

DEVELOPING DEMAND PREDICTIONS FOR A STUDY OF INTERREGIONAL TRANSPORT

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1. BACKGROUND

The island of Ireland lies off the northwest coast of Europe; it consists of two political units, the Republic of Ireland (population 3.6 million), a sovereign state and member of the European Union, and Northern Ireland (population 1.6 million), forming part of the United Kingdom. Its most unusual feature in external transport terms is the absence of a fixed link (road or rail) to the European mainland; since the 1994 completion of the Channel Tunnel, this renders Ireland the largest and most populous island in the EU, and the Republic its only member state, without such a link.

The transport of passengers and freight between the island of Ireland and the rest of the EU is thus entirely dependent upon air and sea-based modes. The literature indicates that this may have adverse effects on transport costs for Irish firms relative to European competitors, although it must be pointed out that locational decisions may obscure the full implications of this, i.e. firms whose products are particularly costly to transport may avoid locating in the country because of its poor external links, thus depressing the average figures. It appears that transport time-related costs contribute as much as, if not more than, direct expenditure on transport to the problem. In passenger transport, the heavy dependence on aircraft poses environmental problems- and, potentially, economic and competitiveness ones too, if (as seems likely) taxation on fuel is introduced on a Europe-wide basis. It is also clear that multi-modal chains are involved in the vast majority of both passenger and freight trips, which contributes both to transport costs and to the complexity of modelling the system.

It must also be taken into account that the present Irish access transport system (i.e. the links between Ireland, Britain and the continent of Europe) has contributed to the uneven distribution of development on the island, and particularly its concentration (in both the Republic and Northern Ireland) along or close to the east coast. In the Republic in particular, as national wealth increases, the emphasis of public policy has shifted from bringing the nation as a whole up to European living standards to bringing the poorer western regions into line economically with the east coast.

1.1 The research project

In view of the considerations outlined above, and given various current developments in surface and air transport technology applicable to interregional movements (including, but not limited to, the water-crossing phase of the trip) over similar distances to those involved in Irish access transport, it was considered that a study of the broad strategic

options for the future of the system, including both existing and new modes, would be of value. This is particularly true in view of the general absence of consideration of multi-modal aspects or strategic timescales in previous studies.

Work commenced in October 1998 and to date has been predominantly concerned with the evaluation of possible methodologies for the prediction of passenger and freight demand. A design year of 2015 was initially chosen. The area of interest has been defined as all passenger and unitised (i.e. non-bulk) freight traffic between the island of Ireland and Great Britain, France, Benelux and Germany. The extent of coverage of mainland Europe was decided with reference to patterns of trade and scheduled sea and air services. Zonification was at a regional ("NUTS2" in EU terminology) level in the UK and Ireland, with the five Continental European countries considered being represented as three zones.

1.2 The policy context

Almost all aspects of policy relating to access transport are, in Ireland, under the control of central government, in the form of the national government in the Republic and the Northern Ireland Office (whose responsibilities should eventually largely be transferred to the new Northern Ireland Assembly). The principal exception is the area of development planning and control (possibly relevant to new fixed infrastructure provision), which is a local responsibility in the Republic.

A National Development Plan for the period 2000-2006 is currently being prepared by the Republic's government. Although it has not been finalised at the time of writing, it can be inferred from the previous (1994-1999) plan (Government of Ireland 1993) and a study carried out by the Economic and Social Research Institute (Fitz Gerald et al. 1999) that, although access transport will continue to be seen as vital to the economy, port and airport investment will be scaled down. It is also likely that investment in the national road network, which plays a very important part in access transport, particularly for the more remote regions, will increase noticeably; significant investments in mainline railways were made under the previous plan, but some resources in this area may be switched to urban transport in the next.

There is no formal policy provision for either access transport planning beyond the horizons of the National Development Plan or response to technological change in access transport.

In Northern Ireland, current access transport policy is essentially outlined in the Northern Ireland Transport Policy statement, "Moving Forward" (Department of the Environment for Northern Ireland, 1998a), a follow-on to the UK Integrated Transport White Paper. No radical changes of policy are projected in the access field; most relevant objectives relate to the ownership and regulation of ports.

However, Northern Ireland has also prepared a strategic physical plan for the period 2000-2025, "Shaping Our Future", which currently exists in draft form (Department of the Environment for Northern Ireland, 1998b). The development of the access transport system is amongst the objectives of the plan, which also envisages directing appropriate land uses towards port/airport areas and key internal transport corridors. No mention is made of alternative technologies.

1.3 The role of demand prediction

It has been clear from the earliest stages of the study that, in order to facilitate a meaningful appraisal of different future transport strategies, it would be necessary to predict future demand for transport, both passenger and freight. It is a trivial observation that environmental impact, operating costs, socio-economic benefits and so forth depend upon demand levels, but nevertheless underlines the centrality of demand predictions to any realistic study. The principal issue emerging from the initial examination of the subject was exactly how demand was best predicted.

It must be remembered at all times that demand prediction is only one of a range of components in the overall research, so that the time and other resources available to it have necessarily been constrained, and this factor has played a role in the process of identifying and selecting solutions.

2. SPECIAL FACTORS AND CONSTRAINTS

As is readily seen from the introductory description of the work, there are several unusual aspects to this study in a general transport context. This section aims to outline how some such factors impact on the process of deciding on a demand prediction methodology.

2.1 Inter-urban vs. urban transport

Most literature on predicting transport demand deals with urban transport issues and only a comparatively small amount with inter-urban systems. Indeed, virtually all full-scale modelling work in Ireland to date has been in urban contexts. Ortúzar and Willumsen (1994, 13.1.1) suggest that political priorities tend to favour urban transport studies since the most readily visible problems of congestion, pollution etc. and the greatest concentration of population occur in these areas. Nevertheless, it is important to remember that, because of the country's peripheral geographical position in Europe, public policy in the Republic of Ireland has given more attention than might otherwise be expected to the question of external access, and a similar tendency has been apparent in Northern Ireland. However, it has not (so far) extended to formal models for demand prediction. The literature reflects a worldwide tendency to prioritise urban transport issues, but there have nevertheless been a number of important studies in inter-urban/interregional transport over distances broadly similar to those involved in this study. Of particular note is a recent EU 4th Framework project, focusing specifically on intermodal chains, known as STEMM (Strategic European Multi-Modal Modelling), the final report of which was, regrettably, still unavailable at the time of writing.

2.2 Freight vs. passenger transport

Passenger transport modelling predominates over freight in the general literature for much the same reasons as urban does over inter-urban. Urban studies rarely treat freight in the same detail as passengers because of the small proportion of total traffic volumes it represents and the fact that modal split issues generally do not arise. Furthermore,

additional difficulties of obtaining calibration information (particularly given the confidentiality of shipper-carrier contracts) and of dealing with the varying characteristics of different commodities are involved in freight demand prediction.

In spite of this, freight demand prediction appears to receive more or less the same level of attention in the inter-urban context as does passenger. Furthermore, a distinctly wider variety of methodologies exists, something which will be considered in greater detail at a later stage.

2.3 Induced demand

It is now well recognised that the level of transport supply influences the level of demand at all geographical levels. However, many forms of demand prediction- most notably the classical four-stage model- treat demand as entirely independent of supply. The most important question from the point of view of this study was whether the influence in question was so weak as to be disregardable in the Irish access transport market.

To take one example, it is widely known, even amongst the general public, that UK/ Republic of Ireland airline deregulation since the mid-1980s has resulted in a significant increase in total demand for passenger access transport services. Burke (1990) confirms this; he observes that, of the increase in passenger numbers on the Dublin-London route post-deregulation, "at least 30%...relates to passengers travelling for the first time who would not have travelled if low fares had not been available and 10%...previously travelled by sea. Lower and unrestricted airfares have also increased the frequency of air travel..."

Given this, a model or other method of demand prediction which assumed fixed total demand levels would experience problems in adequately representing the effects of a major supply-side change such as this. The ability of a demand prediction methodology to represent changes in demand as a result of changing supply hence became an important factor in the selection process, at least for passenger transport. Freight demand can respond to supply through firms' locational decisions and the restructuring of supply chains (e.g. greater centralisation of distribution as transport costs fall) but the evidence of this occurring in the market in question is less clear.

2.4 New modes

It is inherent in the purpose of this study that the effects of the introduction of new transport modes into the market will have to be assessed. This immediately imposes a further series of constraints on the selection of demand prediction methods. Unlike the situation where only present systems are considered, ignoring modal split (as in the KPMG study cited below) is not a realistic possibility. It must also be possible to represent the new mode(s) accurately for the purposes of modal split (and preferably also the estimation of induced demand- see above). This problem is not unique to the present research; indeed, as will shortly be seen, at least one form of inter-urban model has been developed specifically to permit the introduction of new modes.

2.5 Calibration data

The problems of obtaining suitable data for calibration purposes have already been referred to in the context of freight demand prediction. In the Irish access market, similar difficulties are also experienced in respect of passenger transport. Essentially, no published origin-destination data exist for either passenger or freight traffic; the major exception, the Road Freight Transport Survey (Central Statistics Office 1995), has not been updated in recent years, only gives origins and destinations within Ireland and only considers movements by Republic of Ireland-registered trucks, as well as suffering several further disadvantages which affect its utility as a data source. Data on movements of passengers and sometimes freight via individual sea and air routes, as well as port and airport traffic figures, are available from a variety of sources. Total passenger numbers and freight tonnages (i.e. including all traffic to and from Northern Ireland or the Republic of Ireland, as the case may be) can be obtained comparatively readily but are of limited use on a more disaggregate spatial level.

3. REVIEW OF METHODOLOGIES

3.1 Previous studies in the Irish access market

As has been mentioned above, transport studies dealing with inter-urban matters are a comparative rarity worldwide by comparison with their urban counterparts. This is even more true of Ireland, where no truly comprehensive studies have ever been carried out. The widest-ranging to date was that by KPMG and CHL (1990, 1992). This study, intended primarily to assess freight transport investment needs, did not consider modal split aspects; total volumes were predicted using econometric models and assigned to corridors on the basis of the 1988 pattern of movement. Typical of the models applied is:

$$\log MT = -2.6 + 1.6 \log FD - 0.1 \log (PMT/AAEI) - 0.3 \log CAP$$

where:

MT = total imports to Ireland in constant 1980 money values

FD = Final Demand, i.e. consumer spending + government spending + investment changes in stock + exports.

PMT = index of price of total imports.

AAEI = annual average earnings in industry (current money values)

PMT/AAEI = price index of import value relative to value of labour.

CAP = capital stock of manufacturing industry (an indication of how feasible it is to substitute home production for imports).

Econometric models of this form are unfortunately of limited value on the regional (rather than national) spatial scale of the present study, or for disaggregation by commodity, in the context of the available Irish economic data. Nevertheless, it is worthy of mention because of its previous, relatively successful, employment in a role not dissimilar to that involved in this study.

Few other examples of formal modelling methodologies appear to exist in studies of the Irish access market; demand predictions are more often derived by extrapolation and/or judgement.

Several previous studies of Irish access transport identified qualitative factors influencing modal split (e.g. KPMG 1990, Smyth 1991, Transport Policy Research Institute 1995, National Institute for Transport and Logistics 1999) but none of these attempted any formal modelling.

3.2 The general literature- passenger

Quite a variety of inter-urban passenger transport models exist, but they are generally capable of being divided into a small number of generic model structures, which will be outlined here.

The classical four-stage sequential model, as traditionally applied in urban transport planning, has found some application in inter-urban uses. This very well-known method involves generating trips by zone, distributing them to form a matrix, calculating modal split and assigning the movements to networks. Owing to the sequential nature of the model, it is not normally possible for demand to vary in response to supply-side changes. Specifically developed for, and predominantly applied in, inter-urban situations, the direct demand model is an attractive alternative format. In direct demand models, trip generation, distribution and modal split are handled simultaneously rather than sequentially. The generic form of such a model is:

$$T_{ijk} = \phi_k f(P_i, P_j, I_i, I_j) g(t_{ijk}, c_{ijk})$$

where i, j, k denote origin, destination, mode respectively, P, I population and income, t, c travel time and cost; f and g are functions of the input variables.

Many variations on the direct demand model exist (Ortúzar and Willumsen 1994, 6.6; Crow et al. 1973). Amongst the best known is the abstract mode model, originated by Quandt and Baumol (1966); this views all modes as variants of an "abstract mode" and relates modal properties in the trip generation equation to those of the "best" (e.g. cheapest, fastest) mode in respect of that property on the relevant origin-destination pair. The model was intended to facilitate the ready introduction of new modes, although opinions differ as to its accuracy. A disadvantage suffered by all conventional direct demand models in the context of this study is that only a single corridor is assumed per mode and origin-destination pair; in the Irish access market, choice between corridors within a single mode (e.g. ferry) is too important a factor to ignore. Quasi-direct models are a variant of the direct demand model involving separation between trip generation/distribution and modal split.

Direct demand models are not the only possible simultaneous (rather than sequential) approaches to the demand prediction problem. There also exist several variants of the four-stage model involving the simultaneous solution of two or more stages; of these, STEM (Simultaneous Transportation Equilibrium Model- not to be confused with STEMM), developed by Safwat and Magnanti (1988) was considered the most promising. STEM involves the simultaneous solution of all four stages of the classical model; they

are translated into an "equivalent convex program" and an equilibrium state reached by applying a variant of the Frank-Wolfe linear programming algorithm. This obviously permits demand to vary in response to a change in supply, offering an important advantage over the sequential model. STEM has been successfully applied in inter-urban transport modelling in Egypt (Moavenzadeh et al., 1983), although its total number of applications to date appears to have been small.

3.3 The general literature- freight

The problem of inter-urban freight transport modelling has attracted an even larger number of different approaches than its passenger counterpart. It is impossible to summarise all the various alternatives in the space available; instead, it is intended to concentrate on the principal categories, as in the case of passenger modelling. Bayliss (1973), Gray (1982) and Friesz et al. (1983) present excellent overviews of the area.

Four-stage sequential modelling is often applied to freight demand prediction, although its utility in this field is apparently more disputed than in passenger applications. Trip generation and distribution methods are broadly similar to those used in passenger modelling, but a great variety of modal split sub-models exists.

In respect of alternatives to the four-stage sequential model for freight purposes, a few direct demand freight models (including a variant on the abstract mode model) have been applied with varying degrees of success. Simultaneous multi-stage models have occasionally been implemented for freight. STEM (see above) was applied to inter-urban freight as well as passenger traffic in Egypt, as described by Moavenzadeh et al. (op. cit.) but evidence of other freight implementations of the model is scarce.

More ambitiously, economic equilibrium models have occasionally been proposed for freight transport (Friesz et al. 1983), usually including some representation of commodity price mechanisms in origin and destination regions or input-output analysis of the regions' industries. These generally, however, require considerably more economic input data than is readily available.

3.4 Possible alternatives to modelling

Although the discussion up to this stage has centred exclusively on modelling, it was recognised that a model might not be the most effective method of developing demand predictions. Three principal alternatives were considered.

The first was a market research-like approach involving the identification of those segments of the freight and passenger markets utilising existing modes which were potentially "shiftable" to a new mode and assuming that a reasonable proportion of this traffic actually would transfer, thus obtaining future demand levels for both existing and new modes. The complexity of such a process and the difficulty in taking spatial factors into account led to its rejection.

Secondly, the use of observed modal shifts resulting from the introduction of new modes into other markets to predict their effect on Irish access transport was considered but rejected on the grounds that the limitation of new modes to those already well established