The National Telecommunications

Policy and Planning Simulation Model

Review

of

Recent Activity

by

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Economics Branch

Department of Communications

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Introduction

The National Telecommunications Policy and Planning Simulation (NPPS) project was begun in 1973 in an attempt to create an analytical tool capable of performing telecommunications policy and regulatory analysis at the national level. Members of the project team have included several staff members of the Department of Communications, members of Le Laboratoire d'Econométrie de l'Université Laval, Sorès Limited and Quasar Ltd. of Montreal. The project has passed through five major phases of activity. The first three phases have been concerned with devising a methodology for creating a model capable of analyzing a wide variety of issues in telecommunications policy, development and testing of this model as well as checking the models accuracy through the application of benchmarks. The succeeding two phases of activity have been concerned with policy and regulatory analysis of telecommunications issues in Canada.

The object of this report is to review very briefly the structure of the NPPS model, to report on the results of policy analysis and experiments made with the model and to make recommendations as to the future of the model.

Objectives of the NPPS Project

The objective of the NNPS project was to create a simulation model of Canada's interregional telecommunications system capturing its institutional

character so as to simulate the financial and economic consequences on the interregional telecommunications carriers in Canada of various costing and accounting procedures, revenue sharing schemes, demand changes and alternative institutional scenarios.

From an institutional perspective the NPPS model was designed to experiment with alternative institutional arrangements primarily with respect to the TCTS so as to achieve the same desirable federal policy results that could not be achieved by the reality of factors affecting the status of the TCTS (i.e., federal regulation of the TCTS).

On the accounting side, the NPPS model was designed to study particular problems such as the effects of expensing or capitalizing certain items, the effects of alternative methods of depreciation, asset valuation, rate of return methodologies and to study optimal financial structures of the regulated carriers.

On the demand side, the model is capable of analyzing the impact of various routing strategies, the financial consequences of varying the quality of service and to study the importance of excess capacity in the network.

Finally, the NPPS was designed to address the important problem of service costing with a view to evaluating the cross-subsidy patterns among services, among customer classes and among regions. In this context, the model will optionally consider marginal and average costs and temporal aspects such as retrospective, current and prospective costs. It will also address the problem of the allocation of joint and common costs which are so important to telecommunications. The model can therefore be used to establish relationships between the tariffs and costs of the services and to determine through the means of simulation the existence of a subsidy-free tariff structure.

Structure and Operation of the NPPS Model

In order to appreciate the model from a different perspective, it is important to understand its logical features. The model is composed of four modules or blocks capable of individual or sequential execution. These four blocks are the operating block, costing block, sharing block and the accounting block.

The operating block takes the traffic demand by origin-destination pair and transforms this into usage on each link of the physical network. The usage of facilities is fed into the costing block and the gross operating revenues are fed into the sharing block. The costing block associates costs with the physical facilities of the network and allocates all costs to various services and message streams which are fed into the sharing block. It produces other information such as plant assets by plant category and carrier which is fed into the accounting block. The sharing block contains the schemes by which carriers divide the revenues received from the provision of joint services, i.e., interregional services. Post-settlement revenues and intra-carrier revenues together provide the total operating revenues of each carrier and this is fed into the accounting block. The accounting block produces financial statements for each carrier as well as several financial ratios such as rates of return and debt/equity capital ratio.

Phases I, II and III - 1973 - 1976

The first three phases of the NPPS project to 1976 were concerned with the development, refinement and benchmarking of the simulation model. It was during these three phases that emphasis was placed primarily on the accounting and demand oriented features and the objectives of the project as described above. At the end of phase three, each block of the model had been

developed into a complex system of relationships in order to achieve a sufficiently high degree of disaggregation necessary for achieving all the objectives at hand including service costing and financial performance by carrier.

It was during phase three that the Maritimes Regional experiment was undertaken. This experiment was a service costing exercise which focussed on the maritimes region the object of which was to operationally test the conceptual and software aspects of the model and demonstrate the capability of producing a regional focus. The experiment did highlight several weakness of the model, the most important of which was the accuracy of the NPPS data bases themselves for without accurate information on facilities and equipment, no model can be expected to track costs. Although the costing aspects of the telecommunications carriers in the model was highly developed relative to its revenue aspects, the model showed a poorer ability to track actual costs than actual revenues. Secondly, the model was more accurate in tracking Bell Canada than other TCTS carriers. This, undoubtedly, reflected the increased information available for Bell Canada as well as the higher degree of usage in Bell Canada's network from the demand side. Finally, it was concluded that the model at that stage of development better enabled the project team to assess the sensitivities and impacts of various scenarios. All of these conclusions emphasized the importance of accurate information to the NPPS model.

Phase IV - 1976 - 1977

Phase four of the NPPS project was entitled "Development and Empirical Evaluation of Cross-Subsidy Tests and Associated Costing Procedures for the National Planning and Policy Simulation (NPPS) Model". That phase of the project, as the title indicated, was devoted to a review of the theoretical literature on cross-subsidization and the formulation and implementation

of several cross-subsidy principles.

Cross-Subsidy Tests

After enhancements were made to the model including improvements in the costing block a series of cross-subsidy tests were conducted. The first series of tests was aimed at comparing generated revenues of a service to its incremental costs based on the current use of the telephone plant. Tests were performed on public message and private line services, long and short distance toll service, peak and off-peak traffic and regional, adjacent, non-adjacent and Canada - U.S. traffic. In this series of texts and subsequent series, the conclusions were always the same; "... a definition of cross-subsidy based on incremental costs alone is not sufficient given the importance of the common costs and other non-directly allocatable costs and given that total costs must eventually be recovered".

Two other approaches were used. The first consisted of increasing the incremental costs by incorporating the required growth reserve associated with the service. This led to the elaboration of tests based on the prospective use of equipment. Although consideration of a three year growth reserve significantly increased the incremental costs of private line services, these revised costs were still very small relative to their revenues.

The second approach consisted of the formulation of several full-cost allocation formulae and their associated cross-subsidy tests. It was found that a full-cost allocation formula in which the costs of capacity in use, growth reserves and pure excess capacity were allocated according to usage, resulted in a revenue deficit for private line services.

Private line services, therefore, were being subsidized by the revenues from message toll services according to this test. The enormous differences on

the cost side of private line services in these tests were due to the inclusion of unused capacity costs in the full allocation formula. Unused capacity costs represented more than fifty percent of total capacity costs. These results were subjected to sensitivity tests with the conclusion that these were insensitive to such factors as indivisibilities, growth rates, planning horizon, multiplexing representation and other costs.

Intertemporal Cross-Subsidy

A second area of investigation the project team endeavoured to study was the problem of treatment of excess capacity and testing for intertemporal cross-subsidy. The problem can be stated in the following way. A very large part of the capital costs in telecommunications plant is due to excess capacity, most of which is designated for growth reserve. The problem arises as to who should pay for these costs and how. When services are considered in an intertemporal sense, the problem is to ensure that the allocation of these costs do not burden either present or future customers and that both classes of customers benefit from any economies of scale or other goods. Although the Laval team did develop theoretical methods for dealing with this problem using a game-theoretic approach, it was not in a form capable of implementation into the NPPS model.

Phase V - 1977 - 1978

This phase of the NPPS project was concerned with further development and testing of several costing methodologies, enhancements to overcome several weaknesses of the model as well as the application and policy analysis of several critical issues confronting policy makers in telecommunications. The work proceeded on three major fronts. Laval University pursued several theoretical problems and tried to devise a method for their implementation in the NPPS model while Sorès was concerned with making enhancements to the model and the pursuit of several policy oriented problems. Quasar Limited of Montreal was also contracted to perform some feasibility studies and to analyze several policy scenarios.

Implementation and Testing FDC Method 7

An important objective of this phase of Sorès' work was the implementation and testing of the fully distributed cost method precribed by the FCC. Method 7, as this is called, takes into account the current relative use of the telecommunications system and its forecast relative use as a means of allocating all cost including the important excess capacity costs. Implementation of Method 7 required the use of a sophisticated demand module, a technique for translating message volumes into facility requirements and a process for distributing all plant dollars over all services. The objective of Method 7 is to facilitate or enable the calculation of the operating cost and rate base for each service in such a way that once its revenues are known, the rate of return for each service can be calculated. Comparison of rates of return among services with certain bounds can suggest evidence of cross-subsidy between services.

Implementation of Method 7 and the associated testing for cross-subsidy was hampered by several obstacles. First of all, Method 7 required a

sophisticated demand module capable of forecasting future demand and secondly, the demand model must incorporate demand elasticities and cross-elasticities among services. The NPPS module did not have a demand module anywhere approximating these needs. As a result, there was no way of evaluating the demand reactions to tariff modifications nor of allocating fungible plant dollars available for future growth among service categories in order to obtain operating costs and rate base per service.

The project team did consider matching a simplified NPPS model and a simplified demand model with the required characteristics but time limitations and the presence of higher priority projects terminated this work.

Interregional Cross-Subsidy Tests

A series of cross-subsidy tests was devised during this phase of the NPPS project to complete the series on incremental cost tests begun during the previous phase. This time, however, the emphasis was on detecting cross-subsidization between carriers.

Two types of tests were considered. The first series of tests was based on the incremental costs for interregional traffic originating in one carriers territory while the second series was based on incremental costs for interregional traffic using one carrier's facilities. The purpose of the former tests was to ensure that the total costs incurred by all TCTS members for interregional traffic originating in company X are at least covered by revenues collected by X. The purpose of the second series of tests was to check whether post-settlement revenues for carrier X covered the costs it incurred for all TCTS interregional traffic using its facilities.

This series of tests confirmed the conclusions drawn in the series of cross-subsidy tests based on incremental costs found in the previous phase of the

the project, namely that incremental cost tests are not a sufficiently powerful tool for detecting cross-subsidies in the telecommunication where a large portion of the costs is fixed. In this series of tests, revenue to cost ratios of 13. to 18. were obtained indicating the fact that incremental costs for interregional traffic is very small indeed.

Hypothetical Division of Bell Canada

The issue of a division of Bell Canada into two provincial telecommunications carriers - Bell Quebec and Bell Ontario, for example - is one which has been raised several times by federal and provincial governments. The NPPS project team decided to tackle this problem to determine its impact.

The implementation in the NPPS model of the division of Bell Canada into Ontario and Quebec carriers was straight forward. The results however, required careful interpretation and the use of data outside the domain of the NPPS model including the cost of local service.

In general, division of Bell would affect all of the TCTS members in one way or another depending upon the revenue sharing scheme used. This division would no longer make N.B. Tel and Ontario nor Quebec and Manotoba Telephone adjacent members. Ontario and Quebec would have adjacent member agreements. Consequently, part of the adjacent member revenues of N.B. Tel and Manitoba Tel. would become trans-Canada revenues and all members would share this. This means that these two carriers would be loosers while the other TCTS members would be beneficiaries of the division.

Bell Ontario would be much larger than Bell Quebec with 70% of Bell's toll assets in Ontario according to the NPPS model. Investment per circuit mile was $12. for Ontario and $19. for Quebec, indicating the greater concentration of population in Ontario. The Bell Ontario toll network would

seem to be more efficient and profitable than that of Quebec because it is more highly utilized internally and because it carries more interregional traffic. Since toll revenues are used to subsidize local service, and on the assumption that the cost structure of the local distribution system is identical for Ontario and Quebec, this could mean that ceteris paribus local rates in Quebec would have to increase while those of Ontario could decrease. Of course, the revenue sharing scheme would be critical to the outcome so that one would expect that the provinces would press for changes in the TCTS revenue settlement Plan.

Analysis of Quebec Telephone

In 1976, Quebec Telephone applied for membership in the TCTS and was rejected by the TCTS. The main argument of Quebec Tel. was that it would gain through the revenue sharing scheme. The TCTS argued that the agreement between Bell Canada and Quebec Tel. was fair and that Quebec Tel. would not gain from membership in the TCTS. The NPPS project team decided to study the problem with the aid of the NPPS model.

It was discovered that Quebec Telephone's network was under-represents in the NPPS model. An attempt to improve this information proved futile. With this in mind, the team nevertheless pursued the analysis. It was determined that the toll network of Quebec Tel was underutilized. Furthermore, it is improbable that Quebec Tel would gain through membership in the TCTS unless the capacity costs of Quebec Tel. were borne by members of the TCTS either through the Adjacent Member Settlement or the TCTS Revenue Settlement. Since most interregional traffic is with Bell Canada, revenues from this traffic would not change significantly as these would be administered by an Adjacent Member Agreement. Finally, it was concluded that Quebec Tel. might be better off settling with TCTS members individually rather than the attempting to negotiate with TCTS for membership.

Profitability Analysis by O - D Pairs

During this phase of the project, the CNCP Application for interconnection with Bell Canada came before the CRTC. An attempt was made by the project team to use the NPPS model to study and analyse issues pertinent to the application with a view to addressing DOC concerns. This was not an easy task because the NPPS model assumes a single integrated network. Interconnection, on the other hand, is a problem concerning competing networks.

The project team decided that it would be useful to use the NPPS model to determine the relative profitability of message toll and private line services between selected origin-destination pairs in Bell Canada territory. The team felt that CNCP would be more likely to select those results which offered the greatest profit to the company on which to provide service initially.

The results of the study were not very surprising. The main corridor between Quebec City and Windsor offered the highest revenue-to-cost ratio for both private line and message toll services. This corridor included Montreal and Toronto as well as smaller cities in the vicinity of these two centers such as Sherbrooke, Kitchener and Hamilton. The ratio of revenues to costs was much higher for message toll than for private line services in almost all cases. It was, however, rather surprising to learn that the revenue to cost ratio was larger for centers close to Montreal and Toronto than for the routes between Quebec City, Montreal, Toronto and Ottawa. The total profit potential by route, however, would correspond to those routes between the major centres the team concluded that CNCP would have the greatest profit incentive to concentrate their markeitng on the two major centers; Toronto and Montreal, and those satellite cities surrounding them.

NPPS Extensions to Study Telsat, TCTS, Interconnection

Although the NPPS model had been designed to study TCTS issues, it was obvious that there was a need to study other issues of equal significance to national telecommunications policy. These issues concerned satellite policy, the membership of Telesat in the TCTS organization, CNCP and its application for interconnection. Jim Cluchey of Quasar Limited was awarded a contract to study the feasibility of extending the NPPS model to study these issues and to make recommendations to DOC.

Mr. Cluchey observed that the current state of the NPPS was very complex conceptually and that extensions to include Telesat and CNCP would not make the model much more so. The most significant requirements were the use of a better demand module incorporating all competitive services, a more efficient algorithm for circuit allocation involving both data and voice services, an improved costing algorithm and a methodology for modelling competitive networks through interconnection. Mr. Cluchey was also asked to submit estimates of resource requirements to complete the extensions. Mr. Cluchey concluded that approximately 600 man days of effort would be required. This included updating all of the databases in the NPPS model and the programming the new revenue sharing schemes, financial statements ,etc.

TCTS and Telesat

It was obvious to DOC participants in the NPPS project that several problem areas concerning the effect of satellites on TCTS could be simulated using the NPPS model even though Telesat was not represented in the model. The simulation of satellite links between major Canadian centers could be achieved by adding these links to the NPPS transmission data base and adding the associated costing information to the costing database. Since the capacity

of a channel in Anik A was 1200 two-way circuits, it would be intresting to learn how traffic would be routed over the satellite and terrestrial networks in response to cost changes in the space-earth station segments of the two networks.

The first scenario considered was one in which earth stations were placed in Toronto and Vancouver and one channel was leased from Telesat by the TCTS. At a cost of $5,000 per circuit per annum only 96 circuits would be used between Toronto and Vancouver. When this cost was lowered to $3,000 per annum, 192 circuits were occupied, the increase being due to the effects of backhaul of Alberta traffic through Vancouver and that of parts of Manitoba through Toronto to Vancouver. When the cost was lowered to zero, the maximum channel usage was 540 circuits. In this case, more traffic is backhauled through Vancouver and Toronto but blocking takes place on the links into Vancouver from Alberta and into Toronto from Manitoba and parts of Ontario and Quebec. With such low usage of satellite channels, it was concluded that at the estimated 1976 cost of a channel and two earth stations of $2,500 per circuit annually, TCTS revenues from traffic routed via satellite would not cover their costs by a large amount.

The low use of Satellite circuits was due to lack of demand as well as the blocking of links into the two centers. To remedy this, it was decided to extend satellite service to Edmonton, Regina, Winnipeg, Ottawa and Halifax. Costs of the space segment would not change but the demand would increase substantially.

At the lease price of $2,700 per circuit, the NPPS model predicted 1,152 circuits would be routed via satellite. This was sufficient to fill one channel but the costs of the earth stations and the satellite channel were not covered. At a cost of $50 per circuit the usage of the satellite increased

to 9,500 circuits and the deficit of costs over revenue increased further.

There were several important conclusions drawn from this experience. Earth stations should be placed in those cities with high requirements for incoming and outgoing trunks. This is intimately related to the topology of the network. Therefore, the advent of satellite service should be expected to change the configuration of the switched network with Vancouver and Halifax becoming homing centres instead of Regina, for example. The second conclusion reached was that only if the 1976 lease rates for earth stations and satellite channels were cut in half, would the traffic revenues cover their costs.

Future of the NPPS Model

There is very little doubt that the experience the department has gained through the NPPS project has provided very valuable insight into the economic, financial, engineering and institutional issues confronting national telecommunications policy in Canada. The NPPS model provides perhaps the only detailed tool for studying these issues. The major weakness of the model are the absence of an adequate database on the current transmission and switching networks, costing of facilities and the demand for services by origin-destination pairs. Unless these databases can be updated regularly and benchmarks established, the results obtained from the model will always be subject to suspicion and, indeed perhaps should not be taken seriously for the pursuit of policy analysis. However, the model does provide benefits as a learning tool for policy analysis since it can be used in its present form to simulate the relative effects of alternative telecommunications principles and policies.

I would like to conclude this report with several recommendations.

Future work on the NPPS model should be pursued only if it can be reasonable ensured that traffic estimates for message toll, private line and data communications services will be forthcomming through the regulatory process or other services. Although detailed estimates may not be available, there is a need for a demand model which adequately reflects the reality of existing situation.

If access to traffic estimates can be ensured at some time in the near future, then work should continue toward the following activities:

1) Streamlining the operating block and incorporating a more efficient algorithm for circuit allocation involving multiservice competing networks capable of simulating interconnection,
2) Updating the traffic estimates and incorporating a demand module capable of forecasting future traffic.
3) Updating the transmission database to include TCTS, Telesat and the CNCP network (DOC is currently building such a database).
4) Implementation of the new TCTS revenue sharing scheme, the Telesat - TCTS agreement and possible TCTS - CNCP revenue settlement schemes,
5) Updating the costing functions in the model and the addition of costing functions for CNCP and Telesat.

Finally, it is important to make a recommendation about the management of further work on the NPPS model. Should the decision be made to pursue further development of the model it is important that capable people from within DOC and outside be devoted to this activity on a full time basis. Continuity of staff is also very important. It is my opinion that this could be achieved by allocating one full-time DOC person to this development with another as backup. Furthermore, it will require at least three persons from outside the

department on contract working for the project for one to two years. The total cost of the work pursued outside the department should be in the vicinity of two hundred thousand dollars and should be concentrated in a time period not exceeding two years.

sorēs inc.

NPPS/Estabrooks
Hunter

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