The Economic and Social Research Institute

AN ECONOMETRIC STUDY OF THE IRISH POSTAL SERVICES

PETER NEARY

Paper No. 80

April, 1975

An Econometric Study of
the Irish Postal Services

Copies of this paper may be obtained from the Economic and Social Research Institute, (Limited Company No. 18269*), (Registered Office)* 4 *Burlington Road, Dublin* 4.

Price £2.00

*(Special rate for students £*1·00*)*

Peter Neary, formerly Junior Lecturer in Economics at Trinity College, Dublin, is now a student of Nuffield College, Oxford. The paper has been accepted for publication by the Institute which is not responsible for either the content or the views expressed therein.

An Econometric Study of the Irish Postal Services

PETER NEARY

ISBN 0 901809 94 2

Acknowledgements

The research underlying the present paper was undertaken by the author on behalf of The Economic and Social Research Institute. For helpful discussions at all stages of the project as well as extensive assistance with data problems, I am indebted to a number of officials in the Department of Posts and Telegraphs, in particular to M. J. Coady, P. Forde and J. Joyce. In addition I wish to thank my colleagues in Trinity College, Dublin, M. J. Harrison and D. A. McAleese, as well as T. J. Baker, R. C. Geary, K. A. Kennedy, R. O'Connor and B. M. Walsh (all of ESRI), P. T. Geary (UCD), C. McCarthy (IPA) and the referee for helpful comments which substantially improved earlier drafts. Needless to say, all remaining errors and all opinions expressed are my own responsibility.

CONTENTS

		Page
	General Summary *by Gerard Wright*	11
Part 1	INTRODUCTION	16
Part 2	THE DEMAND FOR MAIL SERVICES	18
2.1	Introduction: Overall Trends, 1949–69	18
2.2	Theoretical Determinants of Postal Demand	22
2.3	Time Series Demand Functions, 1949–69	28
2.4	Cross Section Demand Functions, 1965	32
2.5	Cross Section Demand Functions, 1960, 1965 and 1969	39
2.6	The Use of Estimated Equations for Forecasting	43
2.7	Summary	51
Part 3	POSTAL COSTS AND PRODUCTIVITY	53
3.1	The Structure of Aggregate Postal Costs	53
3.2	A Digression on Marginal Costs	60
3.3	Specifying an Econometric Model for the Production of Postal Services	62
3.4	Growth of Post Office Labour Productivity, 1951–65	65
3.5	Production Functions for Post Office Operations, 1965	70
3.6	Evaluating the Performance of Individual Post Offices	74
3.7	Summary	79
Part 4	IMPLICATIONS FOR POSTAL PROFITABILITY AND FINANCES	81
Appendix A	EVIDENCE ON PERSONAL DEMAND FOR POSTAL SERVICES FROM HOUSEHOLD BUDGET INQUIRIES	85
Appendix B	DATA SOURCES	89
B.1	Data Referring to the Postal and Telephone Services	89
B.2	Macroeconomic Data External to the Postal Services	94
REFERENCES		97

LIST OF TABLES

Table		*Page*
1.1	Income of Department of Posts and Telegraphs, Financial Years 1960–61, 1965–66 and 1971–72	17
2.1	Number of pieces of mail posted in different categories, 1949–69 (in thousands)	19
2.2	Simple correlation coefficients and average annual growth rates of different mail categories, 1949–69	21
2.3	Average annual growth rates of selected mail categories in 50 head post office districts, 1949–69	23
2.4	Time series regressions: total mail per head regressed on different income variables, 1949–69	29
2.5	Time series regressions: different mail categories regressed on selected independent variables, 1949–69	*facing page* 31
2.6	Cross section regressions for total mail per head, 1965	35
2.7	Cross section regressions for different mail categories, 1965	37
2.8	Selected cross section demand functions: 1960, 1965, 1969, and all three years pooled	40
2.9	Analysis of variance and covariance for pooled cross section demand functions	42
2.10	Projections of independent variables for forecast periods	48
2.11	Forecasts of mail volume: 1973, 1976, 1981, 1986	50
3.1	Analysis of costs in British, United States and Irish postal services, Financial Year 1960–61	54
3.2	Revenue, costs, and surplus or deficit by category of mail	55
3.3	Percentage of each category in total prepaid mail, and estimated revenues and costs per piece of mail	57
3.4	Analysis by function of costs of postal operations (per cent)	58
3.5	Average annual growth rates of output, labour force, and labour productivity in Irish post offices, 1951–65	66
3.6	Cross section regressions: determinants of labour productivity changes in 49 head post offices, 1951–65	68
3.7	Cobb-Douglas production functions for 49 head post offices, 1965	73

Table		*Page*
3.8	Distribution of values of productivity index derived from production function G3	78
3.9	Correlation coefficients between alternative productivity indices	78
A.1	Expenditure by urban households on postage, telephone and telegrams in 1951–52 and 1965–66, classified by town size and income	86
A.2	Relationships between average weekly expenditure on postage, telephone and telegrams, and income and household size	88
B.1	X–11 Seasonal correction factors for months of mail counts	90

General Summary

Part 1: *Introduction*

This paper sets out to examine the operation of the mail services in the Republic of Ireland.

The objectives of the paper are as follows:

(*a*) To examine the demand for mail services over a period of time for the country as a whole, and within the different counties for individual years. It also endeavours to project future levels of postal demand up to 1986.

(*b*) To examine the structure of post office costs and productivity (i.e. trends in the number of pieces of mail handled per postal worker).

(*c*) To determine the likely future trends in post office profits and the implications of these trends for the financing of the postal services.

Throughout the paper mail is classified as either total, first or second class. Total mail for the purpose of this paper is the grouping of the four categories, letters, postcards, printed papers and newspapers. Letters and postcards constitute first class mail while second class mail consists of printed papers and newspapers.

Part 2: *Demand for Mail*

In the twenty years between 1949 and 1969, it was found that the total volume of mail posted increased by 1·72 per cent per annum, a very moderate rate of increase when compared with the growth rates of consumer spending and GNP over that period. Similarly, both first and second class mail increased in volume over that period, although second class mail increased at a much faster rate, leading to a decline in the share of first class mail in total mail.

To account for the rate and pattern of growth in mail volume, certain statistical techniques were applied to the annual data and also to the data for different counties. In doing this analysis it was expected that the growth in mail services would be associated with,

(*a*) income level

(*b*) cost of postage stamps (price)

(*c*) price and availability of competing services such as the telephone

(*d*) population density.

When these factors were analysed it was found that over time (time-series analysis) demand for mail services was significantly related to income level. A 10 per cent increase in income per person was associated with a 5·0 per cent to 9·5 per cent increase in postal service usage depending on the type of mail handled. The response of first class mail to changes in income was fairly moderate while that of second class mail was relatively greater. The reaction of first class mail to price changes was also very moderate while that of second class was ambiguous, showing a slight response in one test and none at all in another. A satisfactory link could not be established between telephone availability and the demand for postal services, due to the inadequate data available.

A further series of tests was carried out over a number of counties (cross section analysis), firstly for the year 1965 to establish certain relationships and later for the years 1960 and 1969 to see if these relationships persisted. Results here showed that the volume of first class mail was unrelated to income or to any of the other determinants listed above. Second class mail, however, was significantly related to income and population density.

The results of the time-series analysis were used to forecast demand to 1986 and these forecasts implied growth in total mail volume, of between 1·2 per cent and 4 per cent per annum (depending on the assumptions made about spending and price trends), with a continuation of the tendency for second class mail to grow at a faster rate than first class. First class mail would, however, continue to be the dominant category in 1986.

Part 3: *Postal Costs and Productivity*

Part 3 begins with a descriptive survey of the structure of total post office costs, which were found to be relatively similar to the cost structure of American and British postal services. It was found that letters were profitable but printed papers were unprofitable in all three countries and that the structure of postal charges in the three countries effectively subsidised second class mail. An examination of the various stages of mail handling showed that second class mail cost relatively more to collect and deliver than first class, but relatively less to handle.

It was considered surprising that the cost structures of postal services were similar in the USA, UK and Ireland since wage rates were so much higher in the US. This relative similarity in postal costs implied inefficiency in the Irish postal service. However, it was suggested that the similarity of postal costs between Ireland and the US was the result of two opposing sets of influences. The higher wage costs in the US were offset by the greater size and concentration of population being served by the US post offices and, more importantly, by the lower standard of postal services they provided. While these influences could not be accurately quantified, they implied that there was no reason to believe that Irish postal services were inefficient by international standards.

It was also illustrated that postal services in Ireland were "labour intensive", i.e. that wages constituted the greater proportion of postal service costs. For this reason it is imperative that the number of pieces of mail handled per worker be increased, if the cost of postal services is to be prevented from increasing at a much faster rate than other consumer prices, or than the prices of telephone services which do not possess the same labour content.

The study also examined variations in costs between different post offices throughout the country with the following results. Total mail volume (postings and deliveries) in 50 Irish post offices grew by 2·28 per cent per annum on average between 1951 and 1965. The labour force, however, grew by only 0·12 per cent per annum, which meant that the number of pieces of mail handled per worker (productivity) increased in fact by 2·17 per cent per annum over that period. It was noted that productivity in Dublin was considerably higher than in the rest of the country, though its rate of increase between 1951 and 1965 was slower than elsewhere. The slower rate in Dublin was explained as a consequence of moderate rates of increase in both output and employment, whereas the more rapid rate of increase in the country, other than Dublin, was due to an actual fall in employment of 0·43 per cent per annum, with the result that the increase in productivity was greater than the increase in output.

Finally, it was shown that it is possible to establish a relationship between the sum of postings and deliveries for an individual post office and the following factors:

(*a*) quantities of labour (postmen, sorters, clerks, etc.),

(*b*) transport vehicles (delivery vans),

(*c*) population density,

(*d*) proportion of population living in urban areas.

From this relationship indices of the number of pieces of mail handled per individual worker (termed "productivity indices"), were constructed.

These indices are described as being potentially useful measures of performance at individual office level; low values of an index imply below average productivity, which might be caused by serious under-utilisation of capacity, inadequate or obsolete premises or equipment, or a host of other reasons. The indices would thus be a useful tool in deciding on future budgetary allocations and modernisation programmes.

Part 4: *Likely Future Trends in Post Office Profits and the Implications of these Trends for the Financing of the Postal Services*

From the findings in Parts 2 and 3, future trends in post office profits were deduced and it was suggested that because of the increasing relative importance of second class mail, the rate of increase of total post office costs was likely to accelerate.

The effects of these trends in demand and costs on post office profits would obviously depend on the objectives being pursued by the Department of Posts and Telegraphs. The accepted objective of the Department in the past, was to cover its costs on a long-term basis. This resulted in recurrent increases in postal charges, which were necessary to erase the deficits brought about by wage increases, while at the same time avoiding any deterioration in the standards of services provided.

In the light of these findings, it is evident that the major problems facing the Department of Posts and Telegraphs, are how to increase the number of pieces of mail handled per postal worker over a period (to increase productivity) and how to moderate the rate of increase in costs. Certain very minor cost savings may be achieved by reorganising some services, but apart from these, it is suggested that there are two ways in which savings can be made:

(*a*) greater mechanisation of the service

(*b*) reductions in the standard of postal services.

The merits or otherwise of implementing these two policies are examined but it is emphasised that decisions on such matters can only be made in the light of social and political constraints as perceived by the policy maker. The alternative policy changes discussed are simply suggestions from the findings, which are offered for discussion.

The policy of greater mechanisation would appear to have little relevance in the Irish context. The greatest benefits to be derived from technological developments are in the mail handling area but the scale of postal operations in Ireland, with the possible exception of the Central Sorting Office, would not be sufficient to permit savings from this source. The major cost area in the Irish postal services is in delivery, an area where automation can have little impact.

This leaves only the policy of reducing the standards of postal services or alternatively forcing customers to bear some of the costs of handling mail. A reduction in the standard of postal services would entail the adoption of mail procedures on the lines of those obtaining in the USA where, for example, deliveries are not made to the door of each house but are deposited in collection boxes at the end of driveways. US mail users are also obliged to hand in second class mail at post offices. The Department of Posts and Telegraphs is already considering a number of changes in this area and separate studies are being carried out as to their acceptability to the public. In the context of the present paper, very little in fact can be said about the effects of these changes on mail volume though it is conceivable that a major deterioration in standards of service would lead to a switch away from postal services by regular users.

The conclusion then on a change of policy was that changes in the standard of services would be the only certain way of avoiding steady increases in postal charges, otherwise a major change in the method of financing postal services would have to be adopted. If the latter course is adopted three alternative means of financing mail services are suggested,

(*a*) Explicit subsidy of the postal services from general taxation. This would be the most expedient method.

(*b*) Bring charges on first and second class mail into line with their actual costs and so end the effective subsidisation of second class mail which is in operation.

(*c*) Subsidisation of postal services from the telephone services, which are relatively more profitable.

The merits or otherwise of these different methods of financing the postal services are beyond the scope of this paper, but they are offered on face value with a cautionary word, that their implications should be studied from a number of points of view, before their adoption is seriously considered.

GERARD WRIGHT

Part 1

Introduction

THIS paper is an attempt to apply modern quantitative techniques of economic analysis to the operation of the mail services provided by the Department of Posts and Telegraphs of the Republic of Ireland. This Department is one of the largest organisations in the State, administering a network of 52 head post offices and 2,160 branch and sub-offices, and employing a staff of 21,137 in 1970–71. However, as can be seen from Table 1.1, less than 50 per cent of its income derives from mail services as such and in recent years this proportion has fallen below 40 per cent. The remainder is accounted for by the telephone and telegraph services, and by a variety of other services provided on an agency basis on behalf of other government departments and of the Post Office Savings Bank.

Because of the scale of the Department's operations, and their importance in the national economy, there are a great many questions of interest which could be asked about them. In order to ensure adequate treatment, however, it has been necessary to be highly selective as regards the topics covered. The paper, therefore, confines its attention to the mail services provided by the Department. Furthermore, within those limits, it has concentrated on areas which are amenable to quantitative econometric techniques.

The plan of the paper follows the economist's traditional distinction between demand and supply. Part 2 considers the demand for mail services, and Part 3 examines the determinants of costs and productivity on the supply side. Each of these parts begins with a general descriptive survey, and then attempts to apply econometric tools to the area being studied. Thus, demand functions for mail services are estimated in Part 2, both over time, and over a cross section of Irish counties. These estimated demand functions are then used to project postal demand up to 1986. Part 3 examines the behaviour of labour productivity over time in Irish post offices, and also estimates production functions for a single year. The results of this analysis are then used to evaluate the performance of individual post offices using methods developed by Feldstein (1967). Both Parts 2 and 3 conclude with a non-technical summary of their findings.

Finally, the implications of these findings for postal profitability and finances are discussed in Part 4. No specific recommendations on pricing or financial

TABLE 1.1: *Income of Department of Posts and Telegraphs, Financial Years* 1960–61, 1965–66, *and* 1971–72

Sources of income (excluding Government subvention)	1960–61	1965–66	1971–72
	£000	£000	£000
Telephone Service	4,711	9,367	21,666
Telegraph Service	424	723	1,608
Agency Services*	1,139	1,810	3,417
Postal Service	5,187	7,981	15,773
of which: Mail Service	*4,936*	*7,665*	*15,268*
Remittance Services (Money Orders and Postal Orders)	*202*	*213*	*315*
Miscellaneous	*49*	*103*	*189*
Total	11,460	19,891	42,464

*Agency services comprise over-the-counter services such as the issuing of pensions, licences, etc. on behalf of other government departments and of the Post Office Savings Bank.
Source: Department of Posts and Telegraphs, Commercial Accounts.

policy are made, since it is considered that decisions on such matters can only be made in the light of social and political constraints as perceived by the policy maker. However, the relevance of the paper's findings to a number of alternative policy changes is discussed. The paper therefore attempts to provide the essential background information on which policy decisions should be based, but does not attempt to influence the outcome of those decisions.

By its nature, this paper should be of most interest to those who are directly concerned with postal policy, or who are interested in the problems faced by the Irish postal services or by similar service industries. Readers in this category who are not interested in the details of the econometric analysis may wish to confine their attention to the introductory and summary sections of Parts 2 and 3, and to the discussion of policy implications in Part 4. However, it is hoped that the techniques used in the paper may also be of more general interest. The sections on the specification and estimation of demand and production functions raise issues which are not peculiar to postal services, and the same is true of the sections which apply these methods to demand forecasting and to the construction of performance indicators for individual offices. The latter application in particular should be of interest to those concerned with improving efficiency in other large organisations, especially in the public sector, whose operations are decentralised and not subject to the usual criterion of profit-maximisation.

Part 2

The Demand for Mail Services

2.1 *Introduction: Overall Trends 1949–69*

As stated in Part 1, this paper is concerned solely with the mail services provided by the Department of Posts and Telegraphs of Ireland. Accordingly, in studying the demand for mail services, attention is focused on the number of pieces of mail carried in different categories. Furthermore, since the act of sending a letter may be considered more "voluntary" than that of receiving one, it seems logical to deal with the number of pieces posted rather than the number delivered.[1]

Table 2.1 gives the basic data relating to the total number of pieces posted in various mail categories. As with all the data on mail volume used in Part 2 of this paper, the data are taken from a series of returns of the volume of mail posted in a representative week of each of fourteen years covering the period 1949 to 1969. It would, of course, be preferable to have a continuous series, giving the number of pieces posted in every year, but such data are not available. One compensation for this irregular coverage is that, for each of these fourteen years, a very detailed breakdown is available, giving the number of pieces posted and delivered in each category in 52 head post office districts.[2]

The most obvious feature of Table 2.1 is the dominance of letters and printed papers over the other categories. On average, over the whole period, they account for 59·6 per cent and 31·6 per cent of the total and they exhibit fairly steady upward trends. Of the remaining four categories, on the other hand, only postcards have increased, while the volume of newspapers, parcels and registered items posted have fluctuated around downward trends.

These trends are shown more clearly by the last three columns of Table 2.2, which give the average annual growth rates of all categories for the country as a whole, as well as for Dublin and the rest of the country separately. The latter distinction is made both because of the extreme importance of Dublin—

1. The number of pieces posted and delivered move very closely together, with the latter exceeding the former by an average of 8 per cent over the period, indicating a net inflow of mail into the country from abroad.
2. For a further discussion of the data used, see Appendix B.

TABLE 2.1: *Number of pieces of mail posted in different categories,* 1949–69 (*in thousands*)

Week ending	*Letters* (1)	*Printed papers* (2)	*Newspapers* (3)	*Postcards* (4)	*Parcels* (5)	*Registered articles* (6)	*Total* (7)	*First class mail* (8)	*Second class mail* (9)
2 April 1949	3,128·3	1,336·9	157·8	151·4	188·8	80·5	5,043·7	3,279·7	1,494·7
27 October 1951	3,178·6	1,283·4	150·5	144·5	175·5	87·1	5,019·6	3,323·1	1,433·9
18 October 1952	3,262·6	1,409·0	130·5	142·3	167·7	86·9	5,198·9	3,404·9	1,539·5
17 October 1953	3,170·1	1,534·7	125·9	165·3	165·1	81·4	5,244·6	3,337·4	1,660·6
16 October 1954	3,208·7	1,748·0	128·1	171·2	158·6	81·0	5,495·6	3,379·9	1,876·1
15 October 1955	3,340·8	1,943·5	136·2	181·8	159·0	81·0	5,842·2	3,522·6	2,079·7
19 October 1957	3,431·6	1,648·9	121·4	185·2	140·2	67·7	5,595·1	3,616·8	1,770·3
18 October 1958	3,476·7	1,847·6	132·1	143·6	133·3	70·3	5,803·6	3,620·3	1,979·7
15 October 1960	3,629·3	1,965·1	130·7	146·5	141·3	63·2	6,076·2	3,775·8	2,095·8
20 October 1962	3,700·4	1,982·9	135·5	157·7	141·5	59·6	6,177·5	3,858·1	2,118·4
22 February 1964	3,778·7	2,085·6	135·8	155·2	138·1	62·7	6,356·1	3,933·9	2,221·4
16 October 1965	3,668·2	2,304·9	128·6	166·9	136·1	65·3	6,470·0	3,835·1	2,433·5
19 October 1968	4,013·8	2,356·6	128·6	182·3	147·2	67·0	6,895·4	4,196·1	2,485·2
18 October 1969	4,085·3	2,562·6	117·5	174·4	150·3	67·1	7,157·2	4,259·7	2,680·1

Notes to Table: First class mail = letters + postcards.
Second class mail = printed papers + newspapers.

its share in the national total of all categories is over 40 per cent—and because of the difference in trends between the two areas.

From the table it may be seen that the total volume of mail posted increased by 1·72 per cent per annum between 1949 and 1969, a moderate rate of increase, especially when compared with the growth rates of consumer spending and GNP over the same period. Even the fastest growing category, printed papers, grew by only 3·13 per cent per annum, while letters grew by 1·34 per cent, and the smaller categories either grew more slowly or declined. It can also be seen from the table that the rate of increase of letters and printed papers has been faster in Dublin than in the rest of the country, whereas newspapers and postcards have sharply declined in Dublin despite their moderate increase elsewhere. (The decline in newspapers posted in Dublin has been fairly steady, whereas that in postcards is largely attributable to a sudden and inexplicable drop of 36,000 between 1957 and 1958.)

The remaining columns of Table 2.2 show the simple correlation coefficients between the different mail categories over the period. All of these coefficients are consistent with the rates of growth shown in column (9): the categories with positive growth rates—letters, printed papers and postcards—form one mutually correlated block, while those with negative growth rates—newspapers, parcels and registered items—form another. Notice also that despite the high correlation (r=·916) between the two major categories, letters and printed papers, the latter have risen at a much faster rate than the former; this is equally true of the whole country, and of both Dublin and elsewhere.

This difference between the growth rates of letters and printed papers suggests that they deserve individual consideration. Furthermore, their much greater importance than the other categories implies that little will be lost by concentrating attention on them. Accordingly, this is what has been done in most of the subsequent analysis, except that, in order to conform with post office practice, postcards have been grouped with letters to form first class mail, and newspapers with printed papers to form second class. As can be seen from the last two rows of Table 2.2, each of these aggregate classes is statistically indistinguishable from its principal constituent (r=·999 in both cases). Note, finally, that since parcels and registered articles are henceforth ignored, the term "total mail" when used in the remainder of Part 2 of this paper, refers to the sum of the first four mail categories only.

It may be remarked in passing that the distinction between first and second class mail, in addition to its convenience, has an economic significance. Second class mail comes principally from the business sector, while a large proportion (though by no means all) of first class comes from the personal sector. This matter is pursued further in section 2.2 below.

Turning now to the behaviour of mail postings at a disaggregated level,

TABLE 2.2: *Simple correlation coefficients and average annual growth rates of different mail categories,* 1949–69

	Correlation coefficients								*Average annual growth rates, per cent,* 1949–69 *(standard errors in parentheses)*		
	Letters (1)	*Printed papers* (2)	*News-papers* (3)	*Post-cards* (4)	*Parcels* (5)	*Regis-tered articles* (6)	*Total mail* (7)	*First class mail* (8)	*All country* (9)	*Dublin* (10)	*Rest* (11)
1. Letters	1·000								1·34 (·08)**	2·14 (·19)**	·65 (·08)**
2. Printed papers	·916**	1·000							3·13 (·31)**	3·38 (·43)**	2·71 (·15)**
3. Newspapers	—·492	—·572*	1·000						—·68 (·28)*	—2·47 (·82)*	·11 (·19)
4. Postcards	·305	·460	—·516	1·000					·56 (·39)	—4·19(1·12)**	1·92 (·29)**
5. Parcels	—·656*	—·683**	·622*	—·200	1·000				—1·19 (·32)**	—·47 (·41)	—2·02 (·25)**
6. Registered articles	—·796**	—·733**	·382	—·183	·825**	1·000			—1·63 (·35)**	—1·16 (·40)*	—2·13 (·48)**
7. Total mail	·972**	·984**	—·538*	·417	—·662**	—·762*	1·000		1·72 (·10)**	2·35 (·19)**	1·05 (·05)**
8. First class mail	·999**	·924**	—·509	·348	—·655*	—·793*	·977**	1·000	1·30 (·08)**	2·00 (·18)**	·73 (·07)**
9. Second class mail	·917**	·999**	—·553*	·453	—·676*	—·733*	·984**	·924**	2·87 (·29)**	3·17 (·41)**	2·38 (·13)**

* = significant at 95 per cent level
** = significant at 99 per cent level

Notes to Table: Total mail = sum of categories 1 to 6.
First class mail = letters + postcards.
Second class mail = printed papers+newspapers.
All magnitudes in the table, except those in the last two columns, refer to the whole country.
All correlation coefficients are based on the absolute levels of the variables.
Average annual growth rates in the last three columns are calculated by regressing the natural logarithms (not the absolute levels) of the appropriate variable on a time trend, as suggested by Geary (1972). Figures in parentheses are standard errors of the estimated coefficients of the time trend.

Table 2.3 gives the average annual growth rates of total, first class, and second class mail, as well as of the ratio of first class to total mail,[3] for fifty head post office catchment areas. It is apparent that the same trends which were shown by the country as a whole also apply to practically all these head post offices: total mail has increased in all but two catchment areas between 1949 and 1969, though at fairly moderate rates (on average by 1.21 per cent per annum); similarly, both first and second class mail have in general increased in volume, but the latter has increased at faster rates, leading to a decline in the share of first class mail in total mail.

Of course, not too much importance should be attached to the absolute magnitudes of the growth rates in the table, since they take no account of differential movements in the population or income of different offices' catchment areas. However, a casual inspection suggests that the decline in the share of first class mail has been slower in the less developed areas of the country. A final point worth noting from the table is that the growth rate for the country as a whole of each of the three mail categories shown is markedly higher than the average of the corresponding growth rates over all fifty post offices. This is so because the areas with the largest shares of mail volume (particularly Dublin, which accounts for over 40 per cent of the total in each category), had greater than average growth rates.

In conclusion, this section has noted a number of features of the trends in mail volume between 1949 and 1969 which merit further study. These include, the relatively low growth rates of all categories, the faster growth of second class compared with first class mail, and a slower decline in the share of first class mail in the less developed areas of the country. In order to investigate these and other aspects of mail growth, the next sections examine the determinants of the growth in mail volume. The main conclusions reached are summarised in section 2.7.

2.2 *Theoretical Determinants of Postal Demand*

Needless to say, to account for the rate and pattern of growth in mail volume is considerably more difficult than to describe it, and requires the explicit application of econometric techniques. The first stage in such an application is to list the influences which, on an *a priori* basis, may be expected to affect the demand for postal services. As in any demand study, these should include, at a minimum, some measure of income, the price of the good or service in

3. The growth rate of this ratio is given in preference to the difference between the growth rates of first and second class mail, because the former conveys additional information. This may be seen from the formula $g=(1-F)(f-s)$, where g is the growth rate of the ratio of first class to total mail, $(f-s)$ is the algebraic difference between the growth rates of first and second class mail, and F is the average ratio of first class to total mail over the period. The signs of g and $(f-s)$ will always be identical, and by using this formula the approximate value of $(1-F)$ F and $(1-F)$ in any office may be calculated from the table.

TABLE 2.3: *Average annual growth rates of selected mail categories in 50 head post office districts, 1949–69*

	Head Post Office	Average annual growth rates, %, 1949–69 Total mail	First class mail	Second class mail	Ratio of first class to total mail
1	An Uaimh	2·39	1·85	4·71	—·65
2	Athlone	1·91	1·32	3·74	—·65
3	Ballina	·44	·12	1·99	—·36
4	Ballinasloe	·80	·76	2·27	—·21
5	Bandon	2·27	2·24	2·91	—·17
6	Bantry	·75	·43	3·94	—·47
7	Birr	·0	—·82	2·90	—·97
8	Bray	·46	·02	2·37	—·59
9	Carlow	2·21	1·42	4·34	—·92
10	Carrick-on-Shannon	·0	—·18	1·57	—·29
11	Castlebar	·75	1·30	1·02	·42
12	Castlerea	·39	·31	1·35	—·17
13	Cavan	1·56	·45	4·89	—1·22
14	Ceanannus Mor	1·10	1·04	2·64	—·26
15	Claremorris	·87	·71	2·27	—·28
16	Clonmel	1·13	·72	2·49	—·52
17	Cork (including Cobh)	1·53	1·38	2·16	—·30
18	Donegal	—·69	—·87	·36	—·21
19	Drogheda	1·84	1·11	3·31	—·82
20	Dundalk	·73	·74	1·49	—·23
21	Ennis*	·73	·85	·68	·03
22	Enniscorthy	·59	·26	1·99	—·50
23	Galway	1·91	1·85	2·47	—·12
24	Gorey	·45	—·22	3·95	—·77
25	Kilkenny	1·85	1·49	3·21	—·49
26	Killarney	1·76	1·87	1·71	·02
27	Kilmallock	·33	·10	1·71	—·33
28	Letterkenny	1·11	·80	3·69	—·48
29	Lifford	1·31	1·68	1·27	·08
30	Limerick	2·15	1·89	2·93	—·33
31	Longford	—·38	—·65	1·00	—·33
32	Mallow	1·19	1·29	1·26	·01
33	Monaghan	·62	·44	1·88	—·30
34	Mullingar	·20	·03	1·12	—·28
35	Naas	2·92	2·21	5·45	—·83
36	Nenagh	2·00	2·04	2·31	—·06
37	Port Laoise	1·44	·91	3·84	—·62
38	Roscommon	2·93	2·06	6·27	—·87
39	Skibbereen	·98	·87	2·21	—·26

continued

*Figures for Ennis in 1969 were not available. Accordingly the growth rates shown are based on the change between 1949 and 1968.

Note: All growth rates were calculated using the usual compound interest formula. This accounts for the small discrepancies between the figures given here for Dublin and All Country, and the corresponding figures in Table 2.2.

TABLE 2.3—*continued.*

Head Post Office	*Average annual growth rates, %, 1949–69* Total mail	First class mail	Second class mail	Ratio of first class to total mail
40 Sligo	1·54	1·41	3·68	—·28
41 Thurles	1·42	1·04	3·17	—·58
42 Tipperary	·50	·33	1·87	—·29
43 Tralee	1·48	1·31	2·29	—·25
44 Tuam	·99	1·08	1·46	—·10
45 Tullamore	3·49	3·14	5·63	—·50
46 Waterford	1·45	1·65	1·59	·02
47 Westport	·99	·96	1·87	—·20
48 Wexford	·85	1·02	·74	·09
49 Wicklow	1·03	·35	3·51	—·75
50 Dublin (including Dun Laoghaire)	2·26	1·73	3·28	—·63
All Country	1·89	1·32	2·96	—·56
Mean of 50 offices	1·21	·96	2·62	—·38
Standard Deviation	·86	·84	1·35	·32

question, and the price and availability of competing or complementary goods and services.

Considering income first, it is customary to take personal expenditure on consumers' goods and services as the appropriate independent variable in a study of consumer demand. This is done because the traditional static theory of consumer demand deals only with the allocation of a fixed budget between different commodities and ignores inter-temporal considerations. In other words, it is assumed that the consumer (or, in aggregate, all consumers) maximises utility by a two-stage process, first dividing current income between consumption expenditure and saving, and then imposing this chosen level of total consumption expenditure as a fixed constraint on the maximisation of utility from current consumption.

In the case of postal services, however, the fact that a large proportion of mail posted comes from the business sector suggests an alternative approach to the choice of income variable. Instead of treating the volume of postal demand as the outcome of utility maximisation on the part of consumers, it may be viewed as a consequence of profit maximisation (or cost minimisation) on the part of firms. This type of reasoning, though rarely explicitly worked out in a formal model, is often used to justify treating the demand for goods as a derived demand, resulting from the use of such goods as inputs in the production process. The implication of such an approach is that the appropriate "income" variable to use in a demand equation should be some proxy for the level of general business activity, gross national product being the obvious and most common choice.

In the present study, the choice of variable to represent income was further complicated by the availability of data. As explained below, it was desired to estimate cross section as well as time series demand functions; however, the only income variable for which data covering Irish counties is available is personal income, as estimated by M. Ross (1972). This is not a very satisfactory variable, since it includes both savings and direct taxation. However, where no alternative was available, it was necessary to make use of it.

To sum up, three possible measures of "income" have been suggested. Of these, personal consumer expenditure is the most appropriate on theoretical grounds, at least as far as personal demand for postal services is concerned. It has therefore been used in this study wherever possible. However, because some elements of doubt remain about its appropriateness, the performance of all three variables is investigated empirically in section 2.3 below.

As far as the magnitude of the income elasticity is concerned, theoretical considerations tell us nothing, though it seems reasonable to expect it to be positive, in other words that postal services are not an inferior good. The only extraneous sources of empirical evidence on this point are the Household Budget Inquiries of 1951–52 and 1965–66, the data from which are discussed in Appendix A. It is shown there that in both inquiries the income elasticity of expenditure on postage and telephones combined was well in excess of unity (1·64 in 1951–52 and 1·82 in 1965–66). The income elasticity of postage alone, however, while greater than unity in the earlier year, appears to have fallen below unity in the latter year. (Unfortunately, the quality of the data does not permit more accurate estimation of the elasticity.) Since, in any case, these data relate only to the purchases of urban consumers, we would not expect them to be identical with the results derived from the study of total postal demand presented in sections 2.3 to 2.5 below.

The next obvious determinant of the demand for postal services is their price. It is possible to say rather more on *a priori* grounds about the likely quantitative effect of postal charges on mail volume than could be said in the case of income. Specifically, there are good reasons for expecting that postal charges are unlikely to have a significant effect on the number of items posted provided they do not diverge markedly from their historic levels. One reason is the nature of postal traffic: given present technology there is no equally inexpensive substitute for mail services as a method of distributing large numbers of items such as bills, cheques, receipts, etc.[4] Though no direct evidence is available,

4. See, however, the discussion in section 2.6 below.

these items alone must constitute a sizeable proportion of total mail traffic A second factor is that for most business mail, the postage charge is only a small proportion of the costs of sending a letter.[5] A report by the British Post Office (1970) attempted to estimate this proportion. For 1970, it found that average typing costs were 10p per letter in London and 7½p elsewhere in Britain to which must be added the costs of drafting, dictating and checking. Even though the marginal costs associated with these activities may be considerably lower, they are still likely to be substantial compared with postal charges of 2p and 2½p. It seems likely, therefore, that moderate increases in real postal charges would have relatively little effect on the total cost of sending a business letter. Of course the same argument cannot be applied to non-business mail; on the contrary, there is a widespread belief that recent increases in postal charges have led to a falling-off in the volume of personal mail posted.[6] Nevertheless, it seems likely that the overall impact of changes in postal prices on the volume of mail posted will not be very substantial; on balance, therefore, we would not expect a variable for postal prices to be very significant in a regression analysis of the volume of mail posted. Note, finally, that what is being discussed here is the long-term effect of postal charges on mail volume. Nothing in what has been said negates the possibility that increases in postal charges, especially large and well-publicised increases, may have a short-run effect of causing a falling off in demand in the period immediately after their introduction.

Turning next to complementary and competing goods, an obvious competitor to postal services is the telephone. Thus, when telephones become more widely available, or when telephone prices fall relative to postal prices, we would expect the demand for postal services to fall as a result. Both these influences have therefore been tested, although it is worth remarking that a single equation framework (the only econometric method used in this paper) is not a very accurate way of measuring cross-elasticities between different goods and services, while adequate data for jointly estimating the demand functions for both postal and telephone services were not available.

So far, the discussion of the determinants of postal demand has followed the conventions of demand theory by focusing on the behaviour of individual consumers. The present study, however, is concerned with the total demand for postal services, from all private and business users. This fact poses a serious problem of aggregation to which no fully satisfactory solution is possible. One common type of corrective action which was adopted, was to estimate all equations in *per capita* form—this at least ensures that variations in the volume

5. An exception to this would be the case of an advertising campaign carried on by post, for which mail charges might account for a substantial proportion of total costs.

6. A frequently cited example is the decline in the number of Christmas cards posted; however, this may equally have been caused by increases in the price of cards themselves.

of postal services demanded due to population changes are not attributed to other influences.[7]

There is, however, a further aspect of the aggregation problem which arises in any study of the demand for communications, namely, the likelihood that such demand will be influenced by the spatial characteristics of the area considered. The direction of the influence involved is not obvious on *a priori* grounds.

On the one hand, it could be argued that greater agglomeration of population is more conducive to face-to-face communication, and so should reduce the demand for postal services.[8] On the other hand, increases in population density could act as a proxy for some influences (other than income or telephone availability) such as greater commercialisation or more intensive business activity, which would tend to increase postal demand, especially from the business sector. Misleading conclusions could be drawn from a study which uses data at national or county level, unless some attempt is made to incorporate these factors explicitly into the analysis. For this reason, therefore, both the population density and the proportion living in urbanised areas in each post office catchment area, were included as independent variables in the cross section demand study, with the expectation that their effects (if any) should be negative on first class mail and positive on second class.

This completes the list of independent variables to be included in the regression equations. However, before looking at the results, it must first be asked whether it is appropriate to use single-equation techniques to estimate demand functions for postal services, given that traditional economic theory argues that the price and quantity at which any good is traded are determined simultaneously by supply and demand. The possibility that single-equation econometric studies which ignore this fact may be biased by confusing the effects of shifts in demand with those of shifts in supply has been given the name "the identification problem".[9] In the present study, however, this problem is not considered serious enough to merit special attention. This is because the prices charged for postal services do not vary in the short run with the level of demand. Moreover, the post office is legally obliged to accept all duly stamped mail, and has never been unable to deal with all that was posted because of serious lack of facilities.

From the point of view of consumers, therefore, the price of postal services is a completely exogenous (extraneous) factor, and so the use of single-equation

7. The same cannot be done simply by including total population among the independent variables in an undeflated equation. For, since population has been falling over most of the period, any population variable appears with a significantly negative sign, a theoretically nonsensical result.

8. As far as personal expenditure on postal services is concerned, this hypothesis is consistent with evidence from the Household Budget Inquiries, reviewed in Appendix A.

9. This problem is explained in any econometrics textbook. See, for example, Johnston (1972), Chapter 12.

econometric techniques to estimate the demand curve is fully justified. This is in accordance with general practice: as noted by Cramer (1969, page 213), the services of regulated public utilities are one of the few categories to which this fairly simple methodology is more or less completely applicable.

2.3 *Time Series Demand Functions, 1949–1969*

Because of the large quantity of data available on mail postings, a number of alternative approaches were possible to the estimation of demand functions. As with most demand studies, the first approach adopted was to estimate time series equations, and the results obtained are described in this section.

However, the data were relatively unsuitable from the point of view of estimating time series demand functions. In the first place, only fourteen observations were available, making the sample an extremely small one, even by the usual standards of time series econometric work.[10]

A second and related difficulty with the data is the fact that they are not equi-spaced. As a result, the conventional tests and remedies for autocorrelation cannot automatically be applied.[11] Moreover, nothing can be done to investigate the dynamic aspects of postal demand, by applying, for example, the state adjustment model developed by Houthakker and Taylor. This is especially unfortunate, since it makes it impossible to test the conjecture made in section 2.2 above that the long run and short run price elasticities may be different.

Keeping in mind these reservations about the data,[12] the next problem to be considered is the choice of functional form for the equations to be estimated. With only fourteen observations available, it was obviously inadvisable to use up degrees of freedom by considering a large variety of functional forms. Accordingly, attention was confined to the two simplest forms, the linear and the log-linear, even though both of these are only approximations to (and if applied to all goods are not in general consistent with) the complete system of demand equations derivable from the classic theory of consumer behaviour.

Accordingly, the equations presented in Table 2.4 give the results of regressing total mail per head on a time trend and on each of three income variables, in

10. This problem is partly offset by the fact that these fourteen observations cover a period of twenty-one years. They are thus no less variable than a full coverage of the same period would be; and since, by comparison with a sample of fourteen consecutive years, they are more spread out, they therefore exhibit a wider range of variation, and may be said to have a greater information content.

11. For this reason both tables in this section present two tests for autocorrelation, the Durbin-Watson *d* and Geary's *tau*. In normal situations this would not be necessary: since *d* makes use of more information than *tau*, we would expect it to be invariably more powerful. However, in the present case the existence of non-equi-spaced observations means that the tabulated significance points of *d* do not strictly apply, whereas those of *tau* do apply, because the latter's alternative hypothesis is the general one of non-randomness (On this see Belsley, 1973).

12. A further difficulty with the data is that the counts of mail volume, from which they are derived, were not taken in the same month of each year. This raises the possibility that the data from different years may not be comparable because of seasonal variation. This problem is investigated in Appendix B, where it is found that the bias involved is likely to be small.

TABLE 2.4: *Time series regressions: total mail per head regressed on different income variables, 1949–69*

Equation No.	*Equation (t-values in parentheses)*	$R^{2'}$	τ	d
A1	$Q = 1{\cdot}569 + 0{\cdot}389T$ $(70{\cdot}12)\ (20{\cdot}20)$	·972	6	1·89
A2	$Q = {\cdot}718 + {\cdot}00525X_1$ $(5{\cdot}61)\ (9{\cdot}78)$	·889	2**	·50**
A3	$Q = {\cdot}802 + {\cdot}00563X_2$ $(5{\cdot}40)\ (7{\cdot}89)$	·839	2**	·42**
A4	$Q = {\cdot}583 + {\cdot}00787X_3$ $(4{\cdot}13)\ (9{\cdot}83)$	·889	4	·45**
A5	$\log Q = {\cdot}465 + {\cdot}0199T$ $(34{\cdot}86)\ (17{\cdot}38)$	·964	5	1·50
A6	$\log Q = -3{\cdot}001 + {\cdot}673 \log X_1$ $(8{\cdot}18)\ (9{\cdot}99)$	·899	2**	·54**
A7	$\log Q = -2{\cdot}694 + {\cdot}633 \log X_2$ $(6{\cdot}23)\ (7{\cdot}76)$	·850	4	·44**
A8	$\log Q = -3{\cdot}151 + {\cdot}741 \log X_3$ $(8{\cdot}00)\ (9{\cdot}68)$	·897	4	·47**

Notes: In all the time series regressions appearing in this and subsequent tables the number of observations is 14. As explained in the text, only 14 observations on the mail data were available, covering, at irregular intervals, the period 1949–69. All logarithms are natural logarithms.

Key: $R^{2'}$ = Coefficient of multiple determination, adjusted (where necessary) to measure goodness of fit in "original variable space" (i.e. for equations A5 to A8, this statistic gives the squared correlation between Q and the anti-logs of the predicted values of $\log Q$).

τ = Geary's *tau* statistic, testing for non-randomness of the residuals:
** indicates that the null hypothesis of randomness may be rejected with 95 per cent confidence;
The (single-tailed) critical values are tabulated in Habibagahi and Pratschke (1972).

d = Durbin-Watson statistic, testing for first order autocorrelation of the residuals:
** indicates that the hypothesis of no positive autocorrelation can be rejected with 95 per cent confidence;
* indicates that the test is inconclusive.
(See footnote in text for reservations concerning the applicability of this test to the present case, where the data are not equi-spaced.)

Variables: Q = Total pieces of mail posted per head of population in a representative week of each year (includes letters, printed papers, newspapers and postcards, but excludes parcels and registered letters).
T = Time in years (1949=0).
X_1 = GNP (Gross National Product) per head of population at constant (1958) prices.
X_2 = Personal income per head, deflated by consumer price index (1958=100).
X_3 = Personal expenditure on consumers' goods and services per head, at constant (1958) prices.

both linear and log-linear form. (For reasons given in the previous section, all the demand functions in this paper have been estimated in *per capita* form.) To permit comparisons between the two equation forms the coefficients of multiple determination (R^2) for the log-linear equations have been recalculated in "original variable space"; in other words they give the squared correlations between the actual values of the dependent variable and the anti-logs of the values predicted by each equation.

The first noticeable feature of the table is the considerably better performance of the time trend compared with any of the income variables. Equations A1 and A5[13] have appreciably higher coefficients of determination than any others, and they are also the equations which show least evidence of autocorrelation, as measured by both Geary's *tau* and the Durbin-Watson *d*. This is a worrying result, since no unambiguous economic interpretation can be attached to a regression on a time trend, no matter how satisfactory the equation by the conventional tests. Nevertheless, from the point of view of forecasting, it suggests that the most satisfactory forecasts of future mail volume will be those derived from a time trend equation. This point is pursued in section 2.6 below.

Secondly, different income variables make relatively little difference to the goodness of fit. The worst performer (though the differences between R^2's are far from significant) is X_2, personal income per head. This is only to be expected, since the variable measures neither consumers' purchasing power nor the level of business activity, and is only included to permit comparison with the cross section equations in section 2.4 below. On the other hand, X_1 (GNP) and X_3 (Personal consumers' expenditure), give almost identical results, despite the very different theoretical reasons for including them. Since the theoretical grounds for including X_3 are rather stronger, and since its performance is as good as or better than that of the other two variables, it is therefore included in all the remaining regressions in this section.

Finally, it may be seen from the table that it makes virtually no difference to the goodness of fit whether a given equation is estimated in linear or log-linear form: the adjusted R^2's for corresponding equations, for example, A2 compared with A6 and A3 compared with A7, are virtually identical. Accordingly, nothing is lost by concentrating, in the remainder of this section, on the log-linear formulation, which from an economic point of view has the convenient property that its coefficient estimates are also estimates of elasticities.

Having determined the choice of income variable and functional form, Table 2.5 gives more regressions for total, first class and second class mail, all per head of population. Considering first those with total mail as dependent

13. Notice that the growth rate of total mail per head implied by equation A5 (1·99 per cent per annum) is marginally higher than the growth rate of total mail given in Table 2.2. This is caused, of course, by the downward trend in population over the period.

TABLE 2.5: *Time series regressions: different mail categories regressed on selected independent variables*, 1949–69

Equation No.	*Dependent variable*	*Equation (t-values in parentheses)*	$\bar{R}^2$	τ	*d*	*Chi-square*
B1	Total mail per head	$\log Q = \cdot465 + \cdot01991\ T$ (34·86) (17·38)	·959**	5	1·50	
B2	,,	$\log Q = -3\cdot151 + \cdot741 \log Y$ (8·00) (9·68)	·877**	4	·47**	
B3	,,	$\log Q = -2\cdot397 + \cdot846 \log Y - \cdot279 \log P$ (3·77) (8·29) (1·47)	·888**	4	1·19*	8·27
B4	,,	$\log Q = -4\cdot683 + \cdot916 \log Y - \cdot312 \log P + \cdot454 \log P_T$ (4·78) (10·77) (2·06) (2·72)	·929**	9	2·20	6·68**
B5	,,	$\log Q = -2\cdot054 + \cdot013 \log Y + \cdot255 \log Tel$ (5·62) (·02) (2·53)	·948**	5	1·68	·90**
B6	First class mail per head	$\log Q = \cdot087 + \cdot01451\ T$ (7·97) (15·40)	·948**	5	1·26*	
B7	,,	$\log Q = -2\cdot549 + \cdot540 \log Y$ (8·54) (9·31)	·868**	4	·66**	
B8	,,	$\log Q = -1\cdot660 + \cdot640 \log Y - \cdot305 \log P$ (4·15) (10·89) (2·78)	·916**	4	1·38*	11·30
B9	,,	$\log Q = -2\cdot907 + \cdot662 \log Y - \cdot282 \log P + \cdot226 \log P_T$ (3·83) (12·18) (2·83) (1·87)	·931**	7	1·59*	8·78*
B10	Second class mail per head	$\log Q = -\cdot691 + \cdot03014\ T$ (20·23) (10·26)	·889**	7	1·70	
B11	,,	$\log Q = -6\cdot141 + 1\cdot117 \log Y$ (7·93) (7·42)	·806**	4	·84**	
B12	,,	$\log Q = -5\cdot837 + 1\cdot198 \log Y - \cdot152 \log P$ (6·24) (5·93) (·62)	·796**	4	1·01*	10·11
B13	,,	$\log Q = -11\cdot228 + 1\cdot510 \log Y - \cdot465 \log P + 1\cdot151 \log P_T$ (5·75) (8·08) (2·16) (2·97)	·880**	10	2·75	5·57

Key: $\bar{R}^2$ = Coefficient of multiple determination, adjusted for degrees of freedom:
*indicates that the associated *F*-statistic is significant at the 95 per cent level;
**indicates that it is significant at the 99 per cent level.
τ = Geary's *tau* statistic, as in Table 2.4.
d = Durbin-Watson statistic, as in Table 2.4.
Chi-Square = Bartlett-Haitovsky Chi-Square statistic, testing for absence of multicollinearity:
**indicates that the hypothesis of perfect multicollinearity cannot be rejected with 95 per cent confidence;
*indicates that it can be rejected with 95 per cent but not with 99 per cent confidence. See Haitovsky (1969) for an explanation of this test.

Variables: Q = Number of pieces posted in relevant mail category per head of population in a representative week of each year:
Total mail: As in Table 2.4.
First class mail: letters + postcards.
Second class mail: printed papers + newspapers.
Y = Personal expenditure on consumers' goods and services per head, at constant (1958) prices.
P = Price index of relevant mail category, deflated by consumer price index.
P_T = Price index of telephone charges, deflated by consumer price index.
Tel = Number of telephones in country per head.

variable, equations A5 and A7 have been repeated as B1 and B2, to facilitate comparison with B3, B4, and B5. It is apparent that B1, the simple regression on a time trend, is still the best equation in statistical terms. However, on economic grounds, equations B3 and B4 are of more interest: both show significantly negative own-price elasticities, while equation B4 has a significantly positive cross-price elasticity with respect to telephone charges. This latter equation is extremely satisfactory in both economic and statistical terms, and despite the presence of multicollinearity, indicated by the value of the Chi-Square statistic, its coefficients may be considered the best parameter estimates available. Expressed in terms of 95 per cent confidence intervals, these coefficients imply that the true value of the income elasticity lies between 0·73 and 1·11, of the own-price elasticity between −0·65 and 0·03, and of the cross-price elasticity with respect of telephone charges between 0·08 and 0·83. Although these ranges are, undoubtedly, rather wide, they are the best that can be obtained with the available data.

The last equation in this group, B5, gives the regression of total mail on expenditure and telephones; the coefficient of the latter variable is significant but with a theoretically unlikely positive sign, and the two independent variables appear to be highly multicollinear, leading to an insignificant coefficient for Y. This is all the more noteworthy since Y performs very well in the other three equations where it is included: the estimated elasticity is significantly different from zero at the 0·1 per cent level, and except in equation B4, it is significantly different from unity at at least the 25 per cent level. It must therefore be concluded that this attempt to measure the effect of telephone availability on postal demand has not been successful.

Turning to the equations for first and second class mail, it is apparent that the different trends in these two magnitudes, already noted in section 2.1, are matched by different responses to economic influences. Thus, the income elasticity for first class mail is significantly less than unity, while that for second class is greater than unity (though not significantly in equations B11 and B12).[14] As for own-price elasticities, that for first class mail is consistently significant with a value around −0·3, but that for second class mail is ambiguous, being insignificant in equation B12 but significant in equation B13. It seems safest to conclude that the influence of its own price on the demand for second class mail must remain an open question. Equation B13 also gives an estimated elasticity for second class mail with respect to the level of telephone call charges of 1·15, which, though rather high, is not implausible since it is reasonable to

14. Since it has been argued that second class mail is composed mainly of business mail, some experimentation with GNP as income variable was carried out, along the lines of the equations for total mail in Table 2.4. However, the results were not sufficiently different from those using consumers' expenditure as independent variable to merit reproduction.

expect business mail to be more responsive to the price of alternatives than private (i.e. first class) mail.

Finally, all the equations shown were separately re-estimated for both Dublin and the rest of the country. The dominant position of Dublin, accounting for over 40 per cent of the national total in all categories, and its faster rate of growth, have already been mentioned in section 2.1. As a result of the latter, the share of Dublin in national mail has been increasing for both major classes of mail over the sample period, but from a lower level and at a faster rate for first class than second class. This can be seen from the following time trend equations, where the dependent variable in each case is (the natural logarithm of) the share of Dublin in the national total of the relevant mail category:

Total mail: $\log S_1 = \underset{(621\cdot1)}{3\cdot921} + \underset{(6\cdot35)}{\cdot0064}T$ $\quad \bar{R}^2 = \cdot752, \quad d = 1\cdot79$

First class mail: $\log S_2 = \underset{(521\cdot4)}{3\cdot796} + \underset{(6\cdot01)}{\cdot0070}T$ $\quad \bar{R}^2 = \cdot730, \quad d = 0\cdot92$

Second class mail: $\log S_3 = \underset{(515\cdot5)}{4\cdot121} + \underset{(2.38)}{\cdot0030}T$ $\quad \bar{R}^2 = \cdot263, \quad d = 1\cdot82$

Both the intercepts (which give the logarithm of the predicted share for $T=0$, i.e. 1958), and the slope coefficients, differ significantly between the last two equations, at the 95 per cent level at least.[15] It would be of interest to see whether these differences in trends could be explained by differential movements in the factors affecting mail volume in both categories between the two areas. Unfortunately it was not possible to investigate this, since separate figures for the principal independent variable, personal consumers' expenditure, are not available. Accordingly, although some equations were estimated for Dublin and the rest of the country, national personal consumers' expenditure had to be used as independent variable; and since, apart from the estimated coefficients of this variable the results were not noticeably different from those in Tables 2.4 and 2.5, it was not considered worthwhile reproducing them.

2.4 *Cross Section Demand Functions, 1965*

As already mentioned, a time series analysis is only one of many possible approaches to the estimation of demand functions, given the large data matrix

15. Taken at face value the slope coefficients imply that the share of Dublin in first class mail will overtake that in second class around the year 2040, assuming that past trends continue to repeat themselves.

available for the present study. Furthermore, with only fourteen observations available, the disadvantages of such an approach are magnified, and, in particular, it is not a very sensitive method for discriminating between competing hypotheses. If only as a check on the time series results, it was therefore thought desirable to test the hypotheses put forward in section 2.2 in a cross section framework.

The first problem encountered with this approach was the need to confine attention to those years for which roughly contemporaneous data on potential explanatory variables were available. Effectively, this meant that only the years for which M. Ross has estimated personal incomes by county could be considered, i.e., the returns of mail posted in the weeks ending the 15 October 1960, the 16 October 1965 and the 18 October 1969 were chosen. Furthermore, rather than examine all three years in equal detail, it was decided to begin by concentrating attention on the observations for 1965. The present section therefore discusses the equations which were estimated for that year. Those specifications which gave successful results for 1965 were then applied to the remaining two years, as well as to all three years combined, and the results are given in section 2.5.

The next problem was the need to group the observations so as to ensure compatibility of coverage between the dependent and independent variables. As already mentioned, the data on mail postings which were made available to the author covered fifty-two head post office districts throughout the State. As a first step it was decided to reduce this to fifty by combining Dun Laoghaire with Dublin and Cobh with Cork: since the delineation of boundaries between the catchment areas of each of these pairs of offices is almost certainly fairly arbitrary, and since Dun Laoghaire and Cobh may be thought of as belonging to the greater urban areas of the two cities, little worthwhile information is likely to have been lost in this way. Unfortunately, however, because the principal independent variable—personal income—was available only on a county basis, it was necessary to go further and aggregate the mail data into twenty-six groups, which correspond approximately with county boundaries.[16]

Another problem which was encountered in some preliminary regressions was the fact that the observation on County Dublin lay considerably outside the range of the observations on the remaining twenty-five counties, with the result that the inclusion of Dublin in an equation led to significant changes in the estimated coefficients. Two alternative methods of overcoming this difficulty were available: either the observation on Dublin could be dropped altogether, or the regressions could be estimated for all twenty-six counties, but with some correction for heteroscedasticity. On further investigation, however, both these

16. For details on the problems relating to the income variable, see Appendix B, section B.2.

approaches were found to yield statistically indistinguishable results.[17] Accordingly, the greater simplicity of the first method, omission of the Dublin observation, led to its adoption in all the equations presented in this and the following section.

The only remaining matter to be decided was the functional form of the equations. In the light of the experience with time series models, described in section 2.3 above, it was decided to estimate all equations in log-linear form, with variables expressed in *per capita* terms. Some experimentation with alternative specifications suggested that the findings were not sensitive to the form adopted.

Table 2.6 gives the principal equations which were estimated with total mail per head as dependent variable. The only unusual feature of the table is the final column of *t*-statistics, which test the significance of the difference between the actual value of total mail per head in Dublin and the value predicted by the equation in question. It is apparent that, except for the two equations which contain population density as an independent variable, the predicted value diverges significantly from the actual.[18] This further confirms the advisability of estimating all equations with Dublin omitted.

Turning to the actual equations in Table 2.6, equation C1 gives the simple regression of total mail per head on personal income per head. The degree of explanation is satisfactorily high for a cross section equation and the estimated income elasticity is insignificantly different from the corresponding time series estimate, (i.e., 0·633 from equation A7 in Table 2.4). Some attempts were made to construct proxy variables for the level of business activity in "postage-intensive" sectors, using the data on county employment in Baker and Ross (1974), but in all cases the level of explanatory power attained by them was considerably inferior to that of personal income.

Of the remaining equations in the table, numbers C2 to C4 attempt to test the hypothesis put forward in section 2.2 that an individual consumer's or firm's demand for postal services will be influenced by the spatial characteristics of the area in question. Using aggregate data this hypothesis can only be tested rather crudely by including variables such as population density and the proportion of population in urban areas in the cross section demand equations. It is apparent that the former variable gives more satisfactory results, though it causes a reduction in the estimated coefficient of personal

17. This finding is documented in an unpublished manuscript available on request from the author.
18. The exceptional behaviour of equations C2 and C4 may be explained by the fact that the population density variable is characterised by an enormous gap between the value for Dublin (1,541·4 persons per square mile), and the values for all other counties (the next highest is Cork with 159·8 per square mile, and the lowest is Mayo with a value of 54·9). The consequence of this may be expressed by saying that, from the point of view of calculating the *t*-statistics in the last column of Table 2.6 the population density variable is barely distinguishable from a dummy variable which takes a value of one for Dublin and zero for all other observations.

TABLE 2.6: *Cross section regressions for total mail per head, 1965*

Equation No.	*Regression coefficients (t-values in parentheses)*						$\bar{R}^2$	*Chi-square*	*t*
	Intercept	*Y*	*D*	*U*	*T*	*STD*			
C1	—3·692	·780					·331**		4·97**
	(3·30)	(3·59)							
C2	—2·687	·422	·191				·354**	11·13	1·02
	(2·02)	(1·24)	(1·34)						
C3	—2·188	·374		·161			·347**	8·05	5·16**
	(1·33)	(·95)		(1·24)					
C4	—1·737	·183	·154	·123			·348**	2·54**	1·25
	(1·02)	(·42)	(1·03)	(·91)					
C5	—3·414	·702			·016		·305**	17·43	4·33**
	(2·52)	(2·33)			(·38)				
C6	—3·374	·715				·037	·309**	31·99	4·92**
	(2·62)	(2·82)				(·52)			

Note: Observations on all variables are based on data for catchment areas of 50 head post offices, grouped into 25 geographical units, approximately co-terminous with county boundaries.
County Dublin is omitted from all equations.

Key: See notes to Table 2.5.
t = t-statistic, testing the hypothesis that total mail per head in Dublin comes from the same population as the observations on the 25 counties used to estimate the equation in question; ** indicates that the hypothesis can be rejected with 99 per cent confidence; * indicates that it can be rejected with 95 per cent confidence.

Variables: Dependent: Q = Log {Total mail per head}.
Independent: Y = Log {Personal income per head}.
D = Log {Population density}.
U = Log {Proportion of population living in urban areas}.
T = Log {Number of telephones}.
STD = Dummy variable for availability of STD (Subscriber Trunk Dialling):
0—if no major centres in "county" had STD in October 1965;
1—if all major centres in "county" had STD in October 1965;
value between 0 and 1—if some but not all major centres in "county" had STD in October 1965.

income (equation C2). Moreover, the close relationship between the two spatial variables leads to extreme multicollinearity when both are included in the same equation (C4): the equation as a whole is highly significant by the *F*-test, but none of the individual coefficients are significant even at the 75 per cent level.

The only other determinant of mail volume which was considered was that of telephone availability. Two alternative measures of this influence were tested: the number of telephones per head in each county, and a dummy variable representing the degree of availability of STD (Subscriber Trunk Dialling) in each county in October 1965. This variable is obviously a measure of the quality rather than the prevalence of telephone availability; and its likely influence on postal demand might be thought small in the light of the small proportion of calls accounted for by trunk calls. Nevertheless, post office experience in the past has been that the introduction of STD has led to a marked and immediate increase in the use of existing telephone equipment; and it is of interest to test whether this has had any repercussions on mail volume.

However, neither measure of telephone availability proved significant, as may be seen from equations C5 and C6. Moreover the signs of their estimated coefficients were positive, contrary to theoretical expectations. Accordingly, it must be concluded that this attempt to quantify the inter-connection in demand between postal and telephone services has failed to show that such a link exists, at least between counties in 1965.

The equations so far discussed have referred exclusively to total mail per head. However, it is of some interest to consider the behaviour of the different components of this total. As with the time series data considered in section 2.3, the principal categories are letters and printed papers; taking an average of all 52 post offices, they account for 58·5 per cent and 36·8 per cent of the total respectively, while newspapers and postcards only account for 2·1 per cent and 2·7 per cent. Accordingly, attention is concentrated, as before, on the composite categories of first and second class mail.

The correlation between these two classes in different counties in 1965 was extremely high ($r=0{\cdot}883$); nevertheless their behaviour exhibits significantly different patterns, as may be seen from Table 2.7. In the case of first class mail, its level was totally unrelated to any of the independent variables tested, with the result that the adjusted correlation coefficients in equations D1 to D4 attain their minimum value. Second class mail, on the other hand, is significantly related to both income and population density, and the degree of explanation attained is quite high. The positive coefficient of the population density variable (which performs better than the variable for the proportion of population living in urban areas) confirms the expectation put forward in

TABLE 2.7: *Cross section regressions for different mail categories, 1965*

Dependent variable	*Equation No.*	*Regression coefficients (t-values in parentheses)*					$\bar{R}^2$	*Chi-square*	*t*
		Intercept	*Y*	*D*	*U*	*TOUR*			
Log {First class mail per head}	D1	−·956	·182				0·0		4·69**
		(·83)	(·81)						
	D2	−·744	·107	·040			0·0	11·13	1·79
		(·52)	(·29)	(·26)					
	D3	·144	−·115		·118		0·0	8·05	4 **
		(·08)	(·28)		(·86)				
	D4	·158	−·121	·005	·116		0·0	2·54**	1·93
		(·09)	(·26)	(·03)	(·80)				
Log {Second class mail per head}	D5	−12·599	2·262				·597**		2·31*
		(6·53)	(6·04)						
	D6	−10·063	1·360	·482			·646**	11·13	·76
		(4·60)	(2·42)	(2·06)					
	D7	−9·730	1·488		·307		·612**	8·05	2·54*
		(3·47)	(2·22)		(1·38)				
	D8	−8·496	·965	·421	·202		·644**	2·54**	·43
		(3·05)	(1·36)	(1·72)	(·91)				
Log {Postcards per head}	D9	−8·754	1·129				·008		−1·28
		(1·65)	(1·09)						
	D10	−4·034				·658	·761**		−4·07**
		(29·78)				(8·80)			

Key: See notes to Table 2.6.
Variables: As in Table 2.6, with in addition:
TOUR = Proportion of county work force employed in tourism, 1966.
Note: In equations where the computed value of the adjusted correlation coefficient was negative, its value has been set equal to zero.

section 2.2, that this variable may be acting as a proxy for factors such as concentration of business activity, which we would expect to exert a positive influence on the volume of second class mail posted.

These results obviously put the findings of Table 2.6 in a new light. Since total mail is simply the sum of first and second class mail, it is evident that the only reason for the fairly satisfactory fit of the equations in Table 2.6 was the presence of the second class category, whereas these equations conceal the total failure to provide any explanation for the variation in first class mail. A possible explanation for the difference between the two categories in explanatory power attained is the fact that second class mail has a wider range of variation than first class: their coefficients of variation in 1965 were 0·698 and 0·259 respectively. To some extent, this makes the failure to provide an adequate explanation of variations in first class mail less serious from a policy point of view. Nevertheless, it is a disconcerting feature of this part of the study that no satisfactory cross section equations were obtained for first class mail.[19]

In a final attempt to improve on this situation, separate consideration was given to postcards, the lesser of the two components of first class mail. Both common sense and a cursory inspection of the data suggested that variations in the number of postcards posted in different counties might be related to the level of tourists' expenditure in each county. Unfortunately, no county breakdown of tourists' expenditure is available, so in order to test this hypothesis, recourse was had to a variable measuring the proportion of the county work force engaged in tourism in 1966.[20] As a proxy for the level of tourists' expenditure, this variable has the disadvantage that it implicitly assumes a constant labour-intensity of tourism in all counties. On the other hand, it gives equal weight to domestic and to foreign tourists, which is appropriate, since there is no reason to think that there is any significant difference between the propensities of these two groups to send postcards (the same, of course, would not be true of their expenditure on postal services). In any case, this variable performed extremely well, as may be seen from equation D10: the estimated coefficient is highly significant, and implies that an increase of one percentage point in the proportion of the county work force engaged in tourism is associated with an increase of 0·658 per cent in the number of postcards posted per head. Equation D9 is presented to illustrate the improvement in explanatory power attained by the tourism variable over the simple regression on personal income. It may be concluded, therefore, that satisfactory explanations have been given for intercounty variations in the volume of second class

19. This finding does not necessarily conflict with the highly significant income elasticities for first class mail estimated from time series data in section 2.3 above; the confidence intervals for the two sets of estimates overlap to a considerable extent, mainly because of the very low significance of the cross section estimates. Nevertheless, no satisfactory explanation can be given for the large difference between the two sets of point estimates.

20. The relevant data were taken from Baker and Ross (1974), Appendix 2.

mail and of postcards posted; however, the number of letters posted per head does not appear to be systematically related to any of the independent variables tested.

2.5 *Cross Section Demand Functions, 1960, 1965 and 1969*

Having established which specifications best explained the intercounty variations in mail volume in a single year, 1965, it was decided to estimate the same models for the two other years on which contemporaneous data on mail volume and personal income were available, 1960 and 1969. This restriction of the models considered to those which had proved successful with the 1965 data greatly reduced the number of equations which had to be estimated. However, since it was desired to test whether the same equations were equally satisfactory in all three years, the number of equations which had to be estimated was still relatively large. Accordingly, the full results are not presented (they are available on request from the author); instead, Table 2.8 gives a selection of the equations estimated. Separate equations are presented for each of the three years, as well as some equations estimated from the "pooled" sample, (i.e. using the data on all three years).[21]

Table 2.8 shows that the equations estimated for all three years, both individually and combined, are reasonably similar to those estimated for 1965 alone. Equations E1 to E5 show that total mail per head is significantly related to county income per head, and to population density. However, the remaining equations show that, as in section 2.4, the apparently satisfactory performance of the equations for total mail conceals the fact that first and second class mail behave in very different ways. First class mail is not related to any of the variables tested, with the exception of income per head in the pooled equation, E9 (and even here the adjusted R^2 is only ·076). Second class mail, on the other hand, is significantly related to both independent variables in all the equations presented, and the degree of explanation attained (as measured by the adjusted R^2) is reasonably high for a cross section study.

Having looked at the results of the estimated equations, the next question which logically arises is, are there significant differences between the determinants of postal demand in the three different years? This question is of interest for two reasons. In the first place, we would like to know whether the values of various parameters have changed between the three years. For example, equations E1 to E3 suggest that the income elasticity of demand for total mail has fallen between 1960 and 1969; we wish to know whether this change is statistically significant. Secondly, from the point of view of choosing

21. As in section 2.4, all the equations were estimated in log *per capita* form, excluding Dublin.

TABLE 2.8: *Selected cross section demand functions:* 1960, 1965, 1969, *and all three years pooled*

Dependent variable	*Sample*	*Equation no.*	*Regression coefficients (t-values in parentheses)*	$\bar{R}^2$	*F*	*Chi square*
Log {Total mail per head}	1960	E1	$Q = -4{\cdot}355 + {\cdot}923Y$ (2·85) (3·01)	·252	9·08**	
	1965	E2	$Q = -3{\cdot}692 + {\cdot}780Y$ (3·30) (3·59)	·331	12·89**	
	1969	E3	$Q = -2{\cdot}399 + {\cdot}523Y$ (1·78) (2·07)	·120	4·27*	
	pooled	E4	$Q = -2{\cdot}432 + {\cdot}534Y$ (5·10) (5·77)	·304	33·26**	
	pooled	E5	$Q = -2{\cdot}641 + {\cdot}376Y + {\cdot}234D$ (5·96) (3·95) (3·75)	·409	26·63**	117·91
Log {First class mail per head}	1960	E6	$Q = -2{\cdot}379 + {\cdot}470Y$ (1·68) (1·66)	·068	2·75	
	1965	E7	$Q = -{\cdot}956 + {\cdot}182Y$ (·83) (·81)	0·0	·65	
	1969	E8	$Q = {\cdot}467 - {\cdot}078Y$ (·34) (·30)	0·0	·09	
	pooled	E9	$Q = -1{\cdot}237 + 240Y$ (2·67) (2·67)	·076	7·12**	
	pooled	E10	$Q = -1{\cdot}277 + 210Y + {\cdot}045D$ (2·72) (2·08) (·68)	·065	3·77*	117·91
Log {Second class mail per head}	1960	E11	$Q = -12{\cdot}609 + 2{\cdot}291Y$ (4·65) (4·21)	·411	17·76**	
	1965	E12	$Q = -12{\cdot}599 + 2{\cdot}262Y$ (6·53) (6·04)	·597	36·50**	
	1969	E13	$Q = -11{\cdot}821 + 2{\cdot}050Y$ (4·43) (4·09)	·396	16·71**	
	pooled	E14	$Q = -7{\cdot}799 + 1{\cdot}317Y$ (8·15) (7·10)	·400	50·39**	
	pooled	E15	$Q = -8{\cdot}433 + {\cdot}839Y + {\cdot}708D$ (10·96) (5·08) (6·52)	·618	60·81**	117·91

Key and List of Variables: see notes to Tables 2.5 and 2.6.

the "best" equation to explain or predict intercounty variations in mail demand, it is important to know whether the pooled equations are adequate, or whether it is necessary to estimate a new equation for each year.

In order to answer these questions, we have used an analysis of covariance approach to test for significant differences in the intercepts, the slopes, and both the intercepts and slopes combined of the various equations between the three years.[22] The relevant data and the results of these tests are presented in Table 2.9. Section A of this table gives the sums of squares for six different equations: each of three dependent variables, total, first class and second class mail, regressed on two sets of independent variables, the first consisting of personal income only, and the second of both personal income and population density. The bottom line of this section of the table gives the total sums of squares for each dependent variable, and by reading upwards it may be seen how the residual sums of squares are reduced as the restrictions on the coefficients are successively relaxed, (i.e. as first the intercepts, and then the slopes are permitted to vary between different years).[23] In order to establish whether the reductions in the sums of squares are significant, the appropriate F-values were calculated, and these are given in the analysis of covariance section of the lower half of Table 2.9. For comparative purposes, the standard F-values, testing the significance of each equation's coefficients in an analysis of variance framework, are also given in the table.

For five of the six equations, the results of the analysis of covariance show that nothing is lost (in a statistical sense) by pooling the data for all three years. In the case of the regression of total mail on personal income only, for example, the F-value testing the hypothesis of overall homogeneity is 1.11. This means that the income elasticity has not changed significantly over the period, although, as noted already it has fallen from 0·923 in 1960 to 0·523 in 1969. This example illustrates the important point that the actual parameter estimates may show a wide range of variation, even though there is no statistical evidence of structural change between the three samples.

As for the first class mail demand functions, the hypothesis of no structural change between the three years is also accepted; however, this result is not very interesting in the light of the extremely poor explanatory power of the equations involved. The case of second class mail is more interesting: here constancy of slopes is indicated, but in the equation containing personal income as sole independent variable the hypothesis of constant intercepts is rejected ($F = 9{\cdot}91$,

22. This method is explained in Johnston (1972), section 6.3, and, more succinctly, in Fisher (1970). Essentially it amounts to a generalisation of the Chow test for structural stability, and it is also equivalent to the Gujarati dummy variable technique.

23. It may also be noted that the total sum of squares to be explained is considerably greater for second class than for first class mail. This parallels a similar remark made in section 2.4 with reference to the coefficients of variation of these variables.

TABLE 2.9: *Analysis of variance and covariance for pooled cross section demand functions*

A. *Analysis of covariance table*

Source of variation	*Independent variables* / *Description of sums of squares*	*Income only* — *Sums of squares* — *Total mail*	*First class*	*Second class*	*DF*	*Income and population density* — *Sums of squares* — *Total mail*	*First class*	*Second class*	*DF*
Z	Residual	1·257	1·210	4·193	69	1·022	1·144	3·019	66
	Incremental (differential slopes)	·021	·039	·009	2	·087	·079	·170	4
X and *D*	Residual	1·279	1·249	4·202	71	1·108	1·222	3·189	70
	Incremental (differential intercepts)	·060	·014	1·173	2	·012	·032	·189	2
X	Residual	1·338	1·262	5·375	73	1·120	1·254	3·378	72
	Total	1·948	1·385	9·084	74	1·948	1·385	9·084	74

B. *F-values*

Independent variables / *Dependent variable*	*Income only* — *Total mail*	*First class*	*Second class*	*Income and population density* — *Total mail*	*First class*	*Second class*
1. *Analysis of variance* (within one sample)						
Test of significance of all slope coefficients:						
(*a*) 1960	9·08**	2·75	17·76**	11·13**	3·05	21·78**
(*b*) 1965	12·89**	·65	36·50**	11·13**	·35	22·93**
(*c*) 1969	4·27*	·09	16·71**	3·40*	·15	12·66**
(*d*) pooled	33·26*	7·12**	50·39**	26·63**	3·77*	60·81**
2. *Analysis of covariance* (between different samples)						
Test of constant intercepts, assuming constant slopes	1·65	·39	9·91**	·39	·91	2·07
Test of constant slopes	·58	1·11	·07	1·40	1·13	·93
Test of overall homogeneity	1·11	·75	4·86**	1·07	1·06	1·31

** indicates that the *F*-value is significant at the 99 per cent level.
 * indicates that it is significant at the 95 per cent level.

significant at 99·9 per cent level).[24] This means that, while the assumption of a constant income elasticity of demand may be accepted, some allowance should be made for shifts in the function over time. However, these shifts may be explained by changes in population density, for, when the latter variable is included in the equation, the hypothesis of overall homogeneity is accepted. This leads to the encouraging conclusion that the second class mail demand functions for all three years which include both income and population density as independent variables may be pooled without any loss in explanatory or predictive power.

To summarise, this analysis of the three years combined has reinforced the conclusions derived in section 2.4 from the 1965 data alone. In particular, it has confirmed the finding that first and second class mail behave in very different ways. Intercounty variations in the level of first class mail per head do not appear to be systematically related to either personal income or population density, a finding which is of considerable interest in itself. Second class mail, on the other hand, is closely related to both variables, the value of the income elasticity being about 0·8 when population density is held constant, while a 1 per cent increase in population density, holding county income constant, is associated with a 0·7 per cent increase in second class mail volume. Finally, these cross section results are, in turn, reasonably consistent with the time series findings in section 2.3, although the cross section estimates of the income elasticities for both classes of mail are in general lower than the corresponding time series estimates.

2.6 *The Use of Estimated Equations for Forecasting*

In so far as the equations presented in the three preceding sections throw some light on the trends in and determinants of postal traffic in the past, they may be said to have justified the effort expended on estimating them. However, apart from helping to understand the past, a major aim and a major potential use of applied econometrics is the forecasting of future trends. It is of interest therefore, to see to what extent the results given above can be applied to forecasting. For simplicity, we will deal only with forecasting using time series models, although there is no reason in principle why the cross section equations which have been estimated could not be applied to forecasting mail volume on a county basis.

24. The failure to allow for different intercepts explains why the coefficient of Y, in equation E14, the second class mail demand function estimated from the pooled sample, is very different from any of the coefficients in equations E11 to E13. When dummy variables d_1 and d_2 are added to equation E14 to permit different intercepts in 1965 and 1969, a value for the income elasticity more in line with the results of equations E11 to E13 is obtained, viz.:

$$Q = \underset{(8\cdot99)}{-12\cdot184} + \underset{(8\cdot13)}{2\cdot206Y} - \underset{(1\cdot56)}{\cdot126d_1} - \underset{(4\cdot12)}{\cdot463d_2} \qquad \bar{R}^2 = \cdot518$$

The actual method of forecasting used requires little explanation. Given any model

$$y = X\beta + u \tag{1}$$

where $\hat{\beta}$, the ordinary least squares estimate of β, has been obtained in the usual manner, all that is required is some estimate of the values of the exogenous variables in the forecast period, and the forecast value of y follows immediately:

$$\hat{y}_F = \hat{x}_F^1\hat{\beta} \tag{2}$$

Thus, if we wished to use equation B2 in Table 2.5 to forecast total mail in 1986, assuming that personal consumers' expenditure per head in that year will be £486·3 (see Table 2.10 and accompanying text below for a justification of this assumption) we simply substitute this value into the equation:

$$\log Q = -3{\cdot}151 + {\cdot}741 \log Y$$

to give a forecast value for log Q, of 1·433, and thus a forecast value for Q, total mail per head, of 4·198 pieces. Using a projected value for total population in that year (also taken from Table 2.10), of 3·563 million, this in turn implies a forecast for total mail of 14·931 million pieces per week.

One question which immediately arises is, which of the models estimated should be used to derive forecasts. Obviously, the more satisfactory the original equation, the more confidence we will have in forecasts derived from it. However, this is an ambiguous criterion, for there are a number of different ways in which an equation may be deemed satisfactory. An example of this problem which arises in the present context may be seen by referring back to Table 2.5. Here, the most satisfactory equation for total mail, as judged by goodness of fit and absence of autocorrelation, is equation B1, the simple regression on a time trend. But this equation has relatively little economic content as such, whereas equation B3, though somewhat inferior in statistical terms, is firmly based in economic theory, and yields highly plausible estimates of the relevant income and price elasticities.

No universally acceptable answer can be given to the question of how the forecaster should proceed in a situation such as this: whether to generate forecasts using the economically meaningful equation, B3, or using the statistically superior equation, B1. In the author's opinion, however, equation B3 is a considerably more useful tool for forecasting than a "naïve" equation such as B1. The major reason for this is that equation B1 only provides, for each future period, a single *unconditional* forecast of future mail volume. Equation B3, on the other hand, permits us to calculate an infinite number of *conditional* forecasts, each one assuming a given level of consumers' expenditure and postal prices for the forecast period. It is thus possible to investigate the consequences for the volume of mail of different assumptions about future trends in the independent variables, something which cannot be done with equation B1. This advantage is particularly important in the present case where the values of one of the independent variables are subject to the direct control of the postal authorities.[25]

In any case, both types of forecast, conditional and unconditional, have been calculated, and are presented in Table 2.11. Depending on the reader's tastes, forecasts based on time trend equations such as B1 may be looked on as "best guesses" of future levels of mail volume, whereas those based on equations such as B3 attempt to predict the effects of different values of the independent variables on the volume of mail.

A second issue which must be faced is, how much confidence can we have in any particular forecast? In order to answer this question it is important to emphasise that there is no such thing as a "perfect" forecast. For instance, in the example already given, it need hardly be said that the actual number of pieces posted in 1986 is extremely unlikely to take on the precise predicted value of 14.931 million pieces per week. On the contrary, there are a great many reasons why the true value may differ from the forecast, and they may conveniently be broken into three categories.

The first and most serious source of forecast error concerns the adequacy of equation (1) to represent the process whereby the values of the dependent variable are generated. Obviously any mis-specification of the basic model will seriously impair the quality of forecasts. Possible mis-specifications include errors in the choice of functional form, or in the treatment of simultaneity or autocorrelation. Problems such as these have been discussed throughout sections 2.2 to 2.5.

Another major kind of mis-specification is the omission from the final model of variables which influence the dependent variable. These include variables whose influence has been tested but has been found to be insignificant (at least during the sample period, and with reference to the particular tests employed). An obvious example in the present study is telephone availability. They also include variables which may be very important influences on the dependent variable, but which were not explicitly tested, because they are difficult or even impossible to measure in quantitative terms. Relevant examples in the present context include the standards of service, e.g. the frequency and speed

25. It may also be mentioned that the fact that equation B1 yields a better within sample fit than B3, is no guarantee, even on statistical grounds, that its forecasting performance will be superior.

of delivery; the state of mail technology;[26] and the preferences of consumers. In forecasting the volume of mail, it must therefore be assumed that the demand for postal services will not be seriously affected by major changes in any of these factors.

The second source of forecast error arises from the fact that, even if we assume that the model as in (1) is perfectly specified, it is necessary to base forecasts of the dependent variable on values for the independent variables outside the sample period (x_F) which will usually be themselves forecasts. Except in the case of nonstochastic independent variables, such as a time trend, this introduces a further element of uncertainty into our forecasts.

Finally, even with a perfectly specified model and complete certainty about the values of the independent variables in the forecast period, there will still be a discrepancy between the forecast value of y, given by (2), and the actual value of y in the forecast period:

$$y_F = x^1{}_F\beta + u_F$$

This third source of forecast error arises from the sampling error in estimating β, and the inability to predict u_F, the actual value of the disturbance term in the forecast period.

Having listed the factors which cause discrepancies between actual and predicted values, it is obviously desirable to obtain some measure of the uncertainty to which they lead in any particular forecast. As far as the first source of forecast error is concerned, nothing short of re-estimation of the entire equation can overcome the problems of specification error. The situation is more hopeful with regard to the other two problems however. In the case of the second source of forecast error—lack of knowledge about future values of the independent variables—the simplest procedure is to make a number of alternative assumptions about these values. As already explained, different sets of *conditional* forecasts of the dependent variable can then be calculated, each one based on different assumptions about x_F.[27] Finally, in connection with the third source of forecast error, a standard error of forecast can be calculated to

26. An example of a change under this heading would be the greater dissemination of methods of transmitting written copies of documents by telephone (such futuristic devices are available in the United States, although the cost is as yet prohibitive). Another example would be the advent of chequeless banking, which would avoid the need to transmit cheques by post, as at present. Both of these technological developments, which could conceivably decelerate the growth of mail traffic, have been discussed in a study by Arthur D. Little Inc. of the US Post Office (1968). The study concluded, however, that they were unlikely to have any major effect on mail volume.

27. An alternative and more elegant method of accounting for this second source of forecast error, suggested by Feldstein (1971), is to construct a confidence interval which explicitly takes account of our uncertainty regarding the forecast period values of the independent variables, as measured by a forecast period covariance matrix for the latter. This method has not been used in the present study because in a long-term forecasting exercise based on equations estimated with relatively few degrees of freedom, it yields extremely wide confidence intervals.

measure the uncertainty surrounding a point forecast on account of the sampling error in estimating β and our ignorance of the true u_F. This can then be used to compute a confidence interval around the forecast. In the example already given, the standard error of forecast, in log space, is 0·09299; by applying the usual formula, this yields a 95 per cent confidence interval (for total mail in 1986) of 12·192 to 18·288 million pieces, around the point forecast of 14·931 million.[28]

Before presenting the actual forecasts, it is necessary to discuss how the forecast-period values of the independent variables were derived. Considering population first, projections of this variable were readily available. The methodology of calculating them has been set out by Knaggs and Keane (1971–72), who also present a range of projections based on alternative assumptions about emigration and fertility rates. There is no conceptual difficulty in calculating different forecasts of mail volume corresponding to each set of population projections; however to reduce the computational burden involved, only one was considered, namely, the semi-official projections calculated using Knaggs and Keane's method and given in Appendix 1 of the IDA Regional Industrial Plans (1972). Population projections from this source for the forecast periods (the years 1973, 1976, 1981 and 1986) are given in the first row of Table 2.10.

No official projections of the other independent variables were available, so recourse had to be had to simple extrapolative methods. The procedure adopted was to fit three separate models to the logarithm of each variable for which projections were required: a simple regression on a time trend, a first order autoregressive scheme, and a second order autoregressive scheme. The models were estimated using annual data for the period 1950–73, and then in each case the model which yielded the best fit (measured by adjusted R^2) was used to project the values of the relevant variable for the forecast periods. The results of this exercise are given in Table 2.10. In all cases but one the first order autoregressive model gave the best fit of the three models tested; the exception was the price index for second class mail (row 5 of the table) which was best explained by the regression on a time-trend.

It should be emphasised that the projected values in the last three columns of the table are given for illustrative purposes only, and are not necessarily intended as forecasts in themselves. For example, the projections imply an almost stable relative price of first class mail, but rapid increases in the price of second class mail, obviously a highly unlikely combination. Nevertheless, some of these projections are of interest in themselves, and deserve further

28. The confidence interval is symmetric around the original value of y_F; i.e. $1{\cdot}43288 \pm {\cdot}20272$; however, to express the interval in terms of numbers of pieces of mail we must take the antilogs of the original values, which yields a skewed confidence interval in "real" space. The formula for the standard error of forecast is given in Johnston (1972), page 153.

TABLE 2.10: *Projections of independent variables for forecast periods*

Independent variable	*Method of projection used*	*Actual and projected values of independent variables* 1973 (*actual*)	1976	1981	1986
1. Population (thousands)	Projections taken from Appendix 1 of IDA Regional Industrial Plans (1972)	3,018·8 (estimated)	3,107·2	3,301·5	3,562·8
2. Personal Consumers' Expenditure (£ million 1958 prices)	A. $\log Y_t = -\cdot 160 + 1\cdot 035 \log Y_{t-1}$ $(1\cdot 03)\quad (34\cdot 81)$ $\bar{R}^2 = \cdot 981 \quad d = 2\cdot 28$	792·4	918·2*	1,224·9*	1,732·6*
	B. Annual growth rate of 3 per cent assumed from 1973 onwards.	792·4	865·9	1,003·8	1,163·7
3. Price Index for Total Mail, deflated by CPI (1953=100) (P^1)	A. Annual growth rate of 5 per cent assumed from 1973 onwards	176·7	204·8	261·4	333·6
	B. $\log P_t = \cdot 089 + \cdot 986 \log P_{t-1}$ $(\cdot 16)\quad (8\cdot 31)$ $\bar{R}^2 = \cdot 747 \quad d = 2\cdot 05$	176·7	185·7	200·6	215·7
4. Price Index for First Class Mail, deflated by CPI (1953=100) (P^2)	$\log P_t = \cdot 181 + \cdot 965 \log P_{t-1}$ $(\cdot 36)\quad (8\cdot 91)$ $\bar{R}^2 = \cdot 773 \quad d = 1\cdot 87$	162·8	163·3	164·2	164·9
5. Price Index for Second Class Mail, deflated by CPI (1953=100) (P_3)	$\log P_t = 4\cdot 581 + \cdot 031\, T$ $(100\cdot 2)\quad (7.46)$ $\bar{R}^2 = \cdot 773 \quad d = 1\cdot 10$	227·6	249·9†	292·0†	341·2†
6. Price Index for Telephone Call Charges, deflated by CPI (1953=100) (P_4)	$\log P_t = \cdot 927 + \cdot 796 \log P_{t-1}$ $(1\cdot 34)\quad (5\cdot 25)$ $\bar{R}^2 = \cdot 536 \quad d = 2\cdot 23$	80·0	86·5	91·3	92·9

*Projection equation for personal consumers' expenditure was cast in *per capita* form. Accordingly, forecast-period values were grossed up by multiplying by the IDA population projections given in row 1.

†An intercept adjustment, yielding a zero prediction error for 1973, was applied to the equation used to project the price index for second class mail. All equations were estimated for the period 1950—1973. All logarithms are to base e.

comment. Considering first personal consumers' expenditure, the equation in row 2A yielded a growth rate (in *per capita* terms) of 4·8 per cent per annum between 1973 and 1986; translated into absolute terms (using the population projections in row 1), this implies an annual average growth rate for personal consumers' expenditure over the period of 6·20 per cent. This may be considered the best estimate of the future behaviour of consumers' expenditure in the light of its movements between 1950 and 1973. However, since such a rate of growth may be thought rather high (compared, for example, with average annual growth rates of 2·58 per cent for the period 1950–73 and 3·70 per cent for 1958–73) a second set of forecast period values were calculated for this variable. Given in row 2B, they assume simply a 3 per cent annual average growth in the real value of consumers' expenditure from 1973 to 1986.

In the case of the price index for total mail, the equation in row 3B implies an annual average growth rate for 1973–86 of 1·54 per cent. However, since budgetary constraints on post office operations (discussed in Part 4 of this paper) may require a higher rate of increase in postal prices, an alternative set of projections, assuming a 5 per cent annual growth rate, is given in row 3A. Finally, for the remaining three price indices, no alternative projections to those given by the estimated equations were calculated, since these series are of less interest.

When these projections of the independent variables were combined with the equations from section 2.3 in the manner already outlined, a great many forecasts of future mail volume were derived, and a representative sample of these is presented in Table 2.11. In each case, a point forecast is given for the relevant year, along with the upper and lower bounds of a 95 per cent confidence interval around the forecast.[29] As is well known, the width of this interval is greater the lesser the explanatory power of the original equation,[30] and the greater the difference between the forecast period values of the independent variables and their mean values in the sample for which the equation was estimated.

The salient features of the forecasts in Table 2.11 may be briefly summarised. It is clear that all the forecasts imply continued growth in mail volume, though at different rates depending on the assumptions made about the independent variables. (This may be seen from the last column in the table, which gives the average annual growth rate of the relevant variable implied by each forecast for the period 1969–86.) However, the differences between different forecasts are not large when allowance is made for their respective confidence

29. It will be recalled that, because it is derived from an equation linear in logarithms, this forecast interval is asymmetric.

30. For example, forecasts 1 and 2 give almost identical point predictions for 1986, but the confidence interval around the former is narrower than that around the latter, because equation B1 yields a better fit than equation B3.

TABLE 2.11: *Forecasts of mail volume: 1973, 1976, 1981, 1986*

Variable	Forecasts based on equation number (All from Table 2.5)	Independent variables in forecasting equation	Projection assumptions for independent variables (see Table 2.10 for details)	Forecast number	Number of pieces of mail posted in a representative week of each year ('000's): Actual 1969	Forecasts*: 1973		1976		1981		1986		Average annual growth rate 1969-1986, implied by forecast
Total mail	B1	T	—	1	6,940	7,831	8,404 7,296	8,557	9,222 7,942	10,044	10,911 9,244	11,973	13,125 10,924	3·26
	B3	Y, P_1	$Y{:}A; P_1{:}A$	2	,,	7,191	8,785 5,888	7,854	9,996 6,171	9,450	12,892 6,927	11,975	17,500 8,194	3·26
	B3	Y, P_1	$Y{:}A; P_1{:}B$	3	,,	,,	,,	8,072	9,943 6,553	10,175	12,724 8,135	13,527	17,237 10,617	4·01
	B3	Y, P_1	$Y{:}B; P_1{:}A$	4	,,	,,	,,	7,474	9,555 5,845	7,985	11,080 5,755	8,552	12,933 5,655	1·24
	B3	Y, P_1	$Y{:}B; P_1{:}B$	5	,,	,,	,,	7,681	9,496 6,214	8,598	10,845 6,814	9,661	12,431 7,507	1·97
First class mail	B6	T	—	6	4,260	4,704	4,986 4,438	5,057	5,378 4,755	5,778	6,185 5,397	6,704	7,232 6,216	2·70
	B8	Y, P_2	$Y{:}A$	7	,,	4,297	4,815 3,835	4,767	5,337 4,258	5,850	6,572 5,206	7,496	8,529 6,589	3·38
	B8	Y, P_2	$Y{:}B$	8	,,	,,	,,	4,592	5,143 4,100	5,150	5,770 4,596	5,811	6,517 5,180	1·85
Second class mail	B10	T	—	9	2,680	3,169	3,798 2,643	3,570	4,326 2,947	4,410	5,454 3,566	5,533	7,003 4,372	4·36
	B12	Y, P_3	$Y{:}A$	10	,,	3,044	4,365 2,123	3,561	5,255 2,412	4,852	7,557 3,116	7,070	11,732 4,264	5·88
	B12	Y, P_3	$Y{:}B$	11	,,	,,	,,	3,319	4,914 2,242	3,823	5,990 2,439	4,389	7,304 2,509	2·94

*Each point forecast is accompanied by the upper and lower bounds of a 95 per cent confidence interval.

intervals. This is because the latter are extremely wide, reflecting partly the poor fit of the original equations, but most importantly of all the fact that these equations are based on only fourteen observations. When it is recalled that these forecasts assume that the projected values of the independent variables given in Table 2.10 will hold exactly, it should be clear that they can only hope to give a very approximate indication of the likely future growth in mail traffic.

Despite their imprecision, however, the forecasts cast some light on the effects of different values of the independent variables. Comparing forecasts 2 and 4, or 3 and 5, for example, it is apparent that assuming a high rather than a low growth rate for consumers' expenditure leads to a difference of about 3·5 million pieces per week, or 40 per cent, in the expected value of total mail in 1986. While these differences are not highly significant in a statistical sense they do suggest that different rates of increase in consumers' expenditure may appreciably affect the growth rate of mail volume. The same is less true of postal prices, however. Again, by comparing forecasts 2 and 3, or 4 and 5, it may be seen that assuming a high or a low growth rate for the deflated price index of total mail makes a difference of under 1·6 million pieces per week, or about 12 per cent of the expected value of total mail in 1986. This difference is obviously appreciable, but it is small relative to the uncertainty surrounding the forecasts involved.

Finally, it may be noted that the forecasts given for first and second class mail imply a continuation of the tendency for the latter to grow at a faster rate than the former, although first class mail continues to be the dominant category in 1986. It is also worth pointing out that these disaggregated forecasts are perfectly consistent with the forecasts for total mail. For example, the sum of forecasts 7 and 10 for 1986, 14·566 million pieces, is well within the confidence interval for forecast 3, a fact which enhances the plausibility of the orders of magnitude involved.

2.7 *Summary*

The principal findings of the econometric work in Part 2 may be summarised as follows. *Per capita* demand for mail services was found to be significantly related to income, regardless of the specification adopted. All estimates of the income elasticity were within the range 0·5 to 0·95, and most were significantly less than unity. However, this relative stability conceals significant differences between the behaviour of first and second class mail. The former was moderately inelastic on time series data, and almost completely unresponsive to variations in income in the cross section samples studied. Second class mail, on the other hand, grew at a much faster rate over the period (2·87 per cent per annum as against 1·30 per cent) and was moderately income elastic in both time series and cross section samples.

As for responsiveness to price changes, first class mail appeared to have an own-price elasticity of about $-0{\cdot}3$. The evidence on second class mail however, is difficult to interpret, and is consistent with *a priori* arguments for expecting its price elasticity to be extremely low. Unfortunately, it was not possible to obtain separate estimates of short run, as opposed to long run, elasticities.

Other variables which gave satisfactory results included population density, presumably acting as a proxy for intensity of commercial or "postal-intensive" activity, as a determinant of second class mail; and the proportion of county work force engaged in tourism, which was closely associated with the number of postcards posted per head. No satisfactory explanation was found for the cross section variation in the number of letters posted. However, intercounty variations in the volume of second class mail posted were significantly related to personal income and population density in all the years tested, and the relationship involved appears to have remained constant between 1960 and 1969.

As for the effects of telephone services on the demand for mail, telephone charges were found to exert a positive influence on postal demand over time, with a stronger effect on second class than on first class mail. However, two separate attempts to test the hypothesis that greater telephone availability should reduce the demand for postal services gave negative results: the number of telephone lines did not have a significant influence on mail volume over time or across counties; and counties where STD (Subscriber Trunk Dialling) was available in 1965 did not have a lower demand for postal services than counties without access to this facility. It appears likely that further progress in this area will only come about through more careful specification of inter-related demand functions for both postal and telephone services.

Finally, the results of the time series regressions were applied to forecast future levels of postal demand up to 1986. Both unconditional forecasts, based on a time trend equation, and conditional forecasts, assuming different patterns of growth in consumers' expenditure and postal prices, were calculated. Depending on the assumptions made about these variables, the forecasts implied growth rates in total mail of between 1·2 per cent and 4 per cent per annum, with a continuation of the tendency for second class mail to grow at a faster rate than first class. This is more or less what would be expected from the regression results on which the forecasts were based, as is the finding that the forecasts are moderately sensitive to alternative assumptions about income growth, but rather less sensitive to different assumptions about changes in postal charges.

Part 3

Postal Costs and Productivity

3.1 *The Structure of Aggregate Postal Costs*

THE pattern of post office costs can be studied either for the organisation as a whole, or at the level of individual post offices. Taking the former view first it is of interest to begin by looking at the different components of total costs. Table 3.1 gives the cost structures of the British, American and Irish post offices for the financial year 1960–61. For the British and American data an attempt has been made to distinguish between costs which are fixed, and those which vary in the short-run with the volume of traffic. Unfortunately, the published statistics do not permit us to make a similar distinction for Ireland—separate figures are not given for payments to full-time and part-time employees nor for expenditure on owned and hired transport. However, in the light of the similarities between the cost structures of the three postal services discussed below, it is likely that in Ireland the proportion of fixed costs is as high as that in the other two countries.

Apart from minor differences between the three countries, they have one major feature in common: the overwhelming preponderance of staff costs in total expenditure, or, in economic terms, the marked labour intensity of the supply of postal services. Payments to staff in all forms, whether as salaries and wages, or by way of contributions to pension funds, account for 71·8 per cent, 78·5 per cent and 72·8 per cent of total postal costs in the British, American and Irish post offices respectively. In the case of Ireland, at least, this proportion has grown to 80·1 per cent in the 1971–72 financial year. The same point is shown by the correspondingly small proportion accounted for by capital charges, i.e. interest and depreciation. As Horsefield (1964) comments, despite moderate progress in the development of automatic sorting machines, neither Britain nor the United States "has yet been able to economise substantially in its postal services by capital expenditure"; and the same is equally true of Ireland. Obviously, the implications of this fact depend on the level of earnings of postal workers in each country; for example, the much higher cost of personal services in the United States almost certainly accounts for the higher proportion of staff costs in the American post office. However, in all three countries labour prices have been rising faster than the prices of other factors of production in

TABLE 3.1: *Analysis of costs in British, United States and Irish postal services, Financial Year* 1960–61 (*in percentages*)

United Kingdom		*United States*		*Ireland*	
Fixed Costs	%	*Fixed Costs*	%		%
Salaries and wages	52·6	Compensation of regulars	53·9	Salaries and wages	68·9
Pension liability	8·3	Pension liability	3·5	Pension liability	3·9
Transport services	1·5	Transportation services	2·7	Conveyance of mails	19·3
Accommodation	2·0	Accommodation	3·9	Materials and transport	5·0
Interest and depreciation	2·4	Depreciation of buildings	1·0	Accommodation	1·1
				Depreciation	0·2
	66·8		65·0	Interest	0·6
				Miscellaneous	1·0
Variable Costs		*Variable Costs*			
Sub-postmasters' remuneration	2·6	Substitutes and temporaries	17·5		
Overtime and night pay	8·3	Overtime and night pay	3·6		
Hire of transport	19·4	Hire of transportation	10·8		
Supplies and maintenance	2·9	Supplies and maintenance	3·1		
	100·0		100·0		100·0

Sources: UK and US data from Horsefield (1964), Table 1; Irish data from post office Commercial Accounts.

TABLE 3.2: *Revenue, costs, and surplus or deficit by category of mail (millions of pounds)*

	United Kingdom, 1960–61			*United States*, 1960–61			*Ireland*, 1964–65		
	Revenue	*Costs*	*Surplus* (+) *or deficit* (−)	*Revenue*	*Costs*	*Surplus* (+) *or deficit* (−)	*Revenue*	*Costs*	*Surplus* (+) *or deficit* (−)
Letters and packages[1]	81·9	62·9	+19·0	574	561	+13	4·323	3·546	·777
Postcards	2·5	2·4	+0·1	26	36	−10	·116	·135	−·019
Printed papers	35·1	37·1	−2·0	192[2]	307[2]	−115[2]	1·416	2·065	−·649
Newspapers	2·0	3·4	−1·4	32[3]	158[3]	−126[3]	·127	·110	+·017
Overseas letters	20·3	20·5	−0·2	36	42	−6	·324[4]	·284[4]	+·040[4]
Parcels[5]	31·1	38·2	−7·1	232[6]	268[6]	−36[6]	1·228	1·075	+·153[7]
Miscellaneous[8]	6·2	9·3	−3·1	67[9]	94[9]	−27[9]	·125	·370	−·245
Total[10]	179·1	173·8	+5·3	1,159	1,466	−307	7·659	7·585	+·074

Sources: UK and US data from Horsefield (1964), Table 5; Irish data from Departmental Costing Study, 1964–65.

Notes: 1. Including domestic airmail letters (UK and US).
2. Third class mail plus books and "controlled circulation".
3. Second class mail.
4. Includes only additional surcharges on airmail post, i.e. basic charges on airmail post, as well as all charges on overseas surface mail are included in the letters and packages category.
5. Includes airmail parcels and overseas parcels.
6. Fourth class mail excluding books.
7. This overall surplus on parcels conceals large differences in profitability between the various services. Ordinary and airmail parcels yield large surpluses but customs examination and other additional costs of customs parcels amount to considerably more than the amount of customs fees collected.
8. Registration and other postal services. Note that for Ireland, and probably for the other two countries also, only additional registration charges, (i.e. over and above the basic postal charge) are included in this category.
9. Including also Penalty, franked, and free for blind.
10. Excluding remittance and agency services.

the post-war period: the average salaries of postal employees in Ireland have been increasing by over 10 per cent a year on average since 1964. This means that, unless the productivity of labour employed can be substantially increased, the cost of postal services is likely to increase more quickly than average prices, as measured by the consumer price index, and also more quickly than the cost of telephone services, which are considerably more capital intensive.[31]

Given this apportionment of total costs by final recipient, what can be said about the costs attributable to different mail categories? Tables 3.2, 3.3 and 3.4 summarise the available evidence on this point.[32] Considering first Table 3.2, it is particularly noticeable that of the two principal mail categories, letters are profitable but printed papers unprofitable in all three countries. Another common feature is that all three make proportionately very large losses on registration business (the principal item in the Miscellaneous category). Of the other categories Ireland is exceptional in being marginally profitable in newspapers, overseas letters and parcels, while its small loss on postcards corresponds to a much larger loss in the United States and a tiny profit in the United Kingdom.

The implications of these statistics for post office profitability are seen more clearly when they are expressed in terms of average costs and revenues, as in Table 3.3. It is apparent from this table that, apart from parcels and overseas letters (as well as newspapers in Britain), there is considerably more variation in average revenues for different categories than in average costs. This means that the structure of postal charges in all three countries effectively subsidises second class mail (mainly printed papers) at the expense of first class (mainly letters). The reasons for this rate structure seem to be largely historical;[33] whether it is a desirable one is another matter. In connection with this, two relevant points may be mentioned. In the first place, a policy which, according to Table 3.2, led to a net transfer of over £0·6 million from the personal to the business sector in 1964–65 certainly should have some economic justification if it is to be retained. (For the sake of argument, first and second class mail have been identified with personal and business users respectively.) On the

31. In 1969–70, 44 per cent of expenditure on telephone services was attributable to staff costs, and 41 per cent to interest and depreciation.

32. The data in these tables for Britain and America are taken from Horsefield (*op. cit.*), whose data for America are based in turn on figures given in Baratz (1962). Those for Ireland have been calculated by the present author, using data from a Costing Study carried out by the Department in 1964–65, and estimated traffic statistics for the year 1964. It should be emphasised that these data are subject to the well known accounting problem of deciding how to allocate fixed costs among different mail categories. On top of this conceptual problem, the large number of footnotes to all three tables should be adequate warning that the data given are not strictly comparable between the three countries. Despite these qualifications, however, some common tendencies are sufficiently apparent to merit comment.

33. An obvious example is that of newspapers in the United States, where, to quote Horsefield, "the publishers' lobby is strong, and is supported by the tradition, which dies hard in the United States, that newspapers and magazines render a public service by bringing information to the backwoods".

TABLE 3.3: *Percentage of each category in total prepaid mail, and estimated revenues and costs per piece of mail*

	United Kingdom, 1960–61			*United States*, 1960–61			*Ireland* 1964–65[1] (*at* 1960–61 *prices*)		
	Percentage of total %	*Revenue per piece of mail* d	*Costs per piece of mail* d	*Percentage of total* %	*Revenue per piece of mail* d	*Costs per piece of mail* d	*Percentage of total* %	*Revenue per piece of mail* d	*Costs per piece of mail* d
Letters and packages	53·9	3·36	2·58	52·8	4·15	4·05	60·0	4·22	3·46
Postcards	2·2	2·50	2·37	4·0	2·58	3·46	2·5	2·75	3·21
Printed Papers	36·0	2·16	2·28	28·3	2·58	4·13	33·1	2·50	3·65
Newspapers	1·3	3·50	5·92	12·6	0·93	4·76	2·2	3·45	2·98
Overseas Letters	4·4	10·96	11·06	0·9	15·02	17·64	—[2]	—[2]	—[2]
Parcels	2·2	29·43	36·44	1·4	61·81	71·36	2·2	32·78	28·69

Notes: As for Table 3.2. All unit revenue and costs are in old pence. Because of the relative unreliability of the mail traffic statistics, not very much trust should be placed on the absolute magnitudes of the figures for average revenues and costs. This is brought home, for example, by the fact that the undeflated average revenue figures for Irish letters and printed papers are both marginally *lower* than the minimum tariffs for these categories which were introduced on the 1st June 1964 (5*d* and 3*d* respectively).

1. The average revenue and cost figures for Ireland have been deflated by the increase in the consumer price index between 1960–61 and 1964–65 to make them comparable with the data on the United Kingdom and the United States.
2. Separate traffic statistics for overseas letters are not available for Ireland. Revenues and costs attributable to overseas letters apart from additional airmail surcharges are included under letters and packages.

TABLE 3.4: *Analysis by function of costs of postal operations (per cent)*

	Collection and delivery	*Mail handling*	*Transport*	*Other (including overheads)*
United Kingdom, 1960–61				
Letters	49·4	36·2	6·9	7·5
Postcards	50·9	37·3	1·3	10·5
Printed Papers	52·7	34·1	6·4	6·8
Newspapers	41·0	33·4	18·5	7·1
United States, 1960–61				
First Class	31·4	44·3	4·3	20·0
Third Class[1]	46·2	28·7	6·0	19·1
Second Class[2]	45·8	22·6	14·0	17·6
Ireland, 1964–65				
First Class[3]	50·3	25·5	12·3	11·9
Second Class[4]	53·0	24·0	7·8	15·2
Parcels	18·1	30·3	42·5	9·1

Sources: UK and US data from Horsefield (1964), Table 7; Irish data based on Departmental Costing Study, 1964–65. Note that the methods of cost apportionment are almost certainly different in the three countries, especially given the very different proportions of costs classified as "other".

Notes: 1. Printed Papers.
2. Newspapers.
3. Letters and postcards.
4. Printed papers and newspapers.

other hand, the reservations expressed in an earlier footnote concerning the accuracy of the data in these tables suggest that any conclusions based on them should be treated with great caution. For this reason, and because a full discussion of this question would bring us into the field of pricing policy, which is beyond the scope of this paper, the matter will be pursued no further for the present.

Before leaving the topic of aggregate costs it is of interest to find out which stages of mail handling account for larger proportions of costs. The available data on this point are summarised in Table 3.4, again with comparative data for the UK and US. It can be seen that in all three countries second class mail costs relatively more to collect and deliver than first class, but relatively less to handle, though this tendency is less marked in Ireland and Britain than in the United States. Part of the reason for this may be that a greater proportion of second class mail is meter franked, thus avoiding the need for machine or hand-stamping and cutting down on handling costs. Also, the greater bulk of second class items would explain the larger proportion of their costs which is attributable to collection and delivery. This is in no way incompatible with the much smaller proportion of the cost of parcels due to collection and delivery. For, in absolute terms, these figures still imply a higher average cost of collecting and delivering a parcel.[34] The largest proportion of parcel costs—amounting to 14.43d per item—is, as we would expect, incurred in transporting them.

This concludes our descriptive survey of aggregate post office costs. One major conclusion to be drawn is that the cost structure of the Irish postal services is markedly similar to that of the British and American post offices, despite the very different conditions under which the latter operate. However, a further conclusion which is apparent from Table 3.3 is that the absolute levels of the average costs in all three countries are relatively similar. This is rather surprising, since wage levels for postal workers in the United States are over three times as high as those in the United Kingdom or Ireland. Taken at face value, these facts imply that the United States postal services are considerably more efficient than either the British or Irish services. It is obviously of some interest to inquire whether this conclusion is justified.[35]

There are a number of reasons why the similarity in average costs despite different wage levels need not reflect different levels of efficiency. In the first place, the volume of mail per head of population is substantially greater in the United States than in either Britain or Ireland. In 1958 the United States post office carried 323 pieces per person, compared with 189 pieces per person in the United Kingdom and approximately 230 pieces per person in Ireland.[36] While the existence of economies of scale in Irish post offices is not confirmed by the evidence in section 3.5 below, they may still exist for such wide differences in mail per head between countries. Other things being equal, this would tend to reduce the disparity between American and Irish average costs per piece caused by higher labour costs in the United States.

Another factor which would tend to further reduce this disparity is the low population density of Ireland. It is true that, as a whole, the population density of the United States is actually lower than that of Ireland: 7·2 persons per square mile compared with 15·7 in Ireland and 82·0 in the United Kingdom.[37] However, it is likely that in much of the area served by the United States post office the density of population is considerably greater than in Ireland. If this is the case, it would tend to reduce the average costs of handling a piece of

34. From Table 3.3, the average costs of second class mail (printed papers plus newspapers) and parcels are 4·28*d* and 33·9*d*. Taking the proportions attributable to collection and delivery given by Table 3.4 implies average collection and delivery costs of 1·80*d* (42·1 per cent of 4·28*d*) and 2·75*d* (8·1 per cent of 33·9*d*) respectively.

35. Some of the points in the following discussion are made by Horsefield (1964) section 9, in comparing the efficiency of the US and UK postal services. The discussion has also benefited from the suggestions of B. M. Walsh.

36. *Sources:* US and UK figures from Horsefield (*op. cit.*); Irish figure calculated by author.

37. All figures are for 1958, calculated from the 1965 UN Demographic Yearbook.

mail in the United States compared with Ireland. The evidence presented in section 3.5 below suggests that the more densely populated is an Irish post office's catchment area the smaller the volume of inputs it requires to handle a given volume of mail. There is every reason to suppose that the same relationship will hold between different countries.

A third and final factor which may explain why average costs in the American and Irish post offices are so similar is the fact that the quality of service provided by the Irish post office is considerably higher than that provided by its American counterpart. In Ireland, for example, mail is normally delivered the day after posting, deliveries are twice daily in all cities and large towns, and they are made to the door of each house, rather than deposited in collection boxes at the ends of driveways, as in the United States. When it is recalled that delivery, especially in rural areas, constitutes a major proportion of total costs, it is apparent that these differences must permit considerable savings in the United States relative to Ireland. As for collection and handling costs, United States mail users are required to pre-sort and hand in at the post office all second class mail and three-quarters of third class mail, amounting in total to over a third of all mail handled. According to Horsefield (*op. cit.*) this requirement alone saves the United States post office about 5 per cent of the total cost of carrying all mail.

It may be concluded therefore, that the similarity between average mail costs in the United States and Ireland is the result of two opposing sets of influences. On the one hand, labour costs in the United States are much higher than in Ireland, and both services are highly labour intensive. This is offset on the other hand, however, by the greater size and concentration of the population served by the United States post office, and most importantly, by the lower quality of the postal services it provides. While the precise impact on average costs of these influences cannot be quantified, they suggest that, contrary to the implications of Table 3.3, the Irish postal services are not necessarily inefficient by international standards.

3.2 *A Digression on Marginal Costs*

The four tables given in the last section throw some light on the breakdown of total post office costs, considered from different points of view. However, the information they contain refers purely to total or average costs; they tell us nothing directly about the marginal costs of different mail categories. The importance attached to this cost concept derives from a theoretical economic argument which states essentially that the prices charged by public utilities should be set equal to the corresponding marginal costs. If this is done, the theory shows that under certain assumptions the quantities consumed of the goods or services produced by the public utility will lead to a pattern of resource allocation which will be optimally efficient from the point of view of society as a whole. The details and qualifications attached to this argument need not detain us here. Nor are we concerned with the practical problems of implementing such a policy, among which must be included the fact that it would conflict with the post office's statutory obligation to cover total costs. All that will be mentioned are the difficulties involved in defining and quantifying marginal costs.

No direct estimates of the marginal costs of Irish postal services were available for the present study.[38] In the absence of objective information, it was necessary therefore to fall back on casual observation in order to ascertain the likely magnitude of marginal costs. It has already been remarked, in the context of Table 3.1, that a large proportion of total costs are fixed in nature, which would suggest that marginal costs are low. On the other hand, the fact that additional part-time staff are taken on at Christmas suggests that marginal costs are substantial in magnitude. However, these two apparently contradictory viewpoints may be reconciled, by observing that, while marginal costs are certainly not negligible for all levels of mail volume, it is probably true to say that the marginal cost function is a step-function rather than a continuous curve. In other words, most post offices outside of the largest urban areas are operating for most of the time at less than full capacity, where the additional work-load imposed by an extra piece of mail is negligible. Only if mail volume increases by some minimum threshold amount does it become necessary to increase the amount of overtime worked, use existing transport equipment more intensively, and ultimately hire extra staff. In this sense, therefore, it is quite reasonable to state that, for "normal" fluctuations in work-load, short-run marginal costs are, in fact, zero.

A further consideration is suggested by a comment of Horsefield's, who points out that "collection and delivery costs are proportional rather to the number of points visited than to the number of letters handled".[39] With some modifications (for example, the distance travelled rather than the number of points visited might be a more appropriate criterion), this seems an eminently plausible proposition; and some tentative support for it is given in the econometric results which follow this section. It is also in accordance with post office experience: for example the movement of population from the centre of towns to new housing estates in the suburbs necessitates the provision of additional

38. Estimates of marginal costs are usually obtained by specifying and estimating a model of post office behaviour. See, for example, Merewitz (1971). However, while production functions for Irish post offices are estimated in section 3.5 below, it was not possible to derive estimates of marginal costs from them, because of the lack of data on factor payments in different offices.

39. Though, he adds, "there is a limit, set by the maximum permissible bagweight, to the extent to which intensive correspondence in a limited area enables manpower to be economised".

postal services, without permitting any compensatory running down of services in the town centre. The net result may be a major addition to the network of postal facilities, but no significant increase in mail traffic.

These arguments encourage the conclusion that the marginal cost of an additional piece of mail (whatever about that of an additional delivery stop) is a concept which is neither easy to define nor easy to measure. As already mentioned, it is apparent from Table 3.1 that the greater proportion of total costs are fixed costs, not responsive to the volume of traffic. This suggests that marginal costs are almost certainly lower than average costs; but beyond this it is impossible to be more precise about their level. For this and other reasons, no attempt has been made in this paper to derive an optimal pricing policy for postal services.

3.3 *Specifying an Econometric Model for the Production of Postal Services*

Having looked at the structure of total post office costs, we now wish to consider variations in costs between different post offices. In order to do so in a rigorous manner, it is necessary to have some theoretical basis for explaining how these costs are incurred; in other words, to have some model of individual office behaviour. This section therefore discusses the specification of such a model, and in subsequent sections various empirical relationships derived from it are estimated.

The study of costs and productivity in a sample of plants or enterprises is an area to which econometric analysis has been extensively applied. The usual approach is to begin by assuming that the technical relations applying to the individual plant or firm may be summarised by a production function, relating the volume of output to the quantities of different inputs required to produce that output. This production function may then be estimated directly from the data available. Alternatively, it may be combined with some assumption about the behaviour of each individual firm, such as profit maximisation or cost minimisation, to derive various reduced form equations, such as factor demand functions or cost functions, which are then estimated in the usual way. Both of these approaches have been extensively applied to a wide variety of industries; a particularly relevant application in the present context is a cross section study of 156 US post offices carried out by Merewitz ((1969) and (1971)).

From a number of points of view, the first approach listed above, direct estimation of the production function, is the more desirable. Not only does it provide estimates of all the parameters of the production function, such as the elasticity of substitution and the degree of returns to scale, but it also permits the calculation of an index of productivity for each office (this is discussed further in section 3.6 below). Unfortunately, however, the direct estimation of production functions is open to a number of serious objections, which are well summarised by the following quotation from Griliches (1962):[40]

> The basic problem in interpreting the results of non-experimental firm production-function fitting is in the specification of the economic model that generated these data. If all firms (farms) in an area are faced with the same factor prices, have the same production function, and maximize their profits, they would all use the same combination of resources and we could not estimate a production function. Obviously, they do not all use the same resource combination, but why? Maybe they do not maximize profits, but then they don't have to be *on* their production function. Maybe they all have different production functions—but what is the sense then of estimating one production function for all of them? They could be faced actually with different prices—but then we should use this price information and estimate the structural production function from the reduced form equations (factor demand functions) with prices as exogenous variables. Alternatively, different farmers may form their expectations differently and thus wind up at different points on the production function even though the objective information is the same for all of them. But without specifying explicitly what produces the observed data, it is impossible to draw any "structural" conclusions from non-experimental data.

Taken at face value, this quotation raises grave doubts about the appropriateness of estimating production functions directly from cross section data. However, in the present study no detailed information on factor prices or costs in different offices was available. It was not possible therefore to estimate factor demand or cost functions, which, as pointed out by Griliches, would have overcome the problem of simultaneity associated with direct estimation of production functions. Accordingly, in order to ascertain anything about the production process in Irish post offices it was necessary to resort to direct estimation of the production function despite the many objections to this procedure. Griliches' remarks should therefore be kept in mind in interpreting the resulting direct estimates which are presented in section 3.5 below.[41]

In addition to obtaining direct estimates of the production function, two

40. Though Griliches' remarks were originally made in a review of a text on agricultural production functions, they apply equally well to the present study, provided "post offices" are substituted for "firms" and "minimise their costs" for "maximise their profits".

41. That Griliches' remarks are in the nature of a counsel of perfection is suggested by the fact that the same paragraph has been quoted against the work of Griliches himself! (See Judge, 1963). Since the principal error involved in direct estimation of a production function is that of estimating by ordinary least squares a single structural equation in a simultaneous system, it is also relevant to note that the available Monte-Carlo evidence suggests that the small sample behaviour of ordinary least squares n such situations is by no means hopeless.

further considerations suggested that an alternative approach, that of studying the determinants of the productivity of labour alone, might also yield useful results. In the first place, the extreme labour intensity of the postal services already referred to suggested that the error involved in ignoring the contribution of other factors might not be very great. Secondly, data on labour employed were available for different years, whereas data on the other factor considered (transport vehicles) were only available for a single year. This meant that the determinants of intertemporal changes in labour productivity could be studied rather than merely the determinants of its cross sectional variation, in a single year.

This approach was therefore pursued, and the results are given in section 3.4. By comparison with the estimation of production functions, they suffer from the disadvantages that they make no allowance for the contribution of other factors, and that they do not involve the explicit specification of an econometric model of the production process. On the other hand, in the light of the difficulties associated with estimation of the production function, they provide a useful heuristic method of studying the conditions of production, and the factors which determine changes in labour productivity over time.

A final consideration which applies to both methods of studying postal production is that because of the nature of postal services we would expect the spatial characteristics and the pattern of population distribution in each office's catchment area to affect the productivity of the factors it employs. It seems intuitively plausible that a given volume of mail should require less manpower and transport equipment to handle, the more densely populated and the more urbanised is the catchment area of the office in question. This is consistent with the statement of Horsefield's quoted in section 3.2, that "collection and delivery costs are proportional rather to the number of points visited than to the number of letters handled". Accordingly, it seemed desirable to test this hypothesis by including measures of population dispersal as independent variables in the various production relations which were estimated. The variables chosen for testing were the crude population density and the proportion of population living in urban areas within each post office's catchment area.

Of course, while the general point that the distribution of an area's population will affect the productivity of the factors employed there in the production of postal services seems quite plausible, there is no reason to expect that this effect should be of equal magnitude for all factors.[42] At the same time, it is reasonable to postulate that all factors will be influenced to some degree.

42. By analogy with discussions of technical progress, the point at issue is whether we may reasonably expect the dispersion of an area's population to affect the relevant office's production function in a "neutral" manner.

Economies caused by a less dispersed or more urbanised catchment area can obviously be expected in the case of delivery staff and of transport vehicles. But they are also likely to apply to indoor postal staff and to total office floor space if there are economies of scale in the operation of sub-post offices. In other words, of two head post office districts handling exactly the same amounts of mail, the one whose population is so distributed that it needs fewer and larger sub-post offices than the other can be expected to require fewer indoor staff and less office floor space.

3.4 *Growth of Post Office Labour Productivity,* 1951–65

Data on the average annual growth rates of output, employment, and labour productivity in fifty Irish post offices from 1951 to 1965 are summarised in Table 3.5.[43] It may be seen from the table that output (the sum of postings and deliveries) in the Irish postal services as a whole increased by 2·28 per cent per annum on average between 1951 and 1965. The labour force, on the other hand, grew by only 0·12 per cent per annum, leading to an increase in labour productivity of 2·17 per cent per annum over the period.

As was done in Part 2 of this paper, it is important to distinguish between conditions in Dublin and in the remainder of the country. In 1965 the Dublin postal area handled 49·4 per cent of the total output of the Irish postal services, but employed only 23·5 per cent of their total staff. The level of labour productivity in Dublin was therefore considerably higher than in the rest of the country, even though it grew more slowly between 1951 and 1965 (1·03 per cent per annum compared with 2·00 per cent per annum in the rest of the country as a whole, and 1·93 per cent per annum on average in the other forty-nine head post offices).[44] Moreover, the lower productivity increases in Dublin over the period were the consequence of higher rates of increase of both output and employment. In the rest of the country, on the other hand, employment actually fell by 0·43 per cent per annum on average, with the result that the increase in productivity was greater than the increase in output.

43. In fact, data were available on a total of fifty-two post offices. However, because of the difficulties of defining separate catchment areas for the Dun Laoghaire and Cobh offices, they were combined with Dublin and Cork respectively, as was done in Part 2.

44. It may be noted that the average annual growth rate of productivity in the whole country (2·17 per cent) was higher than the growth rates in both Dublin and the rest of the country. This apparently paradoxical result is due to the fact that between 1951 and 1965 the proportion of the post office labour force employed in the high-productivity area (Dublin) increased, matched by a fall in the proportion employed in the area with lower productivity (the rest of the country). The increase in productivity in the whole country over the period may be decomposed into an inter-regional and an intra-regional component. The latter gives the increase in productivity in the whole country which would have occurred if productivity in both regions had grown at the rate at which it actually did grow, but the proportions of the total labour force employed in the two regions had remained the same. In the present case this calculation yields an intra-regional productivity growth of 1·50 per cent per annum, which lies between the growth rates in Dublin (1·03 per cent) and the rest of the country (2·00 per cent), as of course it must. See Kennedy (1971), pp. 24–26, for details on the calculation of inter- and intra-regional components.

TABLE 3.5: *Average annual growth rates of output, labour force and labour productivity in Irish post offices,* 1951–65

Variable (all expressed as average annual growth rates)	*Growth rate: all country* (%)	*Growth rate: Dublin* (%)	*Growth rate: all country excluding Dublin* (%)	*Mean growth rate* (%) *and standard deviation* (*of* 49 *non-Dublin head post offices*)	*Standardised difference between Dublin and non-Dublin growth rates*
Post Office Output	2·28	3·02	1·63	1·49 (·69)	2·22
Labour force:					
Total Staff	·12	1·98	—·36	—·43 (·61)	3·95
Delivery Staff	·00	2·59	—·59	—·68 (·76)	4·30
Indoor Staff	·27	1·36	—·06	—·09 (·65)	2·23
Labour productivity:					
Total Staff	2·17	1·03	2·00	1·93 (·75)	—1·20
Delivery Staff	2·29	·42	2·24	2·19 (·88)	—2·01
Indoor Staff	2·01	1·64	1·69	1·59 (·81)	·06
Population in office catchment area	—·18	·92	—·55	—·68 (·55)	2·91

Notes: (1) Output data are available for 1951 and 1965, whereas labour force and population data are available for 1951 and 1966. The average annual growth rates given for labour force and population are therefore based on 15 years, while those for output are based on 14 years. Data on productivity in 1965 were calculated by dividing 1965 output data by estimates of the labour force in 1965, obtained by interpolating between 1951 and 1966. The growth rates for productivity are therefore also based on 14 years.

(2) All growth rates were calculated by applying the usual compound interest formula to the data for 1951 and 1965 (or 1966).

(3) Standardised Difference = (Growth Rate in Dublin — Mean growth rate in other 49 offices) divided by standard deviation.

Variables:

Post Office Output = Sum of total mail posted and delivered.
Labour Force = Numbers employed in each category.
Labour Productivity = Output divided by Labour force
For details on the measurement of these variables, see Appendix B.

The contrast between Dublin and the rest of the country is further brought home by the last column of Table 3.5, which gives a measure of the difference between the growth rate of each variable in Dublin and the average growth rate in other post offices. In particular, it may be seen that both output and catchment area population grew reasonably rapidly in Dublin, whereas output grew more slowly elsewhere and population actually fell. These differences emphasise the fact that the postal services in Dublin operate under completely different conditions from those prevailing in the rest of the country. In the case of productivity, however, the difference is completely attributable to delivery staff, whose numbers grew more rapidly than those of indoor staff in Dublin, but declined more rapidly elsewhere. The rate of productivity growth of indoor staff, on the other hand, was very similar in both areas.

It is of interest to note that the pattern of productivity growth in the non-Dublin post offices is totally different from the behaviour observed in most manufacturing industries, as surveyed by Kennedy (1971).[45] More surprisingly, it is also very different from the behaviour of selected United States service industries between 1948 and 1963 as shown in Fuchs (1966). In most of the industries and services considered by these studies both output and employment showed fairly rapid rates of increase, but with the former increasing more rapidly, resulting in moderate increases in productivity. The situation in Irish postal services however resembles more that in agriculture in many countries, where increases in productivity are attributable as much to declines in employment as to increases in output. Even the exceptional industries or services whose behaviour somewhat resembles that of the Irish postal services provide revealing comparisons. For example, of the eighteen services and retail trades considered by Fuchs, the productivity performance of the Irish postal services most resembles that of dry cleaning, and is actually superior to that of hotels, laundries, and cinemas.[46] Similarly, the productivity performance of indoor postal staff shown in Table 3.5 bears a striking resemblance to the behaviour of Irish industry in the comparable period 1950–59 (see Kennedy, Table 2.6, p. 47): the average annual growth rate of output in the latter was rather higher, at 2·14 per cent, than that in the postal services, but employment fell by 0·41 per cent per annum, yielding a ratio of productivity to output growth rates of 1·20. Needless to say, this similarity may be only coincidental; however, it does suggest that, in so far as the productivity behaviour of the postal services is

45. In so far as the data in Table 3.5 can be compared with similar figures for manufacturing industry the relevant point of comparison is the productivity performance of indoor postal staff. This is because employment data for manufacturing industry cover only those employed by the producer, and so relate mainly to indoor staff, rather than to those who, like outdoor postal staff, are involved in transport and distribution. I am grateful to K. A. Kennedy for this point.

46. Fuchs (*op. cit.*), Table 6.

TABLE 3.6: *Cross section regressions: determinants of labour productivity changes in 49 head post offices,* 1951–65

Dependent Variable	*Equation No.*	*Equation (t-values in parentheses)*	$\bar{R}^2$	*t*
Average annual growth rate of productivity of Total Staff 1951–1965	F1	$Y_1 = \cdot925 + \cdot676Q$ $(4\cdot62) \quad (5\cdot54)$	·382	−3·13**
	F2	$Y_1 = \cdot789 + \cdot716Q - \cdot113P$ $(2\cdot73) \quad (5\cdot23) \quad (\cdot66)$	·374	−2·80**
Average annual growth rate of productivity of Delivery Staff 1951–65	F3	$Y_2 = 1\cdot203 + \cdot664Q$ $(4\cdot64) \quad (4\cdot21)$	·258	−3·48**
	F4	$Y_2 = 1\cdot111 + \cdot691Q - \cdot076P$ $(2\cdot96) \quad (3\cdot89) \quad (\cdot34)$	·244	−3·21**
Average annual growth rate of productivity of Indoor Staff 1951–65	F5	$Y_3 = \cdot512 + \cdot722Q$ $(2\cdot34) \quad (5\cdot43)$	·372	−1·56
	F6	$Y_3 = \cdot369 + \cdot764Q - \cdot118P$ $(1\cdot17) \quad (5\cdot11) \quad (\cdot63)$	·364	−1·31

Note: All equations are based on 49 head post offices (i.e. Dublin is excluded).

Key: $\bar{R}^2$ = Coefficient of multiple determination, adjusted for degrees of freedom.

t = t-statistic, testing the hypothesis that the value of the relevant dependent variable corresponding to Dublin is generated by the same relationship as the value for the other 49 head post offices:

** indicates that the hypothesis can be rejected with 99 per cent confidence,

* indicates that the hypothesis can be rejected with 95 per cent but not with 99 per cent confidence.

Independent Variables:

Q = Average annual growth rate of total pieces of mail posted and delivered in head office district, 1951–65.

P = Average annual growth rate of population density in head office's catchment area 1951–65. (This is equal to the corresponding average annual growth rate in population itself.)

comparable with that of industry, then the closest parellel is with the relatively depressed years of the 1950s.

In order to ascertain whether offices whose levels of output increased over the period also experienced increases in productivity, a number of regression equations were estimated, and the results are presented in Table 3.6. The dependent variable in all cases is the average annual growth rate of productivity of the relevant staff category, and each of these is regressed on the average annual growth rates of output and of catchment area population density. Considering first those equations (F1, F3 and F5) where the growth rate of output is the sole independent variable, it is apparent that a reasonably high degree of association is obtained. Moreover, the estimated coefficient does not differ greatly between the two categories of labour, varying within the range 0·66 to 0·77. The intercepts are significantly positive, implying that even if there had been zero growth in output over the period, productivity would still have risen.

These results are moderately satisfactory in statistical terms. However, like the data in Table 3.5 they are somewhat different from the findings of similar studies of manufacturing industry, surveyed by Kennedy (1971). In particular, the degree of association between the two growth rates is rather less than in the studies reported by Kennedy, and the estimated elasticities are quite different. These elasticities are equal to the coefficients of Q in the regressions in Table 3.6, and as already noted, they vary between 0·66 and 0·77, whereas those reported by Kennedy are mostly in the range 0·25 to 0·50 (*op. cit.*, p. 237).

Of course, these differences between the results of the present section and those for manufacturing industry are not really surprising.[47] Rather, they reflect the totally different conditions of production in the two sectors. In particular, it may be recalled that Kennedy's explanation for the close association between the longer term growth rates of output and productivity in manufacturing industries emphasises the role of output growth in facilitating and encouraging the discovery and application of new technological knowledge (*op. cit.*, especially Chapter 6). The situation in postal services, however, is that, partly due to the nature of the service provided, and partly to the scale of operations prevailing in most Irish offices, the level of technology cannot be significantly improved irrespective of the volume of output handled. Given that, in addition, the growth of output has been relatively sluggish, because of the low income elasticities of demand found in Part 2, it is obvious that, despite the high elasticities found in Table 3.6, the nature of the service does not permit the achievement of productivity gains coupled with increases in employment, which tend to characterise manufacturing industries in a growing economy. Indeed, the relationship between output growth and employment growth in the present sample of post offices over the period covered was extremely weak: the correlation coefficient is a mere 0·222. This implies that many offices were operating at less than full capacity, which further reduces the potential for realising dynamic economies of scale as a result of the application of new technology, the factor which Kennedy singled out as the principal source of productivity growth in manufacturing industry.

47. One reason which might be thought to give rise to the differences between the findings reported here and those given by Kennedy, are that the latter deal with a cross section of different industries; whereas in studying the postal services we are considering a cross section of different "plants" (i.e., post offices) within the same "firm" (albeit in a monopoly position, so that the firm and the industry are identical). However, while this fact means that the two sets of results are not directly comparable, it is unlikely to be quantitatively important, since, as may be seen from a comparison of the third and fourth columns of Table 3.5, the behaviour of the postal "industry" as a whole is very similar to the average behaviour of the individual "plants" within it.

A final consideration relating to the results in Table 3.6 concerns the inclusion as an independent variable of the average annual growth rate of population density in each office catchment area. On the basis of the argument in section 3.3 concerning the effects of greater agglomeration of population on postal productivity, we would expect the coefficient of this variable to have a positive sign. (In fact, the population density of office catchment areas fell on average over the period: as shown in Table 3.5, the mean value of P is $-0{\cdot}68$ per cent; however, the argument is symmetric: we would expect this fall to have a negative influence on postal productivity.)

Surprisingly, however, the coefficient of the population density variable is negative in Table 3.6 and it is also completely insignificant. The hypothesis that faster rates of growth in population density should be associated with faster rates of growth in postal productivity must therefore be rejected, at least for changes in post offices over time. However, it is still possible that a better measure of changes in the dispersion of an office catchment area's population might be positively related to the change in productivity. Indeed, one possible rationalisation for the negative coefficients found here is that the declines in population density represented falls in the numbers living in outlying districts, permitting greater concentration of resources on more densely populated districts which, from the post office's point of view, are cheaper to service. Some very tentative evidence for this explanation is provided by the fact that the average annual growth rate of population density in each office catchment area is positively related to its population in both 1951 and 1966 ($r = 0{\cdot}290$ (1951) and $0{\cdot}382$ (1966)). In other words, the more populated areas tended to have faster rates of growth of population density over the period: the national population, though falling in absolute terms, was therefore becoming more spatially concentrated, thus exerting a positive influence on the productivity of postal employees.

3.5 *Production Functions for Post Office Operations*, 1965

Having examined the behaviour of labour productivity in Irish post offices between 1951 and 1965, we now wish to specify and estimate production functions for post office operations in a single year, 1965. The first issue which must be resolved is the measurement of output. As in the last section, output is measured in physical units, by the sum of pieces posted and delivered in each office catchment area. This raises the problem, however, that the dependent variable is a measure of actual output, whereas a production function is usually taken as a relationship between the quantities of factors of production employed and the maximum output which they can produce. In other words, a production function is usually considered to determine the level of capacity output, which is not necessarily equal to actual output; in the present study this is especially relevant in the light of the suggestion in the last section that many Irish post offices may be working at less than full capacity. Unfortunately, while noting the potential gravity of the problem, there is little that can be done about it, since no information on the degree of capacity utilisation in Irish post offices is available. In order to interpret the results given in this section, it is therefore necessary to assume that the degree of under-utilisation of capacity is the same in all offices.

Turning next to the measurement of factor inputs, it would be highly desirable to have information on the quantity of all the factors of production employed in each office. Unfortunately, however, the only factors for which data were available were labour, broken down into indoor staff and outdoor (delivery) staff, and transport vehicles.[48] Furthermore, data on both these factors were only available for a single year, 1966. No data whatsoever were available on other factors; in particular on the volume of office floor space, and the value of capital equipment in each office. The omission of the latter is perhaps not too serious, given the relative lack of mechanisation of the postal services; however the former variable, office floor space, is likely to be of considerable importance in the provision of postal services, and is almost certainly substitutable to some extent for the other included factors. Accordingly, the omission of this variable may be expected to bias the estimated coefficients of labour and transport vehicles, though little can be said about the direction and magnitude of the bias.

Having selected the factors of production for inclusion in the equation, the next problem is the choice of functional form of the production function. Because of the severe data limitations on this study and the resulting specification errors, it was thought that little would be gained by experimenting with very complicated production functions. Accordingly, attention was confined to the familiar Cobb-Douglas function. This has the limitation that it implies a value for the elasticity of substitution between factors of unity, a reasonable but restrictive assumption. The degree of returns to scale, on the other hand, was not constrained to unity, but was estimated directly from the data.

The final specification problem concerned the inclusion of population variables, to test the hypothesis advanced in section 3.3 that the degree of dispersion of an area's population should affect the productivity of the factors employed in that area's post office. This hypothesis was tested in the simplest possible way: the relevant variables were assumed to shift the production function in a multiplicative fashion, leading to the estimation of equations linear in the logarithms of all variables. Of course, more elaborate specifications could have been attempted, such as allowing the measures of population

48. For details on the measurement of these variables, see Appendix B.

dispersal to shift the production function in a non-neutral manner or to affect the value of the elasticity of substitution between factors. However, these formulations were not investigated in the present study.

The equations estimated took the form (with all variables expressed as natural logarithms):

$$\log Q = a_0 + a_1 \log F_1 + \ldots + a_k \log F_k + \beta_1 \log P_1 + \ldots + \beta_r \log P_r + u.$$

Q is a scalar measure of output, equal to the sum of pieces posted and delivered by the relevant office in 1965; the F_i represent k factors of production; and the P_i are r indices of population dispersal. In practice, two measures of the latter were tested: the population density in each office catchment area, and the proportion of the area's population living in urban areas.

The equations actually estimated are presented in Table 3.7, the only feature of note being the inclusion of $\sum a_i$, the sum of estimated factor coefficients, along with its estimated standard error, calculated in the usual manner.[49] This permits the hypothesis of constant returns to scale to be tested. It may be seen that in all cases $\sum a_i$ is within one standard error of unity, implying that the data do not permit us to reject the null hypothesis of constant returns to scale.

It is apparent from Table 3.7 that the contribution of labour to the production of postal services, as measured by its estimated coefficient, is considerably greater than that of transport vehicles. This is as we would expect, in the light of the high degree of labour intensity of the service. The coefficients of both variables are significant at the 10 per cent level or more in all equations, and are little affected by the inclusion of additional variables. Both measures of population dispersal also perform well; however the variable U, measuring the proportion of population living in urban areas, yields larger and more significant coefficients than D, the population density of each catchment area. In addition, when both are included in the same equation (e.g. equation G4) there is some evidence of multicollinearity, implying that the data do not permit us to distinguish between the separate influences of the two variables.[50] The one disappointing feature of the table is the poor performance of the disaggregated labour variables: despite the nominal significance of both variables in equations G5 to G8, their excessive interdependence ($r = 0{\cdot}954$) leads to a high degree of multicollinearity in these equations, and so renders their coefficient estimates highly suspect.

In the light of Table 3.7, which of the estimated production functions can be chosen as most satisfactory? It is evident that the attempt to distinguish the

49. For example, when two factors are included in the equation, the standard error of Σa_i is the square root of: var a_1 + var a_2 + 2 cov $a_1 a_2$.

50. The simple correlation coefficient between their logarithms is ·685.

TABLE 3.7: *Cobb-Douglas production functions for 49 head post offices, 1965*

Equation No.	*Regression Coefficients (t-values in parentheses)*							*Σa_i (standard error in parentheses)*	$\bar{R}^2$	*Chi Square*
	Intercept	*log L*	*log L_1*	*log L_2*	*log V*	*log D*	*log U*			
G1	·081	·874			·167			1·042	·800	30·58
	(·20)	(8·32)			(1·79)			(·075)		
G2	—1·565	·828			·147	·440		·975	·891	28·86
	(3·94)	(10·59)			(2·12)	(6·24)		(·057)		
G3	—1·801	·820			·146		·612	·965	·937	29·03
	(6·15)	(13·85)			(2·77)		(10·07)	(·043)		
G4	—1·998	·814			·143	·142	·503	·957	·941	12·93*
	(6·68)	(14·22)			(2·81)	(2·04)	(6·33)	(·042)		
G5	·644		—·264	1·224	·106			1·065	·842	1·94**
	(2·16)		(1·25)	(5·25)	(1·24)			(·067)		
G6	—·767		·086	·791	·120	·376		·996	·897	1·54**
	(2·07)		(·46)	(3·82)	(1·74)	(5·02)		(·056)		
G7	—1·111		·253	·592	·131		·570	·976	·938	1·48**
	(3·98)		(1·74)	(3·61)	(2·46)		(8·43)	(·043)		
G8	—1·316		·291	·544	·132	·128	·481	·967	·941	·75**
	(4·46)		(2·02)	(3·35)	(2·53)	(1·80)	(5·83)	(·043)		

Notes: Σa_i = The sum of factor coefficients for each equation. The standard error permits a test of the hypothesis of constant returns to scale ($\Sigma a_i = 1$). All logarithms are natural logarithms.

Variables:

log Q = Independent variable: log of average of postings and deliveries for each post office in a representative week of 1965.
L = Total postal staff employed in each office catchment area, 1966.
L_1 = Delivery staff employed, 1966.
L_2 = Indoor postal staff (sorters, administrators, etc.) employed 1966.
V = Number of vehicles in use, 1966.
D = Population density in office catchment area, 1966.
U = Proportion of population in catchment area living in urban areas, 1966.

separate contributions of the two labour variables must be judged a failure. The same applies to a lesser extent to the two measures of population dispersal, population density and urban population as a proportion of total population; although a case could be made for retaining both variables as distinct influences tending to raise the productivity of factors employed in post offices, it seems preferable to look on their effects as being mutually reinforcing, and so to retain only one in the final equation.[51] On the basis of all these considerations, therefore, the most satisfactory production function is equation G3, containing as independent variables the total numbers of staff employed and of transport vehicles in use in each office, as well as the proportion of the population of its catchment area living in urban areas. It may be mentioned that the residuals from this equation show no evidence of misspecification; in particular, the simple correlation coefficient between the absolute values of the residuals and the values of the dependent variable predicted by the equation, is $-0{\cdot}217$, indicating that there is no evidence of heteroscedasticity in the disturbances.

In conclusion, the results of this section are open to a number of criticisms, many of which centre on the data used: not only was it impossible to obtain data on some inputs, but the measures of those variables which were included are somewhat inadequate. Nevertheless, despite these limitations, this exploratory study has shown that it is possible to estimate production functions for Irish post offices which are statistically satisfactory and from which economically meaningful conclusions may be drawn. Among the latter should be included: the confirmation of the overwhelming importance of labour in the production process, the evidence in favour of constant returns to scale, and the corroboration of the hypothesis that an office's productivity is influenced by the spatial distribution of the population in the catchment area which it serves. Finally, the production functions which have been estimated may also be used to construct an index of productivity for each individual post office, and this application is discussed further in the next section.

3.6 *Evaluating the Performance of Individual Post Offices*

The last section has shown how estimated production functions may be used to throw light on the conditions of production in Irish post offices. A further application of these results which may be made is to use them in evaluating the performance of individual post offices. This is a potentially valuable application, since it is particularly important that objective measures of performance be devised for individual plants in public sector enterprises. For, to quote Feldstein (1967), p. 9, there is a danger that "sheltered from the

51. The fact that these two sets of variables are the principal source of multicollinearity in equation G8 was confirmed by a detailed application of the tests suggested by Farrar and Glauber (1967) to this equation.

competitive forces that impel cost reduction and lacking the incentive to efficiency provided by the profit motive, the managers of public establishments may fail to achieve a standard of operation comparable to that of private industry".

As a preliminary to deriving performance indicators, it is necessary first to digress in order to discuss various criteria which might be used in assessing post office performance.[52] From the point of view of post office management, an obvious criterion of performance for an individual office is the costs incurred by it. It is not sufficient to look simply at the total costs incurred however, for obviously an office which handles more than the average volume of mail will have above average costs. What is required is a measure which relates the actual costs incurred in each office to the costs which would have been "expected" on the basis of the volume of business handled by it. Such a measure, known as a costliness index, could be derived by taking the ratio of actual costs in each office to the costs predicted by an estimated cost function. Offices with values greater than unity on this index would then be judged to be above average in costliness.

Unfortunately, as explained in the last section, the data available for this study did not permit the estimation of cost functions. Nevertheless, some progress along these lines is possible because differences in costliness between offices can be attributed in turn to three separate influences:

(1) Differences in Factor Prices

(2) Differences in Productivity

(3) Differences in Input Efficiency.

The first of these influences requires no explanation: obviously higher factor prices will lead to higher costs, other things being equal. However, it is unlikely that very substantial differences in relative factor prices will occur within a comparatively small and homogeneous country such as Ireland. In any case no data on factor prices were available for this study, so this influence has perforce been ignored.

The second influence, productivity, refers to the volume of output which can be produced with various quantities of factors. Thus, of two offices, the one with higher productivity will require less of some or all inputs to produce a given output: in terms of the isoquant diagram, the isoquants of the more productive office will be closer to the origin than those of the less productive. Productivity, in this context, is, therefore, a matter of avoiding wastage

52. The following discussion draws extensively from Feldstein (1967), section 2.4, and Merewitz (1969), chap. 6.

or under-utilisation of any resources, for which reason it is sometimes referred to as "technical efficiency."[53]

Input efficiency, on the other hand, refers to the choice of the least costly technique of producing a good from among all the alternative techniques which can be classed as technically efficient. This choice will therefore hinge on the prices of the different factors of production, i.e. if the price of a particular factor is high, it will not pay to adopt a process which uses a great deal of that factor, even though this process may be efficient in a technical or engineering sense. In terms of the isoquant diagram, all the points on a given isoquant are equal from the point of view of productivity; but given a particular ratio of factor prices, as summarised by the slope of the isocost curve, only one of those points will maximise input efficiency, and thus minimise total cost.

One implication of the distinction between productivity and input efficiency is that looking at output per head alone is not a very reliable guide to the performance of an individual office. This may be seen by considering the following question: if the levels of total mail per person employed in two post offices which face identical operating conditions (as measured by, *inter alia*, volume of mail handled and population density) differ, what does this tell us about the relative efficiency of the two offices? The answer is that it tells nothing unambiguously. One office may be using more labour to handle a given volume of mail than another because its employees are lazier, i.e. less productive or technically less efficient, than those in the second office. Alternatively, both offices may be equally productive, and the difference between them may be due to the fact that the second office has more motorised transport than the first and so needs less labour (in other words, the two offices have different factor proportions). But using so much transport equipment may not be the cheapest means of delivering a given volume of mail, especially if the price of transport is particularly high. In such a situation the office which employs more labour per unit of total mail may, in fact, be superior from the point of view of input efficiency. This hypothetical example is perhaps a fairly fanciful one. However, it does emphasise the fact that, in evaluating the performance of a post office, it is not enough to look at the observed productivity of labour alone. Rather, both the total productivity of all the factors employed, as well as the efficiency with which they are combined, in the light of prevailing factor prices, must be considered, especially where there is considerable potential for substitution between factors.

Unfortunately, because no cost data were available, it was not possible to estimate an index of input efficiency for each post office. However, from the estimated production functions, it is possible to construct an index of produc-

53. Some authors use the terms technical efficiency and economic efficiency rather than productivity and input efficiency. See Merewitz (1971) p. 508 for references.

tivity for each office. Taking the antilog of the predicted value of the dependent variable for each observation gives the volume of output which that office could be "expected" to handle on the basis of the quantities of factors it employs and the spatial characteristics of the area it serves. Therefore the ratio of the actual output of each office to this "expected" or "average" output gives an index of that office's productivity. The expected value of this index is unity, values above unity indicate an office of above average productivity, and conversely for values below unity.

Since the most satisfactory production function in the last section was equation G3 in Table 3.7, this function has been used to calculate productivity indices for each office, and the distribution of index values is set out in Table 3.8. It is apparent that the majority of offices have indices which lie within the range 0·85 to 1·15. However, there are a number of offices outside this range: seven are substantially above average in productivity, and five are substantially below average.[54] In the case of those offices with low productivity, the present analysis would suggest that further investigation on the part of the postal authorities into the causes of their apparently poor performance might be fruitful. The reasons might be purely statistical: for example the data available for those offices might be subject to error. However more substantive forces might be at work: the offices involved may have been operating considerably below capacity in 1966; or they may have been endowed with inadequate quantities of equipment or outdated premises; or, finally, their managements may have been below average in efficiency. It is obviously important for the postal authorities to find out which, if any, of these causes were operating; and the answers to such questions may be of considerable use in deciding on future budgetary allocations.

Of course, decisions based on the values of the productivity index will only be as reliable as the underlying production function from which they are derived. Accordingly, all the reservations put forward in section 3.5 should be kept in mind in interpreting the results of this section. As a final check on these results, the productivity indices from a number of the production functions in Table 3.7 were calculated and compared. The resulting correlation coefficients are presented in Table 3.9, along with the correlations between these indices and the residuals from equation F1 in Table 3.6. The latter residuals are a crude measure of the extent to which the growth in labour productivity in each office between 1951 and 1965 was above or below what might have been expected on the basis of the growth in mail volume handled over the same period. Since it has already been pointed out that labour productivity is not

54. The projected value of the productivity index for Dublin is 2.25. However, this is probably better interpreted as an indication of the very different conditions of production prevailing in Dublin (see the discussion at the beginning of section 3.4), than as evidence of extraordinarily high productivity of those factors employed in Dublin.

TABLE 3.8: *Distribution of values of productivity index derived from production function G3*

Range of Values	>·7	·7–·75	·75–·8	·8–·85	·85–·9	·9–·95	·95–1·0	1·0–1·05	1·05–1·1	1·1–1·15	1·15–1·2	1·2–1·25	1·25–1·3	1·3<	*Total*
Frequency	1	2	1	1	5	9	5	3	8	7	3	3	—	1	49

Note: Each frequency gives the number of offices for which the values of the productivity index for 1966, derived from equation G3, Table 3.7, fall within the relevant range. See text for further details. Calculation of the standard errors of forecast for each office showed that all index values below 0·8 are significantly less than unity and all but one of those above 1·2 are significantly greater than unity, at the 90 per cent level at least. Details of these results are given in a confidential appendix to this section, available on request from the author.

TABLE 3.9: *Correlation coefficients between alternative productivity indices*

No.	*Equation from which Productivity Index is derived*	*Correlation Coefficients* 1	2	3	4	5
1	Table 3.7, equation G1	1·0				
2	„ „ equation G3	·523	1·0			
3	„ „ equation G4	·492	·957	1·0		
4	„ „ equation G8	·475	·937	·983	1·0	
5	Table 3.6, equation F1	—·096	·037	·087	·069	1·0

Notes: Productivity indices derived from equations in Table 3.7 are the actual volume of output in each office in 1966, divided by the volume predicted by the production function in question.

Productivity index derived from equation F1 in Table 3.6 is the difference between the actual average annual growth rate of labour productivity in each office from 1951 to 1966, and the growth rate predicted by the equation.

an adequate measure of total productivity, it is not surprising to find that there is no relation between these residuals and the various productivity indices.

However, there is considerably more consistency between the different productivity indices. The index from equation G1 is somewhat exceptional: the correlation between it and the index from equation G3 is only 0·523. This implies that making allowances for the spatial characteristics of a post office's catchment area, as measured by the proportion of its population living in urban areas, makes a substantial difference to the offices which should be regarded as above or below average in productivity. However, the three indices from equations G3, G4 and G8 are very highly correlated, so it may be concluded that the precise specification of a catchment area's spatial characteristics or an office's labour input makes little difference to one's assessment of that office's productivity.

3.7 *Summary*

Part 3 began with a descriptive survey of the structure of aggregate post office costs, which was found to be relatively similar to the cost structure of the American and British postal services. The main features in common appeared to be: the high degree of labour intensity; the relative equality of average costs for different mail classes; a structure of postal rates which is unrealistic from the point of view of a policy of average cost pricing in that it does not reflect this similarity in average costs for different mail categories; and only fairly minor differences in the functional breakdown of costs for different mail categories, with first class mail costing proportionately less to collect and deliver and more to handle.

Not only the cost structure but the actual level of average costs in the postal services of the three countries was found to be relatively similar. Given that labour costs in the United States are much higher than those in Ireland, this would seem to imply that the Irish postal services are less efficient than the American services. However, it was argued that this is not necessarily the case, since the United States post office serves a larger and more concentrated population, and, most importantly, since the quality of the services it provides is appreciably lower than that provided by the Irish postal services.

Turning from aggregate postal costs to production in individual post offices, labour productivity in the postal services as a whole was found to have increased by 2·17 per cent per annum over the period 1951–65. It was noted that productivity in Dublin was considerably higher than in the rest of the country, though its rate of increase between 1951 and 1965 was slower than elsewhere. The growth rates of labour productivity in different offices were closely associated with the corresponding growth rates in output. However, the estimated elasticity involved was quite high, ranging from 0·66 to 0·77, and the growth rates in output were almost totally unrelated to the growth rates of employment in corresponding offices. This behaviour, though not too dissimilar to the experience of Irish industry in the period 1950–59, is extremely different from that found by most previous studies of manufacturing and service industries, in Ireland and elsewhere. It was argued that this difference reflected the conditions of production in Irish post offices: because of the nature of the services provided, the relatively small scale of operations, and the sluggish growth in demand, increases in postal productivity have arisen more from declines in staff employed than from the exploitation of dynamic economies of scale, such as tend to characterise manufacturing industry in a growing economy.

Production functions for Irish post offices in a single year were then estimated. The results suggested that economies due to increased scale of operations are not important in head post offices; however economies due to increased agglomeration of population do appear to be significant, though the precise channels by which such economies arise could not be ascertained with the data available.

Finally, the estimated production functions were applied to derive indices of productivity for each post office. These indices are potentially useful as performance criteria at office level: low values of the index imply below-average productivity, which may be caused by serious under-utilisation of capacity, inadequate or obsolete equipment and premises, or a host of other reasons. Whichever of these factors is operating, the indices should be a useful tool in deciding on future budgetary allocations and modernisation programmes.

Part 4

Implications for Postal Profitability and Finances

THE findings of Parts 2 and 3 have been summarised in sections 2.7 and 3.7 respectively, and so it is unnecessary to repeat them here. The paper therefore concludes with a discussion, in the light of these findings, of the likely future trends in post office profits, and of the implications of these trends for the financing of the postal services.

Looking first at postal revenue, the econometric results in Part 2 were used to generate a range of forecasts of mail volume, which are presented and discussed in section 2.6. In general these forecasts predict growth rates in mail volume of between 1·2 per cent and 4 per cent per annum, depending on the assumptions made about the independent variables, with the actual rate of growth moderately sensitive to different growth rates of income, and relatively insensitive to different rates of increase in postal charges.

The last finding should not be interpreted to mean however that charges could be increased indefinitely without having any adverse effects on demand. In the first place, the degree of responsiveness which is being discussed is a long run effect; nothing in what has been said negates the possibility that the short-run impact on mail volume of even fairly moderate increases in charges might be substantial. Secondly, it should be emphasised that the relationships which have been estimated can only be presumed to hold when the relevant variables are close to the range over which they have varied within the sample period. Thus, these relationships could not be relied upon to accurately predict the effects of a large departure of postal charges from their historic levels.[55]

For these reasons, the fact that mail volume does not appear to be very sensitive to price should not be taken as justifying very large increases in charges. (Of course, this discussion is concerned exclusively with *real* prices; increases in postal charges which merely keep pace with average inflation involve no increase in real charges).

Another aspect of the demand forecasts which may be mentioned, is that they predicted a continuation of the tendency for second class mail to grow at a faster rate than first class. This latter fact is of some interest for two reasons. First, since second class mail appeared to be even less responsive to price than

55. In technical terms, the point at issue is that the standard error of forecast (measuring the unreliability of the forecast) increases with the distance of the values of the exogenous variables from their within-sample means.

first class, it implies that the price elasticity of total mail is likely to fall gradually over time. Secondly, it may be recalled that the average costs of the two mail classes appeared from Table 3.3 to be marginally different. If the average cost of second class mail has remained higher than that of first class, and if their marginal costs bear the same relationship to one another, then the increasing relative importance of second class mail is likely to accelerate the rate of increase of aggregate post office costs.

So much for the implications for postal revenue of the forecasts of mail volume given in section 2.6. As for future trends in costs, it seems likely that they will continue to grow at a faster rate than average consumer prices if present tendencies continue. This is so because of the exceptionally high degree of labour intensity of the services, and also because of the limited scope for increasing productivity. Both of these aspects have been remarked upon throughout Part 3, and they make it inevitable that pressure for increases in real wages will tend to raise postal costs more quickly than the rate of increase in consumer prices.

The effect of these likely trends in demand and costs on post office profits will obviously depend on the objectives being pursued by the department and on the pricing policies these objectives force them to adopt. In the past the post office's accepted objective has been to cover its costs on a long term basis. This has involved a policy of average cost pricing on its services as a whole (though, as noted in section 3.1, the policy was not applied to the pricing of individual services). As a result, recurrent increases in postal charges have been necessary in order to erase the deficits brought about by wage increases while at the same time avoiding any deterioration in the standards of services. Moreover, this trend is likely to continue, with the rate of growth of postal charges tending towards equality with the difference between the rate of growth of labour earnings, and the rate of growth of labour productivity.[56]

In the light of this discussion it is evident that the major problem facing the Department is how to increase productivity and moderate the rate of increase in costs. Apart from some fairly minor cost savings which might be achieved by reorganising certain services, there appear to be two possible ways in which savings could be made: greater mechanisation of the service, or reductions in the standard of postal services.

The first policy, which has been advocated as a solution to the problems of rising costs faced by the postal administrations of other countries, is to increase

56. It may be mentioned in passing that this conclusion—equality of the rate of growth of prices and the difference between the rates of growth of earnings and labour productivity—is often assumed to be self-evident at both macro and micro levels. That such is not the case is shown by the stringent assumptions which are necessary for the conclusion to hold: a high degree of labour intensity; little potential for factor substitution (or for the shedding of surplus labour); and a policy of average cost pricing (whether permitted by a low price elasticity of demand, or enforced by budgetary guidelines). In the case of postal services, however, these assumptions appear to be approximately valid.

the degree of mechanisation and automation of postal work. The extreme labour intensity of the postal services has already been commented on—though it is arguable that mechanisation could be accelerated even with the existing level of technology. Moreover, while postal technology has hitherto developed relatively slowly, because of the individual treatment required for each item, there are indications that a break-through in mail processing techniques may be imminent. In economic terms this is a perfectly logical development, i.e. as the price of labour rises relative to that of other factors of production, it pays to substitute automated machinery for labour (at least from the organisation's point of view, though the same would not necessarily be true if correct allowance was made for social costs and benefits). However, the feasibility of such a policy is a problem for the postal engineer rather than the economist. Unfortunately, their findings suggest that the scale of postal operations in Ireland, with the exception of the Central Sorting Office in Dublin, is not sufficient to permit savings from automation. Further, the impact of technological developments is most likely to be felt at the mail handling stage; whereas, as can be seen from Table 3.4, the position in this country is that the major cost element is delivery—an area in which mechanisation can have considerably less impact.

Given that productivity increases which can be achieved by greater mechanisation are questionable and possibly not of great magnitude, the only remaining potential source of cost savings lies in reducing the standards of postal services or, alternatively, forcing customers to bear some of the costs of handling the mail.[57] Here the Department is at present considering a number of changes; separate studies are being carried out to test their acceptability to the public, and also to try and quantify the economic costs and benefits they may bring. In the context of the present paper, not very much can be said about their likely effects; for example their impact on demand, if any, cannot be predicted, though it is conceivable that a major deterioration in standards of service would lead to a switch away from the mails by regular users. Nor can their impact on labour productivity be forecast; this would require a more careful study, at the level of individual workers, of the operation of the mail services.

Whatever about their likely effects, it appears that major changes in the standard of services are the only certain way of avoiding or at best mitigating either steady increases in postal charges or a major change in the method of financing the postal services. As far as the latter is concerned, the most obvious expedient is an explicit subsidy of the mails out of general taxation. However,

57. Examples of the former are, reductions in the frequency of collections and delivery, delivery to roadside boxes rather than to individual doors as at present, and so on. Examples of the latter include giving reductions in price and/or in delivery time, to presorted mail, to mail sent in standard-size envelopes or with coded addresses, etc.

it is not the only one. A second possible move would be to bring charges on individual mail classes into line with their average costs, thus ending the effective subsidisation of second class mail noted in section 3.1. Finally, a third option is suggested by the tentative econometric evidence in section 2.3 that postal traffic is positively related to telephone call charges; in other words, that postal and telephone services are competitive in demand. If this is true, it suggests that postal and telephone charges should be set so as to take account of such interactions; which opens up the possibility of permitting cross-subsidisation between the two services. (It will be recalled that telephone services are relatively more profitable than postal services.) This cannot necessarily be rejected on efficiency grounds, since it is by no means certain that a global financial constraint is a satisfactory method of ensuring efficiency in operation. Moreover, in the light of the difficulties faced by the telephone services in satisfying the demand for telephone lines, there may be something to be said for a rate structure which would discriminate against telephone services and in favour of postal services (which do not face any supply constraints).

The merits or otherwise of these different methods of financing are beyond the scope of the present paper. Moreover, the econometric results on which these suggestions are based are fairly tentative. In any case, it need hardly be said that their implications should be studied from a number of points of view before their adoption is seriously considered. For the present, they remain the only apparent alternatives to the dilemma faced by the Department, of either regular increases in postal charges at a faster rate than increases in general prices, or a gradual running down of the standards of services.

APPENDIX A

Evidence on Personal Demand for Postal Services from Household Budget Inquiries

As a prelude to attempting to estimate econometric relationships using aggregate data, it was of some interest to look at the information concerning household demand for postal services given by the two Household Budget Inquiries carried out by the Central Statistics Office in 1951–52 and 1965–66. From the point of view of studying and forecasting total demand for postal services, these data are not very useful, since the inquiries relate only to urban households, and so they give no information on the behaviour of rural households, nor of business and government users. Nevertheless, since urban households do account for a substantial proportion of total mail volume, the trends apparent from these data are of interest in themselves, and may suggest some hypotheses about the behaviour of total mail.

Table A.1 gives expenditure on postage and on telephone and telegrams (henceforth referred to simply as "telephones") from both inquiries, both in absolute form and as proportions of total expenditure, classified according to town size and income.[58] Looking first at the effect of the latter, it is evident that expenditure on both postage and telephones increases steadily with income. However, when expressed as a proportion of total expenditure, outlay on postage increases with income in the earlier sample but decreases with it in the latter. This suggests that the cross-section income-elasticity has fallen markedly over the period, and was less than unity in 1965–66.[59] By contrast the proportion of expenditure devoted to telephones rises markedly with income in both samples. One possible explanation for these phenomena is the availability of telephones: it is reasonable to hypothesise that the higher the income group the greater the number of people in it who possess telephones, and also that between the two samples the number of telephone owners in all groups

58. Expenditure classified by income unfortunately cannot be directly compared between the two surveys, since the income classifications used differ: in the 1951-52 inquiry it is weekly income per person, and in the 1965-66 inquiry, weekly income per household. However the very last row in the table has been included to show that, for the 1965-66 inquiry, average income per person rises broadly in line with total household income. Consequently, for practical purposes, the differences between the two income classifications are not of major importance.

59. In principle, these elasticities could have been estimated directly from the data. However, the relative unreliability of the data at this level of disaggregation, and the fact that expenditure on postage alone could not be cross-classified by income and household size, suggested that precise estimates of the income elasticity would not be very reliable.

Table A.1: *Expenditure by urban households on postage, telephone and telegrams in 1951–52 and 1965–66, classified by town size and income*

Average weekly expenditure per household (shillings)

Date of inquiry	Expenditure category	*Town size*: *National average*	*Dublin and Dun-Laoghaire*	*Other cities, towns and villages of population*: *Over* 10,000	1,500-10,000	*Under* 1,500	*Average weekly income per person*: *Under 30/-*	*30/- to 50/-*	*50/- to 80/-*	*80/- and over*
1951–52	Postage	0·88	0·79	0·72	1·01	1·20	0·34	0·62	1·01	1·60
	Telephones and telegrams	0·39	0·57	0·49	0·08	0·11	0·02	0·03	0·38	1.18
	Total expenditure	215·85	243·11	204·14	18·99	185·96	115·60	177·96	243·67	337·31
	Proportion (%) of total expenditure on:									
	Postage	·408	·325	·353	.532	·647	.294	·348	·414	·474
	Telephone and telegrams	·181	·234	·240	·240	·059	·107	·017	·156	·350

Date of inquiry	Expenditure category	National average	Dublin and Dun-Laoghaire	Over 10,000	1,500-10,000	Under 1,500	*Gross weekly household income*: Under £4	£4 and under £7	£7 and under £10	£10 and under £15	£15 and under £20	£20 and under £25	£25 and under £30	£30 and under £40	£40 and under £50	£50 and over
1965–66	Postage	1·26	1·06	1·28	1·48	1·50	0·56	0·63	0·84	0·99	1·16	1·28	1·31	2·15	2·37	3·30
	Telephone and telegrams	1·88	2·82	1·41	1·11	0·86	0·22	0·32	0·37	0·72	1·27	2·28	2·70	3·78	4·67	7·66
	Total expenditure	424·46	454·52	427·33	397·55	373·55	87·02	153·11	222·92	299·92	391·50	490·74	558·08	692·15	788.69	1,022·07
	Proportion (%) of total expenditure on:															
	Postage	·297	·233	·300	·372	·402	·644	·411	·377	·330	·296	·261	·235	·311	·300	·225
	Telephone and telegrams	·443	·620	·330	·279	·230	·253	·290	·166	·240	·324	·465	·484	·546	·592	·749
	Average gross weekly income per person		110·43	98·87	89·33	79·15	44·93	51·18	65·97	67·76	82·52	95·11	101·73	131·24	157·53	253·46

Notes: Expenditure data are in shillings. All data are taken from the Household Budget Inquiries, 1951–52 and 1965–66, published by the CSO. Figures for total expenditure in the 1951–52 inquiry have been adjusted to exclude social security contributions (which in the 1965-66 inquiry were treated as a form of direct taxation and so not included in total expenditure).

has increased. This would suggest that variables representing telephone availability should be incorporated in estimating demand equations for total mail volume, and so this is done in sections 2.3 and 2.4.

As for the effect of town size, it is noticeable that in both samples expenditure on postage falls, and expenditure on telephones rises both absolutely and proportionally with increases in town size. It is possible that town size is itself a determinant of demand; one might plausibly argue that since greater urban agglomeration is more conducive to face-to-face communication, it develops a preference for verbal rather than written contact. It is more likely however that this variability with town size reflects the fact that the underlying determinants of demand themselves vary with town size.[60] Again, the hypothesis that telephones are more widespread among upper than lower-income groups, and among users in large than in small towns, would explain the behaviour of the data.

Finally, it is clear that proportionally, expenditure on postage fell between the two samples, while expenditure on telephones rose. This could be a result of the rise in national income over the period, or of a change in the relative prices of the two services, or once more of the greater availability of telephones at the time of the second sample.

Because the sample data are less reliable at greater levels of disaggregation, data on expenditure on the two categories are not available classified by both town size and income. However, the published results of the inquiries do cross-classify expenditure on the two categories combined in this way. While this information is not very useful for present purposes, it is nevertheless of interest to look at the income-expenditure (Engel) curves which both Leser (1964) and Pratschke (1969) have estimated from these data, cross-classified, not by income and town size, but by income and household size. Their results are shown in Table A.2.

Obviously, the two equations cannot be directly compared, since they differ both in functional form and in the definitions of the variables used. However, the expenditure elasticities implied by both equations are given in the last column, and these can to some extent be compared. It is evident that this elasticity has risen over the period (though on a statistical basis this inference

60. It might be argued that these figures merely reflect the fact already mentioned that expenditure on postage and telephones depends on income, since it can be seen from the table that total household expenditure increases with town size. Presumably, therefore, average income per household (and per person) also increase with town size—as the last row of the table shows, this is certainly true for 1965-66 (detailed data on income are not available for 1951-52). Since the income elasticities for postage and telephones in 1965-66 are respectively less than and greater than one, this would explain the behaviour of expenditure proportions as town size varies, at least for the 1965-66 sample. However, it does not explain their behaviour in the 1951-52 sample, since despite a greater than unitary income elasticity of expenditure on postage, and a positive relationship between income and town size, the "town-size" elasticity of expenditure on postage is actually negative. Consequently income is not the missing "underlying determinant of demand" referred to in the text.

TABLE A.2: *Relationships between average weekly household expenditure on postage, telephone and telegrams, and income and household size*

Inquiry	*Researcher*	*Estimated Equation*	R^2	*95 per cent confidence region for elasticity of expenditure on postage, etc., with respect to total expenditure*
1952-53	Leser (1964)	$w = \cdot00164 + \cdot00320 \log y + \cdot00013 \log N$ $(5\cdot71)$ $(\cdot25)$	·719	$1\cdot65 \pm \cdot24$
1965-66	Pratschke (1969)	$\log v = -8\cdot964 + 1\cdot825 \log Y - \cdot859 \log N$ $(19\cdot01)$ $(9\cdot76)$	·968	$1\cdot83 \pm \cdot21$

Key: w = proportion of total household expenditure devoted to postage, telephone and telegrams ($= v/Y$)
y = total expenditure per head ($= Y/N$)
N = number of persons in household (i.e., household size)
v = average household expenditure on postage, telephone and telegrams
Y = total household expenditure

Figures in parentheses below estimated coefficients are t values.

is not a very definite one, since the 95 per cent confidence regions for the two elasticity estimates overlap considerably).[61] As for the elasticity of expenditure with respect to household size, from being insignificantly different from zero in 1951–52 it falls to a significantly negative value in 1965–66; this change is difficult to interpret however, and may simply be due to the use of different variables for total expenditure in the equations.

In conclusion it is as well to re-emphasise that Household Budget Inquiry data can only give broad indications as to the determinants of total demand, since they take no account of the behaviour of rural households nor of business customers. Nevertheless, this brief look at the data has suggested some hypotheses which can be tested for their applicability to aggregate demand.

61. The same point—that differences between two figures are not necessarily statistically significant—applies to all the data in Table A.1. Unfortunately the CSO does not give standard errors for cross-classified Household Budget Inquiry data, so it is not possible to make precise statements on this point.

APPENDIX B

Data Sources

B.1 Data Referring to the Postal and Telephone Services

1. *Detailed Mail Returns*

THESE returns are the principal and most detailed source of mail statistics: each return gives a full account of pieces posted and delivered in a given week, disaggregated into six main categories of mail and fifty-two head post office districts.

This is an encouragingly large store of basic data; however it is by no means ideal for econometric analysis. In the first place, returns were not taken every year: only fourteen counts were taken since 1949, of which only six refer to the post-1960 period. A second and more serious drawback concerns the way in which the data were manipulated. Since they were intended to indicate the level of traffic in an "average" week, they were adjusted to allow for special circumstances in the week of the actual count; yet no information is available on the magnitude of the adjustments made, which were presumably subjective and may have varied widely from one office to another. These average figures were then aggregated over all fifty-two head post offices, and multiplied by a common factor to give an estimate of the annual traffic. (The three weeks preceding Christmas were assumed to have double the normal volume of traffic, and so the factor chosen was fifty-five.) Thus, any errors in the original data were magnified; and a further error was introduced, since the arbitrary factor of fifty-five could hardly apply to all classes of mail. On the contrary, post office experience suggests that it underestimated the total annual traffic in printed papers and postcards, and may have overestimated that in letters and newspapers.

A final difficulty with the returns is that they were not always taken at the same time of the year. Of the fourteen returns available, twelve were taken in the second half of October of the relevant year, one in mid-February and one in late March. That the number of items of mail posted or delivered should be subject to seasonal influences is only to be expected (the rush of mail at Christmas already referred to is only one example). Consequently, it is not clear to what extent the figures from different returns are comparable even when considered as referring only to a particular week, and not necessarily to the "average" week in a year. Fortunately, some extraneous information is available on this point, in the form of monthly data on sales of postage stamps since 1951 which are published by the CSO using data provided by the Department of Posts and Telegraphs. This series is discussed further below, as is the approximate method which the author used to deflate it, in order to yield a series of sales of postage stamps at constant prices.[62] Both series were then seasonally corrected using the *X—11* method of the US Bureau of the Census (Shiskin *et al.* (1967)), and the final seasonal factors derived by this method are given in Table B.1.

TABLE B.1: X—11 *Seasonal correction factors for months of mail counts*

Data on number of pieces of mail posted refer to week ending	X—11 *Seasonal correction factors for corresponding month. (Average for each year=100)*	
	Sales of postage stamps (value)	*Sales of postage stamps (volume)*
27 October 1951	96·9	96·4
18 October 1952	96·8	96·3
17 October 1953	96·8	96·4
16 October 1954	96·5	96·2
15 October 1955	96·6	97·5
19 October 1957	97·4	97·5
18 October 1958	97·7	97·8
15 October 1960	97·7	97·7
20 October 1962	96·2	95·9
22 February 1964	89·3	89·3
16 October 1965	92·0	93·2
19 October 1968	93·0	97·1
18 October 1969	94·3	98·9

It is evident from the table that the seasonal factor for October is extremely stable; in other words, ignoring irregular or random fluctuations October tends to account for a fairly constant proportion of real expenditure on postage stamps in a given year (which with relatively little error we can equate to the total volume of mail posted). As we would expect, this stability is more marked in the case of the volume series, which is not distorted by large and irregular increases in postal charges. However, the correction factor for February is markedly different from the others. This suggests that the volume of mail

62. The author explains below his reservations about the accuracy of this deflated series. However in his opinion they do not prevent its being used in the present context.

posted in February is farther below the annual average than that in October.[63] Consequently, treating the results of all the mail returns as if they referred to the same magnitude is likely to lead to biased conclusions, unless it can be assumed that the "averaging" process already referred to has in fact corrected for this factor. However, since twelve of the fourteen observations available refer to the same month, it seems likely that the bias involved is small.

Despite these three drawbacks, the mail returns are the basis of all official mail statistics at least prior to 1968. In this time they were found to be less than satisfactory in revealing trends in the annual totals: a particularly unsatisfactory feature being the crude and arbitrary method of grossing up the weekly figures to give an annual total.[64] With this exception, however, the Departmental officials feel that the method of deriving the data was free of systematic error. They may be accepted therefore as giving a reasonable picture of the breakdown of total mail between different categories and different post offices in a "typical" week of each year (excluding exceptional periods such as the Christmas rush, which affect different categories of mail to different degrees). Accordingly, they form the basic data from which the demand functions in Part 2 of this paper are estimated.

In addition to their use in the demand sections of the paper, the mail data were also used to construct a measure of the output of each post office in 1951 and 1965, equal to the sum of total pieces of mail posted and delivered. It should be noted that this measure of output takes no account of the non-postal work carried out in post offices (i.e., the provision of counter services such as the sale of licences, dispensing of pensions, etc.) It also gives equal weight to all classes of mail, thus implicitly assuming that the labour requirements of different mail classes are the same. However, given the very high intercorrelation between the various classes, as well as the relative equality of their average costs shown in section 3.1 of this paper, the error introduced by this approximation is unlikely to be great.

2. *Time Series of Monthly Sales of Postage Stamps*

The other major source of mail data, to which reference has already been made, is the monthly series of average daily sales of postage stamps, one of

63. A cursory examination of the *X—11* seasonal correction factors for March and April suggests that the same problem may arise in the case of the count in the week ending 2 April 1949, the only one for which contemporary data on the sales of postage stamps are not available. In this case, however, the volume of mail is probably greater than in October, not less; viz., for 1951, the seasonal correction factors for March and April are 104·9 and 97·5 (value series) and 106·9 and 99·5 (volume series).

64. In recent years the Department has introduced a system of sample surveys of mail traffic, instead of attempting a complete enumeration of all items posted and delivered in a given week as the detailed returns did. The results of these sample surveys have proved to be a more sensitive indicator of fluctuations in the volume of mail than the earlier data, and they at present form the basis for most Departmental estimates. However, because they are available for such a short period of time they are not suitable for econometric analysis.

sixty-six economic series published regularly by the Central Statistics Office. The series is continuously available in its present form since 1951. Before that, since 1943 in fact, a similar series is published; the latter however is not strictly comparable with the present one, since it excludes postage collected in cash.[65]

This series is therefore available for virtually the same length of time as the data from the mail returns, and on a much more regular basis. Why then not use it as a dependent variable in the demand study? One reason is that it is not available on a disaggregated basis, broken down either by class of mail or by area. A more serious drawback however is that the series as published relates to expenditure in current price terms on postage, and so must be deflated to yield a series for the volume of expenditure on postage. However, to calculate a reliable deflator requires not just a knowledge of the number of items in each mail category (which is given by the detailed mail returns). In addition, it would be necessary to know the number of items in each weight step within every category, because different weight classes are subject to very different charges. Therefore, since such information was not available when this part of the study was being carried out, it was decided to use only the detailed mail returns to represent total mail volume in the econometric results described in this paper.[66]

Some time after these results were obtained the author's attention was drawn to another source of data, which does in fact provide information on the number of items in each mail category which fall into different weight steps. The source in question is a series of detailed "distribution" returns, which are normally taken some time after each change in charges. Unfortunately these were not available in time to be of use in the results given in this paper. However, since they permit the construction of considerably more accurate price indices than the ones used to date, and so re-open the question of whether to use the time series of stamp sales in preference to the detailed mail returns, it is hoped to use them in further work on this subject.

3. *Price Indices for Different Mail Classes*

Statistics of postal charges were supplied to the author by the Department, and are in any case easily available. However, as already mentioned, the data available on postings were not adequate for the construction of really accurate price indices. Instead, therefore, the minimum charge (that on the lowest weight step) was taken as representative of each category, and the required

65. Such items, i.e., those which are franked by machine and so do not require stamps, have been growing in importance in recent years, mostly for commercial customers. Even in 1951 to 1953 (three years for which both series are available), they accounted for nearly 20 per cent of postal revenue.

66. The figures shown in Table B.1 for sales of postage stamps were derived using an approximate deflator constructed by making the most plausible assumptions about the volume of mail in each weight step.

price indices were then constructed in the usual way (i.e. as Laspeyres indices, using 1953 and 1968 postings as weights). This would not be appropriate to the problem of the last section, namely the construction of a deflator for an expenditure series. However, when the object is to construct a variable to represent postal prices in a regression equation, this procedure is almost certainly adequate, since the charges for different weight steps tend to vary together.

4. *Price Index of Telephone Charges*

Charges for local calls and for trunk calls over various distances are easily available.[67] However, quantity weights were available for only the broad categories of local calls and total trunk calls. All trunk calls were therefore assumed to have taken place over distances of between 35 and 50 miles in length, and a price index was constructed by combining the charge for this length of call with the local call charge, using the number of calls in 1953 and 1968 as weights.

5. *Measures of Telephone Availability*

Data on the number of telephones over time, and in different counties in 1966, were supplied to the author by the Department. In discussing the number of telephones, the distinction between exchange lines and telephone "stations" should be mentioned. The former is a connection with the public exchange, either of a single phone or of a private exchange; the latter is "any telephone, such as an extension on a Private Branch Exchange, from which a call can be made to any other telephone on the system" (Litton (1961–62), p. 92). The two series have tended to move very closely together, and either seems a plausible variable to use as a proxy for the "availability" of telephone services; the number of exchange lines was the one chosen for use in Part 2 of this paper.

A second measure of telephone availability which was used in the cross section demand regressions was a dummy variable measuring the availability of STD (Subscriber Trunk Dialling) in each geographical unit. This variable was given a value between zero and unity depending on the proportion of the major towns in each county where STD was available in October 1965 (the date to which the dependent variable refers). While the scaling of this variable is obviously arbitrary, no information was available on the number of non-coinbox telephones in each town. (At the period in question, only non-coinbox telephones had access to STD facilities.)

67. Litton (1961–62), Table 8, gives telephone charges in detail up to 1959.

6. *Statistics of Employees and Transport Vehicles in Different Post Offices*

In studying differences in productivity and efficiency between different post offices, it would have been preferable to have had full data on the quantities and prices of all the factors of production available to each office. These would have included the quantities of labour and capital equipment of different kinds and the area of office floor-space.[68] However, the only data at the author's disposal referred to the number of staff and of transport vehicles.

The data on staff numbers were available for both 1951 and 1966, and were fairly comprehensive, being broken down into three categories. Under the first category, indoor staff, separate figures were given for head-postmasters, postal supervisors, clerks, postal sorters, telephone supervisors and telephonists. Under the second category, outdoor staff, were included outdoor postal supervisors, postmen, and cleaners. Finally, the third category covered sub-postmasters.

Because of the difficulties of handling a large number of labour variables, it was decided to consider only two groupings of all these staff grades. The first, delivery staff, was taken as equal to total outdoor staff less cleaners. The second, non-delivery postal staff, was taken as equal to the remaining staff less telephone supervisors and telephonists. There is an element of arbitrariness here, since it is likely that some clerks, and, for part of the time, many sub-postmasters, are more closely concerned with telephone and agency services than with postal services. A further source of error is that no allowance could be made for differences in labour productivity between staff grades; for example, all grades of postmen in the same office were assumed to be equally productive, and were included in the general category delivery staff. A refinement which could have been introduced to overcome this problem would have been to construct a weighted measure of labour input, using as weights the wage rates (or average earnings) of different staff grades. However, to do this would have required data on wage rates and on average man days worked for each grade, and such data were not available; in any case, as with the measure of output, the numbers in these grades were very highly intercorrelated, implying that different sets of weights would not have yielded very different measures of labour input. As for transport vehicles, statistics of both owned and hired vehicles were available, and were aggregated by converting hired vehicles to "owned-vehicle equivalents", using data on average hours of usage.

B.2 Macroeconomic Data External to the Postal Services

1. *Income*

The important issue of the choice of an appropriate income variable is fully examined in section 2.3 of the paper. The only additional problem encountered

68. For a study which makes use of such comprehensive data to estimate production, factor demand, and cost functions for a cross section of US post offices, see Merewitz (1969).

was that in the cross section regressions the units of analysis were not coterminous with county boundaries, whereas the available data on personal income were only available on a county basis. (See Ross (1972)). At first, an attempt was made to overcome this problem by allocating the personal income for each county to the different catchment areas within that county in proportion to population. However, this effectively assumed that variations in personal income per head within each county are negligible, which is very far from being true, especially in the case of counties containing one town of considerably greater importance than any others. Thus, regressing mail volume per head for two or more sub-divisions of the county (one of them containing the major town) on the average county income per head led to serious overestimates of mail volume for the rural area and corresponding underestimates for the urban area. As an example, within Cork county, the volume of mail for Cork city was underestimated by the equation and that for Mallow, Skibbereen, Bandon and Bantry overestimated.

Consequently, the attempt to estimate cross section demand functions using observations on all fifty-two post offices was abandoned because of the impossibility of getting accurate income per head data for each office catchment area. Instead, offices were grouped by county and the income per head variable was recalculated, with allowances being made for the spill-over of office catchment areas into adjacent counties. As expected, this variable was only marginally different from the data as published by M. Ross (i.e. referring to integral counties).

2. *Population*

Accurate data on national population are available only for the five census years since 1949. However, official estimates of the total population for intercensal years are available in the Report on Vital Statistics published annually by the Central Statistics Office. These data were therefore used with no adjustments in the time-series regressions.

As mentioned at the end of section 2.3, an attempt was made to estimate separate time-series demand functions for Dublin and the rest of the country. This required the construction of a time-series for the population of Dublin, for which the population in inter-censal years was estimated by simple linear interpolation between the data for preceding and succeeding census years. This extremely crude procedure seems justified by the smoothness of the data, which ensures that any alternative interpolation procedure gives very similar results.[69]

Next, for the cross section demand and productivity regressions, it was required to calculate the population of each post office catchment area in 1951, 1960, 1965 and 1969. Since these catchment areas do not follow county

69. I am grateful to B. M. Walsh for advice on this point.

boundaries, it was necessary to use more disaggregated census data. Each catchment area was therefore taken to be equal to some number of rural districts, and their population was calculated accordingly. Even this does not yield perfect results, since the boundaries of catchment areas, according to a map supplied by the Department of Posts and Telegraphs, are rarely exactly co-terminous with the boundaries of rural districts. However, rather than disaggregate further, which would have required using population data by district electoral districts, it was decided to make do with the more approximate data (especially since using data on rural districts ensures that all major towns are correctly allocated to the appropriate office catchment area). Finally, since 1960, 1965 and 1969 were not census years, it was necessary to calculate the requisite population data for each of four adjoining census years (1956, 1961, 1966 and 1971), and then interpolate between them.[70]

3. *Measures of Population Dispersal*

The population density of each office catchment area was measured by the ratio of its population (as calculated in the last section) to its area in square miles. To calculate a measure of urbanisation, urban population was taken to mean population living in towns with over 1,500 inhabitants, and the data on the proportion of population living in urban areas were therefore calculated on this basis.

4. *Measures of the Level of Business Activity in "Postage-Intensive" Sectors*

In an attempt to construct measures of the level of activity in "postage-intensive" sectors by county in 1966, a number of variables measuring the proportion of the total at work in each county employed in such sectors were constructed. The data used are derived from the 1966 Census, and are conveniently summarised in Baker and Ross (1975), Appendix 2.[71] "Postage-intensive" was taken to exclude those employed in agriculture, domestic service, and Baker and Ross's "social autonomous" sector. Some experimentation was also made with variables which excluded, in turn, those employed in private building and construction, and in retail trade.

In addition, the numbers employed in tourism as a proportion of the county work-force were used as a proxy measure of the level of tourists' expenditure.

70. The method of interpolation used was the same as that in Ross (1972). I am grateful to M. Ross for discussions on this matter.

71. I am grateful to T. J. Baker and M. Ross for permission to use this unpublished data.

REFERENCES

Baker, T. J. and M. Ross, *County Employment Patterns in 1966*, Dublin: The Economic and Social Research Institute 1975 (forthcoming).

Baratz, M. S., *The Economics of the Postal Services*, Washington, DC: Public Affairs Press, 1962.

Belsley, D. A., "The relative power of the τ-test: a furthering comment", *Review of Economics and Statistics*, vol. 55, February 1973, p. 132.

Cramer, J. S., *Empirical Econometrics*, Amsterdam: North-Holland, 1969.

Farrar, D. E. and R. R. Glauber, "Multicollinearity in regression analysis: the problem revisited", *Review of Economics and Statistics*, vol. 49, Feb. 1967, pp. 92–107.

Feldstein, M. S., *Economic Analysis for Health Service Efficiency*, Amsterdam: North-Holland, 1967.

Feldstein, M. S., "The error of forecast in econometric models when the forecast-period exogenous variables are stochastic", *Econometrica*, vol. 39, January 1971, pp. 55–60.

Fisher, F. M., "Tests of equality between sets of coefficients in two linear regressions: an expository note", *Econometrica*, vol. 38, March 1970, pp. 361–366.

Fuchs, V., "A statistical analysis of productivity in selected service industries in the United States, 1939–63", *Review of Income and Wealth*, series 12, September 1966, pp. 211–244.

Geary, R. C., "Two Exercises in Simple Regression", *Economic and Social Review*, vol. 3, No. 4, July 1972, pp. 551–560.

Griliches, Z., Review of *Agricultural Production Functions* (by E. O. Heady and J. L. Dillon), *American Economic Review*, vol. 52, March 1962, pp. 280–283.

Habibagahi, H. and J. L. Pratschke, "A comparison of the power of the von Neumann ratio, Durbin-Watson and Geary tests", *Review of Economics and Statistics*, vol. 54, May 1972, pp. 179–185.

Haitovsky, Y., "Multicollinearity in regression analysis: comment", *Review of Economics and Statistics*, vol. 51, November 1969, pp. 486–489.

Horsefield, J. K., "Some notes on postal finance", *Bulletin of the Oxford University Institute of Economics and Statistics*, vol. 26, February 1964, pp. 39–58.

Industrial Development Authority (Ireland): *Regional Industrial Plans, 1973–77*, June 1972.

Johnston, J., *Econometric Methods*, 2nd ed., McGraw-Hill, 1972.

Judge, G. G., "Discussion: Estimates of the aggregate agricultural production function from cross-sectional data" (by Z. Griliches), *Journal of Farm Economics*, vol. 45, May 1963, pp. 429–432.

Kennedy, K. A., *Productivity and Industrial Growth: The Irish Experience*, London: Oxford University Press, 1971.

Knaggs, J. F. and T. Keane, "Population projections", *Journal of the Statistical and Social Inquiry Society of Ireland*, vol. 22, Part 4, 1971–72, pp. 30–57.

Leser, C. E. V., *A Further Analysis of Irish Household Budget Data, 1951–52*, Dublin: The Economic and Social Research Institute, Paper No. 23, August 1964.

Little, Arthur D., Inc., "A description of the postal service today", Part 8; in: *Report of the President's Commission on Postal Organization:* Annex X, Washington, DC, 1968.

Litton, A. J., "The Growth and Development of the Irish Telephone System", *Journal of the Statistical and Social Inquiry Society of Ireland*, vol. 20, Part 5, 1961–62, pp. 79–115.

Merewitz, L., *The Production Function in the Public Sector: Production of Postal Services in the U.S. Post Office*, Monograph 14, Institute of Urban and Regional Development, University of California, Berkeley, 1969.

Merewitz, L., "Costs and Returns to Scale in U.S. Post Offices", *Journal of the American Statistical Association*, vol. 66, September 1971, pp. 504–509.

Post Office (UK), "The Interaction of Posts and Telecommunications" (mimeo), 1970.

Pratschke, J. L., *Income-Expenditure Relations in Ireland, 1965–66*, Dublin: The Economic and Social Research Institute, Paper No. 50, November, 1969.

Ross, M., *Further Data on County Incomes in the Sixties*, Dublin: The Economic and Social Research Institute Paper No. 64, May 1972.

Shiskin, J., A. H. Young and J. C. Musgrave, "The X–11 Variant of the Census Method 11 Seasonal Adjustment Program", US Bureau of Census, Technical Paper No. 15, 1967.

Printed by Cahill & Co. Limited, Dublin 3.

THE ECONOMIC AND SOCIAL RESEARCH INSTITUTE

Broadsheet Series:

1. *Dental Services in Ireland* — P. R. Kaim-Caudle
2. *We Can Stop Rising Prices* — M. P. Fogarty
3. *Pharmaceutical Services in Ireland* — P. R. Kaim-Caudle assisted by Annette O'Toole and Kathleen O'Donoghue
4. *Ophthalmic Services in Ireland* — P. R. Kaim-Caudle assisted by Kathleen O'Donoghue and Annette O'Toole
5. *Irish Pensions Schemes,* 1969 — P. R. Kaim-Caudle and J. G. Byrne assisted by Annette O'Toole
6. *The Social Science Percentage Nuisance* — R. C. Geary
7. *Poverty in Ireland: Research Priorities* — Brendan M. Walsh
8. *Irish Entrepreneurs Speak for Themselves* — M. P. Fogarty
9. *Marital Desertion in Dublin: an exploratory study* — Kathleen O'Higgins
10. *Equalization of Opportunity in Ireland: Statistical Aspects* — R. C. Geary and F. S. Ó Muircheartaigh
11. *Public Social Expenditure in Ireland* — Finola Kennedy

Publication Series:

1. *The Ownership of Personal Property in Ireland* — Edward Nevin
2. *Short-Term Economic Forecasting and its Application in Ireland* — Alfred Kuehn
3. *The Irish Tariff and The E.E.C. : A Factual Survey* — Edward Nevin
4. *Demand Relationships for Ireland* — C. E. V. Leser
5. *Local Government Finance in Ireland: A Preliminary Survey* — David Walker
6. *Prospects of the Irish Economy in* 1962 — Alfred Kuehn
7. *The Irish Woollen and Worsted Industry,* 1946–59: *A Study in Statistical Method* — R. C. Geary
8. *The Allocation of Public Funds for Social Development* — David Walker
9. *The Irish Price Level: A Comparative Study* — Edward Nevin
10. *Inland Transport in Ireland: A Factual Survey* — D. J. Reynolds
11. *Public Debt and Economic Development* — Edward Nevin
12. *Wages in Ireland,* 1946–62 — Edward Nevin
13. *Road Transport: The Problems and Prospects in Ireland* — D. J. Reynolds
14. *Imports and Economic Growth in Ireland,* 1947–61 — C. E. V. Leser
15. *The Irish Economy in* 1962 *and* 1963 — C. E. V. Leser
16. *Irish County Incomes in* 1960 — E. A. Attwood and R. C. Geary
17. *The Capital Stock of Irish Industry* — Edward Nevin
18. *Local Government Finance and County Incomes* — David Walker
19. *Industrial Relations in Ireland: The Background* — David O'Mahony
20. *Social Security in Ireland and Western Europe* — P. R. Kaim-Caudle
21. *The Irish Economy in* 1963 *and* 1964 — C. E. V. Leser
22. *The Cost Structure of Irish Industry,* 1950–60 — Edward Nevin
23. *A Further Analysis of Irish Household Budget Data,* 1951–1952 — C. E. V. Leser
24. *Economic Aspects of Industrial Relations* — David O'Mahony
25. *Psychological Barriers to Economic Achievement* — P. Pentony
26. *Seasonality in Irish Economic Statistics* — C. E. V. Leser
27. *The Irish Economy in* 1964 *and* 1965 — C. E. V. Leser

Publication Series—*continued.*

28. *Housing in Ireland: Some Economic Aspects* P. R. Kaim-Caudle
29. *A Statistical Study of Wages, Prices and Employment in the Irish Manufacturing Sector* C. St. J. O Herlihy
30. *Fuel and Power in Ireland: Part I. Energy Consumption in* 1970 J. L. Booth
31. *Determinants of Wage Inflation in Ireland* Keith Cowling
32. *Regional Employment Patterns in the Republic of Ireland* T. J. Baker
33. *The Irish Economy in* 1966 The Staff of The Economic Research Institute
34. *Fuel and Power in Ireland: Part II. Electricity and Turf* J. L. Booth
35. *Fuel and Power in Ireland: Part III. International and Temporal Aspects of Energy Consumption* J. L. Booth
36. *Institutional Aspects of Commercial and Central Banking in Ireland* John Hein
37. *Fuel and Power in Ireland: Part IV. Sources and Uses of Energy* J. L. Booth
38. *A Study of Imports* C. E. V. Leser
39. *The Irish Economy in* 1967 The Staff of The Economic and Social Research Institute
40. *Some Aspects of Price Inflation in Ireland* R. C. Geary and J. L. Pratschke
41. *A Medium Term Planning Model for Ireland* David Simpson
42. *Some Irish Population Problems Reconsidered* Brendan M. Walsh
43. *The Irish Brain Drain* Richard Lynn
44. *A Method of Estimating the Stock of Capital in Northern Ireland Manufacturing Industry; Limitations and Applications* C. W. Jefferson
45. *An Input-Output Analysis of the Agricultural Sector of the Irish Economy in* 1964 R. O'Connor with M. Breslin
46. *The Implications for Cattle Producers of Seasonal Price Fluctuations* R. O'Connor
47. *Transport in the Developing Economy of Ireland* John Blackwell
48. *Social Status and Inter-Generational Social Mobility in Dublin* Bertram Hutchinson
49. *Personal Incomes by County,* 1965 Miceal Ross
50. *Income-Expenditure Relations in Ireland,* 1965–1966 John L. Pratschke
51. *Costs and Prices in Transportable Goods Industries* W. Black, J. V. Simpson, D. G. Slattery
52. *Certain Aspects of Non-Agricultural Unemployment in Ireland* R. C. Geary and J. G. Hughes
53. *A Study of Demand Elasticities for Irish Imports* Dermot McAleese
54. *Internal Migration in Ireland* R. C. Geary and J. G. Hughes
    with Appendix C. J. Gillman
55. *Religion and Demographic Behaviour in Ireland* B. M. Walsh
    with Appendix R. C .Geary and J. G. Hughes
56. *Views on Pay Increases, Fringe Benefits and Low Pay* H. Behrend, A. Knowles and J. Davies
57. *Views on Income Differentials and the Economic Situation* H. Behrend, A. Knowles and J. Davies
58. *Computers in Ireland* F. G. Foster
59. *National Differences in Anxiety* Richard Lynn
60. *Capital Statistics for Irish Manufacturing Industry* C. W. Jefferson
61. *Rural Household Budget—Feasibility Study* Sile Sheehy and R. O'Connor
62. *Effective Tariffs and the Structure of Industrial Protection in Ireland* Dermot McAleese
63. *Methodology of Personal Income Estimation by County* Miceal Ross
64. *Further Data on County Incomes in the Sixties* Miceal Ross
65. *The Functional Distribution of Income in Ireland,* 1938–70 J. G. Hughes
66. *Irish Input-Output Structures,* 1964 *and* 1968 E. W. Henry
67. *Social Status in Dublin: Marriage, Mobility and First Employment* Bertram Hutchinson

Publication Series—*continued*

68. *An Economic Evaluation of Irish Salmon Fishing; 1: The Visiting Anglers*
R. O'Connor and B. J. Whelan
69. *Women and Employment in Ireland: Results of a National Survey*
Brendan M. Walsh assisted by Annette O'Toole
70. *Irish Manufactured Imports from the UK in the Sixties: The Effects of AIFTA*
Dermot McAleese and John Martin
71. *Alphabetical Voting: A Study of the* 1973 *General Election in the Republic of Ireland*
Christopher Robson and Brendan M. Walsh
72. *A Study of the Irish Cattle and Beef Industries*
Terence J. Baker, Robert O'Connor and Rory Dunne
73. *Regional Employment Patterns in Northern Ireland*
William Black and Clifford W. Jefferson
74. *Irish Full Employment Structures,* 1968 *and* 1975 E. W. Henry
75. *An Economic Evaluation of Irish Salmon Fishing. II: The Irish Anglers*
R. O'Connor, B. J. Whelan, and A. McCashin
76. *Factors Relating to Reconviction among Young Dublin Probationers* Ian Hart
77. *The Structure of Unemployment in Ireland,* 1954-1972 Brendan M. Walsh
78. *An Economic Evaluation of Irish Salmon Fishing. III: The Commercial Fishermen*
B. J. Whelan, R. O'Connor, and A. McCashin
79. *Wage Inflation and Wage Leadership*
W. E. J. McCarthy, J. F. O'Brien and V. G. Dowd
80. *An Econometric Study of the Irish Postal Services* Peter Neary

Printed by Cahill & Co. Limited, Dublin 3