to spend time in empirical accounts per se, but to formalise, test, use and extend models to shed light on the causal mechanisms that are behind the complexity of social phenomena".

Like all social science research, modelling will provide 'clues' rather than 'answers'.

Finally, it appears that this topic – communication and travel – has not previously been addressed in this way. Search of the Journal of Artificial Societies and Social Simulation (JASSS) reveals the only reference to communications is to innovation in mobiles (Gilbert et al, 2001) although work is being done on how agents develop communications between themselves (e.g. NewTies Project). The key discussion list for "news and discussion about computer simulation in the social sciences" is SIMSOC (http://www.jiscmail.ac.uk/lists/simsoc.html) and on 8 Feb 2007, I posted the following on the SIMSOC mailing list:

> "I am planning to use agent-based models (ABMs) to examine the relationship between communication technologies and travel. I know that communication has featured in ABMs as a way of facilitating co-operation between agents and that ABMs have been used for transport planning. But has anyone used ABMs to look at communications more generally? E.g. some transport models look at people's choice of transport mode to get from A to B: has anyone looked at how people choose which mode of communication to use to send a message from A to B?"

This email went to 724 recipients worldwide. Although I received three substantive replies, none related to the question I am studying.

Case Studies

Agent-based models can be divided into three broad types (David et al., 2004; Boero & Squazzoni, 2005):

- highly abstract
- theoretically based models for investigating phenomena that share common features and
- case-based models.

This thesis uses the latter two: a general theoretically-based model is presented in Chapter 4 and case studies in Chapters 6 and 7. The first case study covers the impact of the penny post and the railways from 1840 to the start of the First World War. The second covers the impact of phones and cars, both of which were available at the start of the twentieth century but neither of which became common in Britain until the second half.

While it is argued that theories of social change should be “grounded” in historical analyses (Stinchcombe, 1978: 1: Tilly, 1981: 7-8), it is also argued that history and sociology are different disciplines, addressing different questions. History and sociology are closely related: indeed “sociology grew out of history” (Tilly, 1981: 37) and it is recognised that sociology must “always be a historical discipline” (Goldthorpe, 1991). According to Weber (1921/1968: 19):

> “Sociology seeks to formulate type concepts and general uniformities of empirical processes. This distinguishes it from history, which is orientated to the causal analysis and explanation of individual actions, structures, and personalities possessing cultural significance”.

Burke (1980: 33) appears to be paraphrasing Weber’s position in saying that history is the study of particular events while sociology is concerned “with general laws”. However, Tilly (1981: 7) dismisses this “conventional division between ‘generalizing’ and particularizing’” instead arguing that historical analysis is distinguished from sociology by its “integration of time and place”, adding that sociologists attempted to create a “timeless natural science of society” (ibid: 38). Giddens (1979) argued that by re-introducing time into sociology, the two disciplines became “methodologically indistinguishable”. While not supporting Giddens’ strong view, Abrams (1980) acknowledges that there is "common ground" in that "both seek to understand the puzzle of human agency and both seek to do so in terms of processes of social structuring". Thus for example events in the life of Queen Victoria are the concern of history and not sociology while both disciplines have a legitimate interest in the everyday life of people in during Queen Victoria's reign.

Nevertheless Goldthorpe (1991) argues that sociologists interested in social change should only turn to history when other means, such as "life-course, cohort or panel studies" are not available, that is when:

> "their concern is with social change that is in fact historically defined: that is, with change not over some analytically specified length of time - such as, say, 'the life-cycle' or 'two generations' - but with change over a period of past time that has dates (even if not very precise ones) and that is related to a particular place."

This is because, he argues, historians are always restricted by the availability of material that has survived from the past while sociologists can collect new data. Yet Tilly (1981:13-14) claims "the supply of information about the past is almost inexhaustible" and the problem faced by historians is to select which data to use. But Goldthorpe has a more subtle point concerning data. When sociologists use historical data, he complains, they usually use the analysis of others, thus "grand historical sociologists" are offering "interpretations of interpretations".

As noted above that there is a particular problem in studying the impact of new technology. It is simply not possible to look at the 'before' situation in the present. Thus I believe that this case meets Goldthorpe's criterion for using history in sociology. This thesis is looking at changes over many lifetimes, not just one or even two. As for the problems with using historical data these are, in my view, no different in kind from using modern secondary sources, although in practice they have to be treated with even greater care. I take the line espoused by Phelps Brown in his Presidential Address to the Royal Economic Society, that by studying history, "we do gain understanding: our experience and awareness are extended, our practical judgment is informed" (Phelps Brown, 1972).

Nevertheless, some argue that the current digital revolution is somehow different from what has been seen before and the past is not relevant. For example in her book *Death of Distance*, economist Cairncross (2001: 3) says:

> "The innovations taking place in electronic communications will be far more pervasive than some of the advances with which they are often compared such as the railways or the telegraph".

However, Cairncross's claim is questionable given her underestimation of the impact of the railways. For example:

- According to Cairncross (2001: 1) the car liberated women to travel yet Simmons (1991: 332-3) points out that as early as 1844 it was noted that the railways had enabled "the fair sex, and particularly of the middle and higher classes" to travel independently.
- According to Cairncross (2001: 2) planes facilitated the growth in tourism enabling "ordinary tourists to visit places that were once the preserve of the rich". Yet in 1832, it was predicted that Brighton would be ruined for 'fashionable society' by the arrival of the railway (Simmons, 1991: plate 41): different places, same phenomenon.

And historian Aldcroft (1992: 75) talks about the "enormous influence the railways had on society as a whole. In terms of mobility and choice, they added a new dimension to everyday life". I think that much the same could be said for the current digital revolution.

Ling et al (2005: 81) note "communications sent via new mediation systems must necessarily draw on elements from existing established genre". I suggest that the 'death of distance' has been a continuing process, punctuated by significant changes in technology, starting in the second half of the nineteenth century and continuing today. At the very start of this Introduction, I likened the continuing growth of communications and transport to the two strands if the DNA double helix, moving on upwards, boosted from time to time by some new innovation in communications or transport. Unlike Cairncross (2001), I do not believe that what we are seeing today is essentially a new phenomenon but rather a continuation of a very long historical trend. The technology may change but what people want to do, such as keep in contact with their friends and family, does not and thus there are clues, maybe even lessons to be learnt, from the past about what is happening today and might happen tomorrow.

Agent-based models can make a significant contribution to the understanding of the past. Two notable examples are:

- The Evolution of Organised Society (EOS) project looked at the development of the Upper Palaeolithic society in France that is associated with the well-known cave art. An agent-based model was used to examine how the society could have evolved from hunter-gatherer to become more complex, centralised and territorial due to environmental changes that affected the food supply. In the model agents were able to "perceive their environment and other agents, formulate beliefs about their world, plan, decide their courses of action and observe the consequences of their actions". The model showed that by grouping together, agents had a better chance of survival when resources were scarce and that if hierarchies formed, they continued even if there were temporary disruptions. (Gilbert & Triotzsch, 2005: 195-197; Doran & Palmer, 1995; Gilbert, 1995).
- The Anasazi tribe in the south-west of the United States were a near-subsistence level farming community who survived for some 3,000 years before disappearing about 1300, leaving a substantial archaeological record. The aim of the project was to gain some understanding as to why they disappeared: was it a result of environmental or cultural changes? Although the model included "only the most basic environmental and demographic specification", it was able to reproduce the change in population size and distribution and provided "a clue" to the relative importance of these factors. By quantifying the fertility and mortality of the population, their food requirements, the size of their harvests and so on, the model made it possible to assess the "relative magnitude" of the environmental and social determinants. The model suggested while environmental factors were important, the tribe could have survived and thus other factors, perhaps cultural or disease, played a role (Axtell et al, 2002; Axtell, 2006).

Both these projects were substantial, involving many person-years of effort (Gilbert & Triotzsch, 2005: 197; Axtell, 2006). Here the aim, must of necessity, be more limited.

4. Outline of the Thesis

This project investigates the dynamics of the relationship between personal communications and travel, using agent-based computer simulation modelling. It focuses on the interaction between social, communication and transport networks. The novelty of the project lies in using this new modelling technique to identify the important factors underlying this relationship, to get a better understanding of why communication and travel have grown together, to address the question 'why are communication and travel complements, not substitutes?' The modelling draws on qualitative and quantitative secondary data, developing historical case studies. The results of the modelling will be used to throw light on the possible long-term impact of the current digital revolution in communications. It is hoped that the thesis will contribute to the development of modelling techniques, to the current economic and environmental debate about transport and to the sociological debate about the effect of new technology on society.

The presentation of this thesis is unconventional because it uses a new methodology that will be unfamiliar to many and because it is such a wide-ranging, multi-disciplinary project:

- As Gilbert & Troitzsch (2005: 26) note, there is "a tension" to be resolved in reporting social simulation modelling, between explaining the social science without too much technical detail while at the same time providing enough information for the modelling to be replicated, replication being essential scientific practice. It would not be appropriate to simply relegate the technical material to an Annex because it is an essential part of the thesis. To address this problem, the technical issues are confined to certain sections which can be skipped by the general reader and a CD-ROM with the coding is provided.
- Almost every chapter includes a review of relevant literature: for example, the literature on social networks is covered in Chapter 1 while the literature on the use of mobile phones is covered in Chapter 8. There is therefore no chapter called "literature review".

The first two chapters set the general scene.

- Chapter 1 starts by examining the concept of social networks, looking at the evidence and finally defining the concept of an 'intentional personal network'.
- Chapter 2 looks at the consumption of new technologies, presenting some basic economic concepts and examining the impact of time and money constraints.

The next three chapters could be described as methodological:

- Chapter 3 examines the relationship between society and individuals, the micro-macro problem, discusses the concept of emergence and relates this to social simulation modelling before introducing agent-based modelling, with a simple example, and comparing it with systems dynamics modelling.
- Chapter 4 sets out a general agent-based model of communication and travel
- Chapter 5 is a technical discussion covering different types of social simulation modelling and specifically at the modelling of social networks, travel and technology adoption.

Then come the results of applying the modelling techniques described in Chapters 3, 4 and 5 to specific technologies and time periods:

- Chapter 6 looks at what happened following the introduction of the penny post and the railways in 1840 and
- Chapter 7 looks at the relationship between fixed-line phones and cars, focusing on the second half of the twentieth century.

The final two chapters draw the thesis together:

- Chapter 8 applies the lessons from Chapters 6 and 7 to the current digital communications revolution, looking first at the implications for social communications and then at the wider implications, such as for commuting.
- Chapter 9 concludes by summarising the results, identifying what is the same across modes and what differs, and considering what the results say about the economic and the environmental impact of travel, the impact of technology on social solidarity and the techniques for social simulation modelling, before offering policy recommendations.