BEFORE THE
POSTAL REGULATORY COMMISSION

SIX-DAY TO FIVE-DAY STREET DELIVERY AND RELATED SERVICE CHANGES, 2010	Docket No. N2010-1

RESPONSES OF NATIONAL ASSOCIATION OF LETTER CARRIERS, AFL-CIO WITNESS DR. MICHAEL A. CREW TO INTERROGATORIES AND DOCUMENT REQUESTS OF THE UNITED STATES POSTAL SERVICE (USPS/NALC-T4-1 Through T4-6)

The National Association of Letter Carriers, AFL-CIO hereby files the responses of witness Dr. Michael A. Crew, NALC-T4, to the following interrogatories and document requests of the United States Postal Service, USPS/NALC-T4-1 through T4-6, filed on August 11, 2010.

Each interrogatory/document request is stated verbatim and followed by the response.

Respectfully submitted,

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USPS/NALC-T4-1

Please refer to the paragraph that begins at the bottom of page 1 of your testimony. Describe the teaching, writing, editing and consulting you have performed in the field of market survey research. Provide copies of all published works you have authored reflecting the execution or supervision of, or the analysis and review of market research, including quantitative and qualitative market research and opinion surveys.

RESPONSE:

In my Managerial Economics course I provide an introduction to issues of demand management, and some of the issues in survey design. As Editor of the *Journal of Regulatory Economics* since 1988, I have made decisions on whether to include papers employing surveys and addressing issues including contingent valuation. Since 1990, as joint Editor of a series of books on postal economics with Paul R. Kleindorfer (Distinguished Research Professor, INSEAD and Anheuser Busch Professor of Management Science Emeritus, University of Pennsylvania), I have made joint decisions on the publication of several articles involving market research. These 18 books are listed in my curriculum vitae, a copy of which is attached hereto.

While my specialty within economics is regulatory economics and not market research, I have technical knowledge of economics generally, especially microeconomics, as it provides a foundation for regulatory economics. An economist does not need to be an expert in market research to have recognized the shortcomings in the market research that ORC performed for USPS in this case. I believe that the shortcomings in the ORC method explained in my testimony are so basic that almost all economists would have sufficient knowledge to recognize them.

USPS/NALC-T4-2

Please refer to the bottom half of page 7 of your testimony.

(a) Provide copies of all of the referenced "econometric studies . . . [that] assess demand elasticity in connection with contemplated service changes" that "other postal operators have used".

(b) Provide copies of all "calibrated simulation studies and sensitivity analyses on the consequences of demand resulting from changes in . . . delivery frequency" to which the studies referenced in subpart (a) have led.

RESPONSE:

(a) Many published papers on demand are available in the 18 Crew-Kleindorfer edited volumes on postal economics listed on my curriculum vitae. These published works are in the public domain and available to USPS. In reading these, it is important to begin with papers covering the general foundations of postal pricing, the USO and service quality, which are important foundations for follow-on econometric studies. The many econometric and empirical studies published in the Crew-Kleindorfer edited books on postal economics cover issues on USO redesign (including delivery frequency, post office locations, etc.), service quality changes *per se*, and postal network design, including post office density and the scope of service offerings. The available published studies address both letters and parcels, and are across a number of countries. A copy of the following, recent unpublished study is attached:

> Veruete-McKay, L., S. Soteri, J. Nankervis and F. Rodriguez (2010), "Letter traffic demand in the UK: an analysis by product and envelope content type" (presented at the Institut d'Economie Industrielle (IDEI) Sixth Conference On Regulation, Competition and Universal Service In The Postal Sector", Toulouse, March 25-26 2010.

In addition, the follow unpublished paper is relevant to the issue, is attached:

> Catherine Cazals, Jean-Pierre Florens, Leticia Veruete-McKay, Frank Rodriguez and Soterios Soteri (2011). "UK letter mail demand: a content based time series analysis using overlapping market survey statistical techniques", forthcoming 2011 in M. A.

Crew and P. R. Kleindorfer (eds), *Reinventing the Postal Sector in an Electronic Age*, Edward Elgar, Cheltenham, UK.

(b) There are many calibrated simulation studies on the consequences of demand changes resulting from changes in delivery frequency and other characteristics of the USO and under different assumptions on competition. Perhaps the best known of these is the prospective study (in which I participated as a consultant) undertaken for all the countries in the European Union in 2005-2006 as a prelude to the EU Third Postal Directive. This study is summarized in the following published paper:

Crew, Michael A., Gonzales d'Alcantara, Paul R. Kleindorfer, Philippe Claeys and Bert Kuypers (2008) "Economic Factors Underlying Postal Reform in the European Union," in M. A. Crew, P. R. Kleindorfer and J. I. Campbell, Jr. *Handbook of Worldwide Postal Reform*, Edward Elgar, Cheltenham, UK.

Another recent calibrated study building on previous econometric work and summarizing earlier work in the area of calibrated simulation studies on changes in the USO, including delivery frequency, is the following:

Borsenberger, Claire, Denis Joram, Clément Magre and Bernard Roy (2010) "Cross-country Comparisons of Optimal Mail Delivery Frequency" in M. A. Crew and P. R. Kleindorfer (eds.), *Heightening Competition in the Postal and Delivery Sector*, Edward Elgar, Cheltenham, UK.

USPS/NALC-T4-3

Please refer to the first full paragraph on page 8 of your testimony. Would it be more accurate to describe the analysis in NALC-LR-N2010-1/12 as *assuming* a two percent across-the-board decline in mail volume (in the absence of any survey research or econometric analysis) rather than *predicting* such a decline? If your response is not wholly affirmative, please explain.

RESPONSE:

The authors of NALC-LR-N2010-1/12, who are experts on issues related to postal USO, state that "[i]t was assumed that the effect of changing from six to five days per week would be modest (a 2% loss)…" *Id.* at p.15. The authors presumably used this figure of 2% because they believed it was a reasonable one and because it represented their considered view. Indeed, the authors of NALC-LR-N2010-1/12, joined by Professor John Panzar, reported a similar figure in their published paper in Crew-Kleindorfer (2010). *See* Robert Cohen, Charles McBride and John C. Panzar, "The Cost of the USO in the United States"-in M. A. Crew and P. R. Kleindorfer (eds.), *Heightening Competition in the Postal and Delivery Sector*, Edward Elgar, Cheltenham, UK: 2010, at pp.258-59.

USPS/NALC-T4-4

Please refer to the paragraph that begins on page 10 of your testimony.

(a) Cite the "accepted principles of project management" to which you refer.

(b) How far in advance of scheduled implementation do the "accepted principles of project management" require for the development of temporal implementation plans for service changes of the type under review in this docket?

(c) Would you regard provision of a cross-functional "temporal template or plan for implementation" by the Postal Service to the Government Accountability Office over six months prior to implementation to satisfy accepted principles regarding timely submission of such templates/plans? If not, please explain.

(d) Is it your testimony that the principles referenced in subpart (a) are violated by the fact that the Postal Service's temporal implementation plans for all technical and personnel changes that will be made in support of the service changes under review in this docket (which are not likely to be implemented before July 2011) were not presented to the Postal Regulatory Commission by the time of the filing of your testimony in August 2010?

RESPONSE:

(a) The principles in question are noted in footnote 5 following the sentence in question. This footnote states in part: "In particular, Table 2 (p. 14) of this GAO report, and the discussion surrounding this Table, makes plain that accounting for uncertainty and undertaking temporal planning of project costs is essential for good program management. Neither of these basic practices is evident in the USPS estimates provided for project costs associated with their proposal."

(b) There is clearly no single answer to this question. Planning for major public projects is often undertaken years in advance of implementation, given the need for budgetary approval and stakeholder discussion. Planning for other types of projects may be done and updated closer to the time of implementation. The GAO report, cited in my testimony as an example of failure to undertake temporal project planning, was less concerned with the question of how far in advance of implementation such planning should take place but rather with the

absence of detailed temporal project planning by NASA. GAO considered this both an indicator of and a contributor to poor financial planning and execution, as well as contributing to misestimating the costs of associated projects. It is in this regard that I cited the GAO study of NASA as relevant to the absence of a temporal template for implementation of the USPS proposal.

(c) Refer to my response to (b).

(d) I reached the conclusions of my testimony based on the materials filed with the Postal Regulatory Commission for this docket prior to filing my testimony. These materials did not reference any detailed temporal implementation plans in the estimates provided for the direct project costs and the transition costs of the USPS proposal to reduce deliveries to 5 days. It was this apparent absence of such a temporal template underlying the project cost estimates provided that I criticized (based in part on the GAO report cited).

USPS/NALC-T4-5

(a) Have you ever have conducted, directed or managed a quantitative market research study?

(b) Have you ever used a quantitative market research survey or study in your studies of regulatory economics and the economics of postal services?

(c) If the answer to either subpart (a) or (b) is affirmative to any degree, please provide a copy of any such study, a summary of the objective of the survey or study, a description of your role and involvement in its design and execution, and your use of its results.

RESPONSE:

(a) No.

(b) Yes.

(c) The entire fabric of postal economics, to which I have made many contributions over the years, is underpinned by demand studies of various types. In particular, the books on postal economics I have edited with Paul Kleindorfer over almost 20 years have many studies of this sort. My own research on postal economics has also relied directly on such studies. For example, my research on the scope of the USO (published in a number of papers cited in my curriculum vitae) relies on econometric and calibrated research studies of demand. Moreover, my research on pricing (published in a number of studies cited in my curriculum vitae) also relies on previous demand studies. I note below two examples of the many such published USO and pricing studies in which I have been involved that rely on previous demand studies, including both quantitative and qualitative market research and demand studies.

(1) Crew, Michael A. and Paul R. Kleindorfer (2002). "Two-Tier Pricing under Liberalization", in Michael A. Crew and Paul Kleindorfer (eds), *Postal and Delivery Services: Pricing, Productivity, Regulation and Strategy*, Kluwer Academic Publishers, Boston. (2) Crew, Michael A., Gonzales d'Alcantara, Paul R. Kleindorfer, Philippe Claeys and Bert Kuypers

(2008). "Economic Factors Underlying Postal Reform in the European Union," in M. A. Crew, P. R. Kleindorfer and J. I. Campbell, Jr. Handbook of Worldwide Postal Reform, Edward Elgar, Cheltenham, UK.

USPS/NALC-T4-6

(a) Have you ever have conducted, directed or managed a qualitative market research survey or study?

(b) Have you ever used a qualitative market research survey or study in your studies regulatory economics and the economics of postal services?

(c) If the answer to either subpart (a) or (b) is affirmative to any degree, please provide a copy of any such study, a summary of the objective of the survey or study, a description of your role and involvement in its design and execution, and your use of its results.

RESPONSE:

(a) The prospective study for the EU Third Postal Directive described in the following paper was a qualitative study, accompanied by a calibrated simulation. It involved surveying all EU Member States and 3 associated other countries (Ireland, Lichtenstein and Norway). Michael A. Crew, Gonzales d'Alcantara, Paul R. Kleindorfer, Philippe Claeys and Bert Kuypers (2008) "Economic Factors Underlying Postal Reform in the European Union," in M. A. Crew, P. R. Kleindorfer and J. I. Campbell, Jr. Handbook of Worldwide Postal Reform, Edward Elgar, Cheltenham, UK.

(b) Yes.

(c) Studies of postal economics, including my own, are informed by empirical studies. Most of the studies that I have written, reviewed and edited for the annual postal economics volumes I edit with Paul Kleindorfer have directly or indirectly relied on previous demand studies. These include studies in Austria, Finland, France, Ireland, Switzerland, and the United Kingdom. The study noted in (a) above incorporated the results of surveys from 30 countries on demand responses to USO and pricing changes. The objective of these studies is typically to improve the efficiency of the postal sector or to evaluate particular proposals for change, such as the liberalization of the sector, access policies, pricing proposals, etc. My role

over the years has been as an active consultant to many postal organizations or regulators, as well as an editor and author. See my curriculum vitae for details on my published studies on the postal sector.

CURRICULUM VITAE

MICHAEL ANTHONY CREW

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Marital Status: Married

Citizenship: United States of America

Schools and University:

Dudley Grammar School:	1953-1960, General Certificate
University of Birmingham:	1960-1963, B. Com. II (i)
University of Bradford:	1965-1972, Ph.D.

Present Position:

Professor II, (with tenure) Rutgers Business School – Newark and New Brunswick, Rutgers University, July 1, 1987-
CRRI Scholar Rutgers Business School – January 1, 2005- June 30, 2008
CRRI Professor of Regulatory Economics – July 1, 2008-

Faculty Appointments:

Visiting Professor of Economics, University of Texas at Arlington, January 14, 1984-May 31, 1984

Professor I (with tenure), Graduate School of Management, Rutgers University, July 1, 1980-June 30, 1987

Associate Professor of Business Administration (with tenure), Rutgers University, January 1, 1977-June 30, 1980

Visiting Professor of Economics, Wesleyan University, spring 1976

Visiting Faculty Member in Economics, Harvard University, summer 1975

Senior Lecturer in Economics, University of Strathclyde, 1974-1977

Associate Head of Department of Social Studies, Paisley College of Technology, 1972-1974

Lecturer in Economics, University of Southampton, 1971-1972

Lecturer in Economics, London Graduate School of Business Studies, 1970-1971

Lecturer in Economics, University of Kent at Canterbury, 1969-1970

Visiting Lecturer/Visiting Assistant Professor of Economics, Carnegie-Mellon University, 1968-1969

Assistant Lecturer/Lecturer in Management Studies, University of Bradford, 1965-1969

Assistant Lecturer in Business Economics, University of Strathclyde, 1964-1965

Administrative Appointments:

Chairman of the Department of Finance and Economics, School of Management, Rutgers University, July 1, 1994-June 30, 1996 (25 faculty; Ph.D., MBA, and undergraduate programs)

Chairman of Finance and Economics Area, Graduate School of Management, Rutgers University, August 1, 1988-September 30, 1991(20 faculty, Ph.D. and MBA programs)

Director of Center for Research in Regulated Industries, Rutgers Business School, Rutgers University, July 1, 1984- (Providing administrative direction, fund-raising, program development, publications, editorial duties, and research: funds raised are in excess of $500,000 per year)

Director of Business Research Center, Graduate School of Management, Rutgers University, June 1, 1977-June 30, 1984

Chairman of Economics, Paisley College of Technology, 1973-1974

Other Appointments:

Chairman of Appointments and Promotions committee, Rutgers Business School, Rutgers University, 2001–2002, 2005-2006.

Member of Editorial Board, *Utilities Policy*, 1990–1994

Editor and founder of *Journal of Regulatory Economics*, 1988–

Editor of Kluwer Series of books *Topics in Regulatory Economics and Policy*, 1986–

Member of Editorial Board, *Journal of Economics and Business*, 1980–1986

Member of Editorial Advisory Board, *Journal of Industrial Affairs*, 1976–1986

Advisor in Business Studies of the Mathematical Sciences and Applications Board, and a member of the Mathematics and Statistics Board and Panel of the Council for the National Academic Awards from December 1973 to March 1977

One of the founders of *Applied Economics* and Executive Editor, Joint Editor and Editor 1968–1972

Ph.D. Thesis:

"Peak Load Pricing and its Application," Unpublished, University of Bradford, 1971

Books:

Theory of the Firm, Longman, 1975; translated into Portuguese, *Teoria da Empresa*

Paying By Degrees, Institute of Economic Affairs, 1977 (with Alistair Young)

Public Utility Economics, Macmillan Press, St. Martin's Press, 1979 (with P.R. Kleindorfer)

Problems in Public Utility Economics and Regulation, (Ed.), Lexington Books, 1979

Issues in Public Utility Pricing and Regulation, (Ed.), Lexington Books, 1980

Regulatory Reform and Public Utilities, (Ed.), Lexington Books, 1982

Analyzing the Impact of Regulatory Change, (Ed.), Lexington Books, 1985

The Economics of Public Utility Regulation, Macmillan Press, M.I.T. Press, 1986 (with P.R. Kleindorfer)

Regulating Utilities in an Era of Deregulation, (Ed.), Macmillan Press, 1987

Deregulation and Diversification of Utilities, (Ed.), Kluwer Academic Publishers, 1989

Competition and the Regulation of Utilities, (Ed.), Kluwer Academic Publishers, 1991

Competition and Innovation in Postal Services, (Ed.), Kluwer Academic Publishers, 1991 (with P.R. Kleindorfer)

Economic Innovations in Public Utility Regulation, (Ed.), Kluwer Academic Publishers, 1992

The Economics of Postal Service, Kluwer Academic Publishers, 1992 (with P.R. Kleindorfer)

Regulation and the Evolving Nature of Postal and Delivery Services, (Ed.), Kluwer Academic Publishers, 1992 (with P.R. Kleindorfer)

Incentive Regulation for Public Utilities, (Ed.), Kluwer Academic Publishers, 1994

Commercialization of Postal and Delivery Services: National and International Perspectives, (Ed.), Kluwer Academic Publishers, 1994 (with P.R. Kleindorfer)

Pricing and Regulatory Innovations Under Increasing Competition, (Ed.), Kluwer Academic Publishers, 1996

Managing Change in the Postal and Delivery Industries, (Ed.), Kluwer Academic Publishers, 1997 (with P.R. Kleindorfer)

Regulation Under Increasing Competition, (Ed.), Kluwer Academic Publishers, 1999

Emerging Competition in the Postal and Delivery Sectors, (Ed.), Kluwer Academic Publishers, 1999 (with P.R. Kleindorfer)

Current Directions in Postal Reform, (Ed.), Kluwer Academic Publishers, 2000 (with P.R. Kleindorfer)

Expanding Competition in Regulated Industries, (Ed.), Kluwer Academic Publishers, 2000.

Future Directions in Postal Reform, (Ed.), Kluwer Academic Publishers, 2001 (with P.R. Kleindorfer).

Postal and Delivery Services: Pricing, Productivity, Regulation and Strategy, (Ed.), Kluwer Academic Publishers, 2002 (with P.R. Kleindorfer).

Postal and Delivery Services: Delivering on Competition, (Ed.), Kluwer Academic Publishers, 2002 (with P.R. Kleindorfer).

Markets, Pricing, and Deregulation of Utilities, (Ed.), Kluwer Academic Publishers, 2003 (with J.C. Schuh).

Competitive Transformation of the Postal and Delivery Sector, (Ed.), Kluwer Academic Publishers, 2003 (with P.R. Kleindorfer).

Obtaining the Best from Regulation and Competition, (Ed.), Kluwer Academic Publishers, 2004 (with M. Spiegel).

Regulatory and Economics Change in the Postal and Delivery Sector, (Ed.), Kluwer Academic Publishers, 2005 (with P.R. Kleindorfer).

Progress toward Liberalization of the Postal and Delivery Sector, (Ed.), Springer Science + Business Media, Inc., 2006 (with P.R. Kleindorfer).

International Handbook On Economic Regulation (Ed) Edward Elgar, 2006. (with D. Parker).

Liberalization of the Postal and Delivery Sector, (Ed.), Edward Elgar, 2006 (with P.R. Kleindorfer).

Competition and Regulation in the Postal and Delivery Sector, (Ed.), Edward Elgar, 2008 (with P.R. Kleindorfer).

Postal Reform, (Ed.), Edward Elgar, 2008 (with J.I. Campbell and P.R. Kleindorfer)

Economics of Privatization and Regulation, (Ed) 2008 (with David Parker)

Progress in the Competitive Agenda in the Postal and Delivery Sector, (Ed.), Edward Elgar, 2009 (with P.R. Kleindorfer).

Heightening Competition in the Postal and Delivery Sector (Ed), Edward Elgar, 2010 (with P.R. Kleindorfer)

Reinventing the Postal Sector in an Electronic Age (Ed), Edward Elgar, forthcoming 2011 with P.R. Kleindorfer)

Professional Papers:

"Pennine Electricity Board," Nelson, 1966; reprinted in Ralph Turvey, (Ed.), *Public Enterprise*, Penguin, 1969

"Capital Costs and the Peak Problem in Electricity Supply: Comment," Manchester School, May 1966

"Pricing for Efficiency in Electricity Supply," in *Essays in the Theory and Practice of Pricing*, Institute of Economic Affairs, 1967

"Peak Load Pricing and Optimal Capacity: Comment," *American Economic Review*, March 1968

"The Optimality of Pure Competition in the Capacity Problem: Further Comment," *Quarterly Journal of Economics*, May 1969

"Coinsurance and the Welfare Economics of Medical Care," *American Economic Review*, December 1969

"Mr. Tipping on Road Pricing," *Economic Journal*, December 1969

"A Note on Peak Loads and Non-Uniform Costs", (with P.R. Kleindorfer), *Economic Journal*, June 1970

"Antitrust: Economics versus Management Science", (with C.K. Rowley), *Moorgate and Wall Street*, Autumn 1970; reprinted in C.K. Rowley, (Ed.), *Industrial Economics*, Macmillan, 1972

"Some Problems of Pricing Under Stochastic Supply Conditions: The Case of Seasonal Pricing for Water Supply," (with G. Roberts), *Water Resources Research*, October 1970

"On Allocative Efficiency, X-Efficiency and the Measurement of Welfare 'Losses'," (with C.K. Rowley), *Economica*, May 1971

"X-Theory versus Behavioral Theory," (with C.K. Rowley and M. Jones-Lee), *Southern Economic Journal*, November-December 1971

"Marshall and Turvey on Peak Load or Joint Product Pricing," (with P.R. Kleindorfer), *Journal of Political Economy*, November-December 1971, reprinted in Ray Rees (Ed.) *The Economics of Public Utilities*, Edward Elgar, (forthcoming 2006)

"Recent Contributions to the Theory of Marginal Cost Pricing: The Problem of Peak Loads," (with P.R. Kleindorfer), *Economic Journal*, December 1971

"Antitrust Policy: The Application of Rules," (with C.K. Rowley), *Moorgate and Wall Street*, Autumn 1971

"A Note on X-Efficiency," (with C.K. Rowley), *Economic Journal*, December 1972

"On Off-Peak Pricing: An Alternative Technological Solution," (with P.R. Kleindorfer), *Kyklos*, 1975

"Optimal Plant Mix and Peak Load Pricing," (with P.R. Kleindorfer), *Scottish Journal of Political Economy*, November 1975

"Peak Load Pricing with a Diverse Technology," (with P.R. Kleindorfer), *Bell Journal of Economics*, Spring 1976, reprinted in Ray Rees (Ed.) *The Economics of Public Utilities*, Edward Elgar, (forthcoming 2006)

"Reliability and Public Utility Pricing," (with P.R. Kleindorfer), *American Economic Review*, March 1978

"Public Utility Regulation and Managerial Discretion," (with P.R. Kleindorfer), *Southern Economic Journal*, January 1979

"An Introduction to Current Problems in Public Utility Pricing and Regulation," (with P.R. Kleindorfer), in M.A. Crew, (Ed.), *Problems in Public Utility Economics and Regulation*, 1979

"Some Elementary Considerations of Reliability and Regulation," (with P.R. Kleindorfer), in M.A. Crew, (Ed.), *Problems in Public Utility Economics and Regulation*, 1979; translated as "Einige Grundlegende Uberlegungen fur Versorgungssicherheit bei offentlichen Unternehmnen" in C.B. Blankart and M. Faber, (Eds.), *Regulierung offentlicher Unternehmen*, Anton Hain, 1982

"Incentives for Efficiency in the Nationalized Industries: Beyond the 1978 White Paper," (with P.R. Kleindorfer and E.F. Sudit), *Journal of Industrial Affairs*, Autumn 1979

"Has the 1970 Act been fair to mailers? Commentary," in R. Sherman, (Ed.), *Perspectives on Postal Service Issues*, American Enterprise Institute, 1980

"Introduction to Issues in Public Utility Pricing and Regulation," in M.A. Crew, (Ed.), *Issues in Public Utility Pricing and Regulation*, 1980

"Public Utility Regulation and Reliability with Applications to Public Utilities," (with P.R. Kleindorfer), in M.A. Crew, (Ed.), *Issues in Public Utility Pricing and Regulation*, 1980

"Regulation and Diverse Technology in the Peak Load Problem," (with P.R. Kleindorfer), *Southern Economic Journal*, October 1981

"Introduction to Regulatory Reform in Public Utilities," in M.A. Crew, (Ed.), *Regulatory Reform and Public Utilities*, 1982

"A Cost Benefit Analysis of Local Measured Service," (with R.E. Dansby), in M.A. Crew, (Ed.), *Regulatory Reform and Public Utilities*, 1982

"Electricity Pricing and Plant Mix under Supply and Demand Uncertainty," (with P.R. Kleindorfer), in M.A. Crew, (Ed.), *Regulatory Reform and Public Utilities*, 1982

"Efficiency and Regulation: a Basis for Reform," *Managerial and Decision Economics*, December 1982

"Comments on Peak Load Pricing of Public Utilities," (with P.R. Kleindorfer), *Energy Economics*, April 1983

"A Note on Regulatory Influences on Managerial Incentives," (with P.R. Kleindorfer), *Southern Economic Journal*, July 1983

"Royalty Contracts: an Efficient Form of Contracting?" *Southern Economic Journal*, January 1984

"Local Measured Service Assumes a New Role," (with C.D. Hammelman), *Telephony*, April 16, 1984

"Opportunities for Regulation and Rate Design of Innovative Metering Technology in Water Utilities," (with D.L. Schlenger), in M.A. Crew, (Ed.), *Analyzing the Impact of Regulatory Change*, 1985

"Governance Costs and Rate of Return Regulation," (with P.R. Kleindorfer), *Journal of Institutional and Theoretical Economics*, March 1985

"Governance Structures for Natural Monopoly: A Comparative Institutional Assessment," (with P.R. Kleindorfer), *Journal of Behavioral Economics*, Winter 1985

"Deregulation as an Instrument of Industrial Policy," (with C.K. Rowley), *Journal of Institutional and Theoretical Economics*, March 1986; to be reprinted in Spanish in *Boletin de Informacion Comercial Espanola*

"Some Questions on the Costs and Benefits of Rate of Return Regulation: A Survey of U.S. Water Companies," (with D.L. Schlenger and F. Gradilone III), *Water*, Summer 1986

"Vertically Integrated Governance Structures and Optimal Institutional Arrangements for Cogeneration," (with K.J. Crocker), *Journal of Institutional and Theoretical Economics*, June 1986

"Dispelling the Disinterest in Deregulation," (with C.K. Rowley), in C.K. Rowley, R.D. Tollison and G. Tullock, (Eds.), *The Political Economy of Rent Seeking*, Kluwer, 1987

Productivity Incentives and Rate-of-Return Regulation," (with P.R. Kleindorfer), in M.A. Crew, (Ed.), *Regulating Utilities in an Era of Deregulation*, Macmillan Press, 1987, reprinted in L. Prosperetti (Ed.), *Producttivita e Competitivita*, Nomisma, 1988

Equity, Opportunism and the Design of Contractual Relations: Comment, *Journal of Institutional and Theoretical Economics*, February 1987

"Governance Costs of Regulation for Water Supply," (with P.R. Kleindorfer and D.L. Schlenger), in M.A. Crew, (Ed.), *Regulating Utilities in an Era of Deregulation*, Macmillan Press, 1987

"Rent Seeking is Here to Stay," in C.K. Rowley, (Ed.), *Democracy and Public Choice: Essays in Honor of Gordon Tullock*, Basil Blackwell, 1987

"Landfill Tipping Fees Should Be Much Higher," (with P.R. Kleindorfer), *Waste Age*, February 1988

"Equity, Opportunism and the Design of Contractual Relations: Comments," *Journal of Institutional and Theoretical Economics*, March 1988

"Toward a Public Choice Theory of Monopoly Regulation," (with C.K. Rowley), *Public Choice*, March 1988

"Competition, Diversification, and Disintegration in Regulated Utilities," in M.A. Crew, (Ed.), *Deregulation and Diversification of Utilities*, Kluwer Academic Publishers, 1989

"Feasibility of Deregulation: A Public Choice Analysis," (with C.K. Rowley), in M.A. Crew, (Ed.), *Deregulation and Diversification of Utilities*, Kluwer Academic Publishers, 1989

"Competition, Diversification and Disintegration in Electric Utilities," (with K.J. Crocker), in *Retrofit Opportunities for Energy Management and Cogeneration: Proceedings of the 11th World Energy Engineering Congress*, Association of Energy Engineers, 1989

"On the Efficiency of Law: A Public Choice Perspective," (with C. Twight), *Public Choice*, September 1990

"Peak-Load Pricing in Postal Services," (with P.R. Kleindorfer and M.A. Smith), *Economic Journal*, September 1990

"Diversification and Regulated Monopoly," (with K.J. Crocker), in M.A. Crew, (Ed.), *Competition and the Regulation of Utilities*, Kluwer Academic Publishers, 1991

"Information Economics and New Forms of Regulation," (with M.R. Frierman), in M.A. Crew, (Ed.), *Competition and the Regulation of Utilities*, Kluwer Academic Publishers, 1991

"Alternatives to Rate of Return Regulation Including Franchise Bidding as Deregulation," (with M. Zupan), in M.A. Crew, (Ed.), *Competition and the Regulation of Utilities*, Kluwer Academic Publishers, 1991

"The Economics of Rowland Hill," (with P.R. Kleindorfer) in M.A. Crew and P.R. Kleindorfer, (Eds.), *Competition and Innovation in Postal Services*, Kluwer Academic Publishers, 1991

"Peak Loads and Postal Services," (with P.R. Kleindorfer) in M.A. Crew and P.R. Kleindorfer, (Eds.), *Competition and Innovation in Postal Services*, Kluwer Academic Publishers, 1991

"Quality and Price Differentiation in Postal Service," in Walpurga Speckbacher (ed.), *Die Zukunft der Postdienste in Europa*, Springer-Verlag, Berlin, 1991, pp. 49-67.(P. R. Kleindorfer)

"Economic Depreciation and the Regulated Firm under Competition and Technological Change," (with P.R. Kleindorfer), *Journal of Regulatory Economics*, March 1992

"Incentive Regulation, Capital Recovery and Technological Change in Public Utilities," (with P.R. Kleindorfer), in M.A. Crew (Ed.), *Economic Innovations in Public Utility Regulation*, Kluwer Academic Publishers, 1992

"The Franchise Rebidding Problem and Public Utility Regulation," (with R. Harstad), in M.A. Crew (Ed.), *Economic Innovations in Public Utility Regulation*, Kluwer Academic Publishers, 1992

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"Qualite et Differenciation des Prix dans les Services Postaux", *Les Cahiers de l'Institut de Recherche d'Etudes et de Prospective Postales*, Vol. 12, September 1992, pp. 132-145. (P. R. Kleindorfer)

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Honors and Awards:

Recipient with Paul Kleindorfer, on behalf of the Center for Research in Regulated Industries, of the Hermes Award, 1992, presented by the European Express Organization, Munich, Germany, June 22, 1992

Recipient of the 2002 Distinguished Service Award, Public Utility Research Center, University of Florida, Gainesville, FL, February 21, 2002

Recipient of 2009 Distinguished Member Award, Transportation and Public Utilities Group, January 2010

Other Professional Activities:

Referee, including the following journals: *American Economic Review, Bell Journal of Economics, Economica, Economic Journal, Economic Inquiry, Journal of Economic Studies, Journal of Institutional and Theoretical Economics, Journal of Political Economy, Journal of Public Economics, Operations Research, Quarterly Journal of Economics, Quarterly Review of Economics and Business, Review of Economic Studies, Review of Economics and Statistics, Southern Economic Journal, Swedish Journal of Political Economy,* and *Zeitschrift fur Nationalokonomie*

Referee of proposals submitted to National Science Foundation

Discussant, International Symposium on Public Policy for Regulated Monopolies and Public Enterprise, Brussels, June 1979

Chairman of session on Public Utility Regulation, South Western Economic Association, Houston 1980

Discussant, Telecommunications Policy Conference, Annapolis, April 1980

Chairman of session, Econometric Society Meetings, Denver, September 1980

Director, Rutgers University Workshop on Advanced Public Utility Economics, 1980-81 (monthly meeting of sixteen professional economists engaged in research in regional utilities and regulatory bodies)

Chairman of session and discussant, Southern Economic Association, New Orleans, November 1981

Discussant, American Economic Association, New York, December 1982

Participant, Emory University Law and Economics Center's Legal Institute for Economists, Dartmouth College, June 1983

Presenter of Paper, "Transactions Costs of Rate of Return Regulation," Conference on New Institutional Economics, Metlach, West Germany, June 26-29, 1984

Presenter of Paper, "Competition, Diversification and Regulation of Telecommunications," New Jersey Bar Association Conference, New Brunswick, NJ, March 24, 1987

Discussant/Chair, Public Choice Society, Tucson, AZ, March 26-28, 1987

Presenter of Paper, "Capital Recovery and Productivity Problems Under Price Caps," Pacific Telecommunications Council, Honolulu, HI, January 14-20, 1989

Presenter of Paper, "Diversification and Regulated Monopoly," Current Issues Challenging the Regulatory Process, Santa Fe, NM, March 7-10, 1989

Presenter of Paper, "On the Efficiency of Law: A Public Choice Perspective," Public Choice Society, Orlando, FL, March 16-19, 1989

Discussant, Bellcore/Bell Canada Cost Forum, San Diego, CA, April 4-8, 1989

Presenter of Paper, "Peak-Load Pricing in Postal Services," Public Choice Society, Tucson, AZ, March 16-19, 1990

Director, Rutgers University Research Seminars in Public Utility Economics and Regulation, (28 one-day conferences held over the period May 1977 to May 2004)

Director, Rutgers University Advanced Workshop in Regulation and Competition, 1981–Present (three meetings per year of currently 70 professional economists)

Director, Rutgers University Annual Eastern Conference in Regulation and Competition, 1982–Present

Director, Rutgers University Annual Western Conference in Regulation and Competition, 1988–Present

Director, Rutgers University Workshops and Conferences on Postal Delivery Economics, 3 Workshops and 13 Conferences, 1990–Present

Testimony Before Congress:

Testimony before the House of Representatives Sub Committee on Postal Service on H.R. 22, "The Postal Reform Act," April 16, 1997

Testimony Before President's Commission:

Testimony before the President's Commission on the United States Postal Service, "Unique Attributes of the Postal Service Business Model: Prepared Statement to the President's Commission On The United States Postal Service," April 14, 2003

Consultancy:

American Telephone and Telegraph (local measured service, access, depreciation, testimony)

U.S. Department of Energy/Argonne National Laboratory/New Jersey Energy Research Institute (community energy planning)

City of Trenton (integrated community energy systems)

New Jersey Board of Public Utilities/Jersey Central Power and Light Company (strategic options for JCP&L arising out of the Three Mile Island accident)

Glitterex Inc. (pre-trial economic analysis for an antitrust case)

National Right to Work Legal Defense Foundation (agency shop in universities)

Stevens Institute of Technology (conference preparation)

Northwestern Bell (competitive pricing policies)

Hackensack Water Company (software development for regulated companies)

New York Telephone Company (capital recovery problems, executive education, price caps)

Manchester Township, N.J. (litigation support for host community benefit)

Niagara Mohawk Power Corporation (maximum demand rates)

United States Postal Service (preparation of testimony on marginal costs according to service level, research on service quality and marginal costs, incentive regulation, conference preparation)

New Jersey Bell Telephone (regulation of competitive and monopoly services)

Michigan Bell Telephone (regulation of competitive and monopoly services)

BellSouth Telecommunications (usage-based pricing)

Royal Mail, United Kingdom (pricing and entry, USO)

United States Department of State (peak-load pricing, conference preparation)

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Deutsche Post (price caps and USO)

Entergy (incentive regulation)

New Zealand Commerce Commission (incentive regulation)

Board of Airline Representatives of Australia (BARA) (airport fees)

Canada Post Corporation (USO, regulation, testimony)

Government of Canada (Testimony on USO)

Federal Trade Commission (Postal Service)

New Zealand Post (regulation)

Australian Competition and Consumer Commission (postal discounts)

European Commission (member, PriceWaterhouseCoopers team on the USO and full market opening of postal markets)

US Treasury (member, Grant Thornton team on costing for USPS competitive products)

Australia Post Corporation (Access)

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Chapter 7

UK Letter Mail Demand: A Content Based Time Series Analysis Using Overlapping Market Survey Statistical Techniques*

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1. INTRODUCTION

The postal market in the UK is experiencing a period of prolonged structural change. The key factors driving such change can be viewed to originate from two quite different sources: those related to the regulatory and policy making framework; and advances in technology that influence customer communication channels. This, combined with the deep recession of 2008-09 and slow economic recovery in 2010, has created a high level of uncertainty with respect to both the short and long term demand for letter mail[1].

Uncertainty is a factor confronted by businesses, consumers and policymakers on a day-to-day basis. Businesses and organisations that have a better understanding of why customers demand their products and what factors underpin that demand are more likely to successfully manage this uncertainty. However, postal operators' information systems mainly focus on the products they sell, which in the UK primarily relate to speed of delivery

and presortation discounts, and tend to contain little information on the types of letter communications customers are purchasing. While letter traffic information based on speed and presortation attributes is essential for many reasons including a range of operational, financial, marketing and regulatory requirements, it is less helpful in providing insights into the reasons for sending letters and for assessing the likelihood that customers will continue to send mail in the future.

Previous UK studies have focused on the demand for letters by speed of delivery and presortation levels, see Nankervis et al (2002) and Soteri et al (2009). In an environment of continuing and evolving structural change it may be as appropriate also to assess the demand for sending different types of letter communications. Unfortunately, letter traffic data by content type is not readily available in the UK. The problem of the absence of letter traffic volumes by content type was confronted by Veruete-McKay et al (2010) (henceforth, VM) by combining Royal Mail total traffic data on addressed inland mail and survey information. That study provided important new insights into the influence of the economic cycle, prices, technology and other factors on the demand for UK letter traffic by content type. In particular, it estimated the price elasticity of addressed direct mail (or advertising) letters to be substantially higher than for other types of letter communications and provided quantitative estimates of the extent to which technology has driven a wedge between the rates of growth of economic activity and letter traffic (referred to by some in the postal industry as the "technology wedge")[2].

The incomplete and overlapping coverage of the survey data used by VM to derive letter volumes by content type led to the generation of two content traffic data series. In general, the econometric results using these series were

broadly similar, but generated some differences. In particular, the magnitude of the estimated price elasticity for direct mail differed markedly when using the two data sets. The two sets of estimated elasticities reported by VM therefore provide a range of values that can be used to inform business and policymaking decisions within the postal industry in the UK.

This paper builds on the approach adopted by VM to further understanding of the demand for letters by content type in the UK and provides two important developments to the literature on the demand for mail. First, the paper shows how maximum likelihood statistical techniques can be used to make more efficient use of information and create a unified framework within which to derive time series content traffic data using incomplete but overlapping survey data. Second, based on this it provides additional insights into the demand for letters in the UK using econometric time series techniques.

Section 2 describes the maximum likelihood statistical methodology used to derive a single time series of letter traffic by content type using limited and partial information sets. Section 3 describes the econometric methodology adopted to estimate the letter traffic content models and reports the results of the econometrics analysis. Section 4 provides a summary and conclusions.

2. DERIVING LETTER TRAFFIC CONTENT TIME SERIES USING INCOMPLETE SURVEY DATA

Letter traffic data by content type for social, commercial (mainly transactional) and direct mail were derived in two stages. In the first stage, information on letter contents was obtained from two Royal Mail surveys by sender and receiver segments. However, as neither of the surveys on their own provided full coverage of addressed inland letter traffic volumes for the whole time series, a maximum likelihood statistical technique was used to derive content

share estimates for each of the three content types by using partial and overlapping information from the two surveys. The second stage then used the content share estimates from stage one and Royal Mail total addressed inland letter traffic data to generate time series data for each of the three content types. This section contains information on the two surveys sources, the maximum likelihood estimation methodology adopted to estimate content shares and the resulting letter content time series data.

2.1 Letter Content Survey Data

Information on letter traffic contents was obtained from two Royal Mail surveys, the Mail Characteristics Survey (MCS) and the Consumer Panel Survey (CPS). The MCS contained information on the content of letters delivered by Royal Mail on an end-to-end (E2E) basis (that is, collected, sorted and delivered by Royal Mail) for UK financial years 1980/81 to 2007/08 and the CPS on mail sent and received by households from 1997/98 onwards[3]. Neither of the two surveys provided a fully comprehensive survey of total letter traffic delivered by Royal Mail. For example, the MCS survey excluded downstream access traffic handled by competitors upstream (that is, mail collected and sorted by competitors prior to handing it back to Royal Mail for delivery) which developed from 2004/05, while the CPS covered all types of Royal Mail delivered volumes except business-to-business traffic.

Time series estimates for letter traffic volumes by content type for social, commercial (mainly transactional) and direct mail were derived from 1980/81 to 2001/02 using information contained in the MCS. For the period 2002/03 to 2007/08 information on each content type for up to four sender-receiver segments was obtained from the two surveys to estimate letter traffic by content shares for Royal Mail E2E traffic and access volumes. Table 1

contains a summary of the coverage of the survey information and data on total traffic that were used to inform the maximum likelihood estimates for letter traffic content shares. Note that both surveys contained some information on E2E letter content sender-receiver segments, that is person to person (P2P), person to business (P2B), business to person (B2P) and business to business (B2B), but only the CPS contained information on access traffic.

Table 1. Data used to estimate letter traffic content shares

	Mail Characteristics Survey (MCS) [1]				Consumer Panel Survey (CPS) [1,4]			
	End-to-end (E2E) mail				End-to-end (E2E) mail			
	Sender-to-receiver segments				Sender-to-receiver segments			
Contents	P2P	P2B	B2P	B2B	P2P	P2B	B2P [5]	B2B
Social	✓	✓	✓	✓	✓	✓	-	-
Direct mail[2]	-	-	✓	✓	-	-	✓	-
Commercial	✓	✓	✓	✓	✓	✓	✓	-
	Access mail[3]				Access mail			
Contents	P2P	P2B	B2P	B2B	P2P	P2B	B2P	B2B
Social	-	-	-	-	-	-	-	-
Direct mail	-	-	-	-	-	-	✓	-
Commercial	-	-	-	-	-	-	✓	-
Data on total traffic[6]								
Total E2E	✓	Total access		✓				

Notes:

1 ✓ indicates survey provided information to maximum likelihood letter content share estimates.
- indicates that no survey information was provided to inform maximum likelihood content share estimates.

2 Sample responses from both surveys suggested a very small quantity of direct mail was sent by private

3 The MCS survey does not cover access mail.

4 The CPS did not cover B2B mail.

5 Prior to 2006/07 the CPS survey did not adequately distinguish between B2P social and commercial letters.

Information from the MCS suggested that social B2P mail volumes were very small and therefore this segment

6 Refers to Royal Mail addressed inland letter traffic mail.

The methodology used by VM to derive letter content traffic data was to estimate two traffic series for each of the three content groups. In particular, VM used each of the two surveys in turn as the primary source of information and then used information from the other survey to complete the data set[4]. This paper follows a similar approach to VM initially, in that it derives letter content traffic time series data by combining survey data and Royal Mail traffic volume data. However, a key development of this paper is that it adopts a maximum likelihood approach to estimate a single set of letter content volume shares using incomplete and overlapping survey data from different sources.

2.2. Deriving Letter Content Share Estimates Using Incomplete and Overlapping Survey Data

This section describes the methodology used to estimate letter traffic content shares for the six year period 2002/03 to 2007/08 using the two survey sources outlined in section 2.1 that provide partial and overlapping information on the population of letter traffic[5]. In the first instance, it describes the methodology using a standard single survey case with three characteristics (letter content types) and generalises this to the case with up to *k* characteristics (letter content types disaggregated further by sender-receiver segments). It then proceeds to explain how the standard single survey case can be extended to cover the case where information is available from two partial samples. Finally, this section summarises how this methodology was applied to estimate letter traffic content shares for UK addressed inland letter traffic.

2.2.1 The standard case using a single sample

In the standard case it is assumed that we obtain a single sample in which we observe letter traffic by content type characteristics. For example, consider three possible content types denoted by *A*, *B* and *C*, for the letter traffic population where the actual proportions of these content types in the letter traffic population are denoted by α_A, α_B, α_C and are the parameters to be estimated.

The sum of the three population proportions must sum to one, that is, $\alpha_A + \alpha_B + \alpha_C = 1$. This identity imposes an adding up restriction which means that only two parameters can be independently estimated subject to the restriction holding. For example, re-arranging the adding-up constraint yields the relationship $\alpha_C = 1 - (\alpha_A + \alpha_B)$ and therefore once estimates for α_A, and α_B are derived subject to the adding up constraint, α_C is also identified.

To estimate the parameters, α_A, α_B and α_C it is assumed that a sample of *n* letters is observed and each has one of the three content types *A, B, C*, such that $n_A+n_B+n_C = n$ and n_k are the observed number of letter traffic items of random variables N_k, *k=A, B, C*. The joint distribution of (N_A, N_B, N_C) is a multinomial distribution, where the probability density function for the multinomial distribution (Mood et al, 1974) is given by:

$$p(n_A, n_{B,} n_C) = \frac{n!}{n_A! n_B! n_C!} \alpha_A^{n_A} \alpha_B^{n_B} \alpha_C^{n_C} \qquad (1)$$

and the log-likelihood function can be expressed as:

$$l = n_A Ln\alpha_A + n_B Ln\alpha_B + n_C Ln(1 - \alpha_A - \alpha_B) \qquad (2)$$

For simplicity, the constant term $Ln\, n! - (Ln\, n_A! + Ln\, n_B! + Ln\, n_C!)$ is omitted since it does not include any of the parameters to be estimated in the log-likelihood maximization. The terms α_k, *k=A, B, C,* in the log-likelihood

function (2) represent the letter traffic contributions to the likelihood, that is the probability that a letter is of content type *k*. The corresponding maximum likelihood estimates of the proportions are:

$$\hat{\alpha}_A = \frac{n_A}{n} \quad \hat{\alpha}_B = \frac{n_B}{n} \quad \hat{\alpha}_C = \frac{n_C}{n} \tag{3}$$

where the estimated proportions are simply equal to the number of observed letter traffic items of each content type in the sample divided by the total sample size.

In the general case where we deal with a set of *k* letter traffic content types differentiated by sender-receiver segments denoted by *K={1,2,…,k},* where *k* has an integer value, the log-likelihood function (2) can be expressed as:

$$l = \sum_{i=1}^{k} n_i Ln(\alpha_i) \tag{2'}$$

where n_i represents the number of items of traffic in the observed sample with letter traffic content types *i*, and α_i is the unknown actual proportion of letter traffic volume with content types *i* in the whole population, for *i=1, …, k*. Obviously, in this case again, the adding up restriction holds (that is, $\sum_{i=1}^{k} \alpha_i = 1$) and one parameter is linearly dependent on the others and the maximum likelihood estimates for the proportions with content types *i* are:

$$\hat{\alpha}_i = \frac{n_i}{n}, \; i = 1,...,k \tag{3'}$$

2.2.2 The case of two partial and overlapping samples

Assume that we have two different samples corresponding to two survey data sets. The first survey, with size *n*, is limited only to the two categories *A* and *B*. So we have information about the number of items of traffic in the sample with letter traffic content types *A*, denoted n_A, and the number of items of traffic in

the sample with content type *B*, denoted n_B, with $n_A + n_B = n$. The second survey, with size *m*, is limited to the categories *B* and *C*. So we have information about the number of items of traffic in the sample with content type B, denoted m_B, and the number of items in the sample with content type *C*, denoted m_C, with $m_B + m_C = m$. That is, we have a case where each survey partially covers the letter traffic population by content type (*A, B* and *C*) and the survey information overlap one another (that is, both contain information on content type *B*).

The objective is to estimate the actual proportions of the three letter traffic content types in the whole population from the information contained in the two incomplete surveys. The log-likelihood function in this case (see Asano, 1965) can be expressed in the following way:

$$l = \underbrace{n_A Ln\frac{\alpha_A}{\alpha_A+\alpha_B} + n_B Ln\frac{\alpha_B}{\alpha_A+\alpha_B}}_{\text{contribution of first sample}} + \underbrace{m_B Ln\frac{\alpha_B}{1-\alpha_A} + m_C Ln\frac{1-(\alpha_A+\alpha_B)}{1-\alpha_A}}_{\text{contribution of second sample}} \qquad (4)$$

The third parameter, α_C, can be deduced from the parameters α_A and α_B, using the adding up constraint $\alpha_C = 1-(\alpha_A+\alpha_B)$. In this case, we are dealing with conditional probabilities. For example, let us consider the contribution of the first sample in the log-likelihood in equation (4): the term $\frac{\alpha_A}{\alpha_A+\alpha_B}$ represents the probability that an item of letter traffic is of content type *A* given that it comes from a sample which only contains content types *A* or *B;* a similar interpretation can be ascribed to the second term $\frac{\alpha_B}{\alpha_A+\alpha_B}$, which refers to letter traffic content type *B* in this sample. Equally, a similar interpretation applies to the contribution of the second sample, where we use the relation between α_C and, α_A and α_B (that is, $\alpha_C = 1-(\alpha_A+\alpha_B)$). The maximization of

log-likelihood function such as (4) has no analytical solution but estimates can be obtained by numerical computation.

The log-likelihood function for the three letter traffic content types case can be generalized to deal with a set of *K={1,2,…,k}* content types disaggregated further to include sender-receiver segments. Here we consider that we have a first sample with size *n* for which we observe a sub-set of letter traffic by content type sender-receiver segments denoted K_1, where $K_1 \subset K$, and a second sample with size *m*, for which we observe only a sub-set of content types by sender-receiver segments denoted K_2, where $K_2 \subset K$, and we have $K_1 \bigcap K_2 \neq \varnothing$ and $K_1 \bigcup K_2 = K$. This more general log-likelihood function can be expressed as follows:

$$l = \sum_{i \in K_1} n_i Ln(\frac{\alpha_i}{\sum_{i \in K_1} \alpha_i}) + \sum_{i \in K_2} m_i Ln(\frac{\alpha_i}{\sum_{i \in K_2} \alpha_i}) \qquad (4)'$$

where n_i represents the number of items of letter traffic in the sample with content types i, $i \in K_1$, in the first observed sample, and m_i represents the number of items of letter traffic with content types i, $i \in K_2$, in the second observed sample. Again, one parameter is linearly dependent on the others due to the adding-up constraint, $\sum_{i=1}^{k} \alpha_i = 1$.

2.2.3 Estimating letter traffic by content shares using information from two partial and overlapping surveys

We applied this methodology to obtain estimates of the actual proportions for three content categories (social, commercial and direct mail) by sender-receiver flows (person to person (P2P), person to business (P2B), business to person (B2P) and business to business (B2B)) and the proportion of access

mail for total addressed inland letter traffic volumes delivered by Royal Mail. The direct mail sender-receiver letter traffic flows in the survey originating from persons were very small in number and their respective proportions in the maximum likelihood estimation were assumed to be equal to zero. Therefore, in total the two surveys provided partial information on up to 12 mail categories that covered the population of total addressed inland letter traffic excluding B2B access mail. More precisely and by reference to Table 1, the MCS data set provided information on 10 sender-receiver mail categories but no information on access mail[6], while the CPS provided information on 8 mail categories (2 access traffic segments and 6 E2E traffic sender-receiver segments)[7]. In addition, since information on the actual proportion of total access volumes was observed this was directly incorporated into the maximum likelihood estimation function to inform the estimated content shares for access mail.

The maximum likelihood methodology was applied to information on the sender-receiver segments from the two surveys for each of the six years 2002/2003 to 2007/2008 to estimate proportions of mail for 12 mail categories. These are reported in Table 1 and are given by each sender-receiver category where there was information from at least one of the surveys. With no overlapping information on access mail volumes from B2B from the two surveys, it was necessary to use data on access mail volumes from B2P. It was assumed that the ratio of direct mail access mail volumes by B2P and commercial mail business access volumes by B2P was the same as the corresponding ratio for B2B. This allowed the shares of access of direct mail and commercial mail volumes send by B2B to be derived.

2.3 Addressed Inland Letter Traffic Trends by Content Type

Once traffic share estimates for the period 2002/03 to 2007/08 were obtained using the maximum likelihood estimation techniques described above, a continuous time series was derived by linking them to those estimated for the period 1980/81 to 2001/02 using MCS information[8]. Estimates of letter volumes by content type ($\hat{V}_i$) were then derived from Royal Mail total addressed inland letter traffic volume index data (*V*) using expression (5)

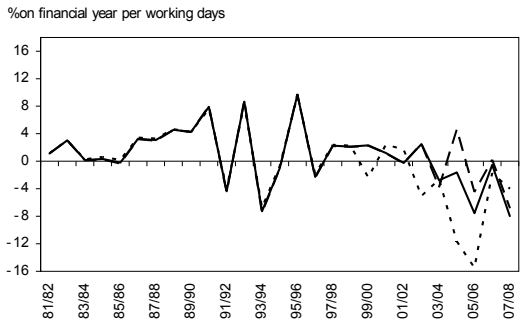
$$\hat{V}_i = \hat{\alpha}_i \; s_i \; V \qquad (5)$$

where $\hat{\alpha}_i$ denotes the estimated share of total addressed inland letter traffic being of i content type; i refers to social, commercial and direct mail; and s_i denotes a scalar to generate index numbers equal to 100 in 2005/06. Note that by definition $\sum_{i=1}^{i=3} \hat{\alpha}_i \hat{V}_i = V$ and $\sum_{i=1}^{i=3} \hat{\alpha}_i = 1$.

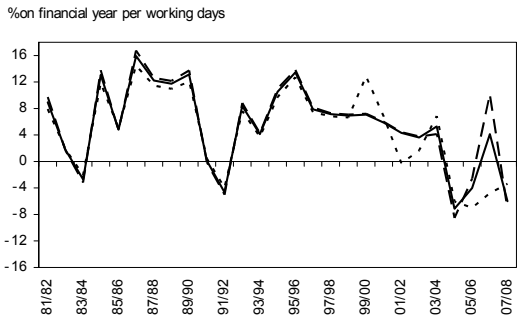
Figure 1 contains a plot of the annual rates of growth for the estimated addressed inland letter traffic data by content type generated by expression (5) and also the corresponding series reported in VM. Two points to note about the different estimates for each content type contained in figure 1 from 2002/03 onwards are: firstly, the estimates informed by the maximum likelihood methodology that used overlapping information from both surveys seem to be less volatile than those derived by VM; and secondly, the maximum likelihood estimates are not equal to the average of the two series derived by VM. In fact, as we assumed that information from the two surveys was equally reliable, the maximum likelihood content share estimates for each year broadly reflect the relative size of the number of items of letter traffic covered by each survey.

Figure 1: Estimated Letter Volume Growth Rates by Content Type

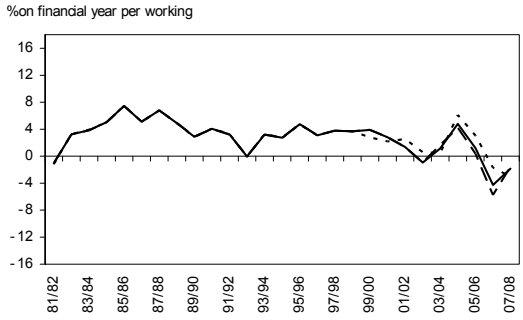
Social mail



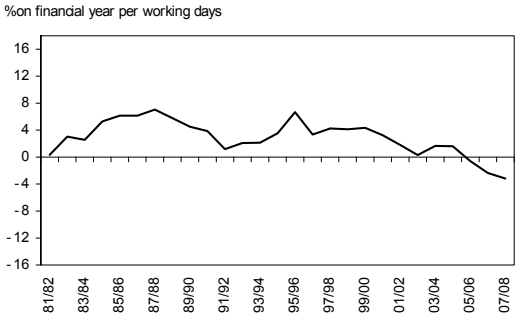
Direct mail



Commercial (mainly transactional) mail



Total mail



— — — VM estimated content growth rate using data method 1

- - - - VM estimated content growth rate using data method 2

——— Maximum likelihood estimated growth rates using overlapping market survey data

Note: Data refers to year-on-year growth in UK Financial years (FY). For example, UK FY 2007/08 refers to the data period April 2007 to March 2008. The two time series data sets derived by VM are denoted in the paper as those derived using "Method 1" and "Method 2". Method 1 was based primarily on information available from the MCS and then used the CPS to complete the data set where data were not available from the MCS (for example, on access). In contrast, Method 2 primarily focused on information available from the CPS and then used information available from the MCS to complete the data set where not available from the CPS (for example, business-to-business segments).

In terms of directional trends, figure 1 shows the annual rate of growth of total UK letter traffic per working day to have been negative between 2005/06 and 2007/08. The three estimated traffic series for commercial (mainly

transactional) mail began to decline a year later than total traffic, while social letter communications were estimated to have started two, or possibly three years earlier. Note also that direct mail volumes are estimated to have declined in at least three out of the four years between 2004/05 to 2007/08, despite the UK economy recording robust rates of growth over this period.

The three quite different estimated rates of growth for direct mail in 2006/07 reported in figure 1 suggest there is some uncertainty associated with data for individual years for letter traffic by content type. However, greater confidence can be attributed to the broad directional movements in the estimates. Bearing this in mind, and concentrating on the annual growth rates of the times series using the maximum likelihood estimates reported in figure 1 which are less volatile than those contained in VM, a number of interesting trends emerge. First, it is estimated that social letter communications increased, on average, by around 2% per annum over the two decades covering 1981/82 to 2000/01, but that between 2001/02 and 2007/08 social mail declined, on average, by almost 4% per annum. Second, direct mail letter communications have historically exhibited high rates of growth and fluctuated with economic activity. Third, commercial (mainly transactional) letter traffic volumes have, similar to direct mail, historically exhibited positive rates of growth and fluctuated in line with economic conditions. However, the demand for commercial letter communications has fluctuated less than that for direct mail.

3. AN ECONOMETRIC ANALYSIS OF UK LETTER TRAFFIC DEMAND BY CONTENT TYPE

3.1 Estimation Methodology

An econometric analysis of the demand for addressed UK inland letter traffic by content type was undertaken using a similar estimation methodology to

VM. In summary, the modelling comprised three relationships: one for social mail letter traffic; a second for commercial (mainly transactional) letters; and a third for direct mail letter communications[9]. The demand relationships were estimated using UK financial year data and single equation static ordinary least squares (OLS) time series models of the following form[10]:

$$q_{it} = \mathrm{A}_i^{'} D_{it} + \Pi_i^{'} x_{it} + \eta_{it} \qquad (6)$$

where lower case letters for Q_{it} and X_{it} denote logarithms of variables in time period t. The variable Q_i denotes the volume of traffic per household per working day for content type *i.* The variable X_{it} denotes a vector of explanatory variables corresponding to each traffic stream *i*. The vector of explanatory variables X_{it} included economic activity, real letter tariff price indices[11] for content type *i*, the quality of letter service delivery, and the proportion of Internet advertising expenditure relative to total advertising expenditure[12]. Initially, X_t included the real price of traditional non-mail advertising media substitutes and a number of variables linked to technology trends. The proportion of households with access to the internet and broadband and real telecommunication prices were examples of these technology trends. D_{it} is a vector of deterministic variables which includes a constant, dummy variables and a number of time trends. Π_i is a vector of long-run coefficients; A_i is a vector of estimated coefficients; and η_{it} is a random disturbance term.

3.2 Estimated Models of Letter Traffic by Content Type

The estimated equations for addressed inland letter traffic by content types, after eliminating insignificant variables, are reported in table 2. The estimated parameters have reasonably high t-statistics and the diagnostic reported tests suggest that the model is statistically sound[13].

The estimated elasticities for the three content types are broadly similar to those estimated by VM. However, there are also a number of differences, particularly with respect to the estimated impact of prices and internet advertising on direct mail and the estimated time trend impacts across all three content types. The estimated long run elasticities and time trends for total addressed inland letter traffic volumes were computed by weighting the long-run parameters for each of the three content types by their respective share of total traffic.

The estimated elasticities for economic activity, quality of service and price of telecommunication reported in table 2 are very similar to those contained in VM. In particular, commercial (mainly transactional) letter traffic is estimated to have a near unit elasticity with respect to economic activity, while direct mail is estimated to be highly pro-cyclical and posses an elasticity of about two. In contrast, social letter traffic is estimated to be independent of economic activity. Furthermore, the estimated elasticities for total letter demand with respect to quality of service and the price of telecommunication are almost identical to those estimated by VM (0.3 and 0.1 respectively). Note in the case of the estimated commercial price and telecommunication price elasticities that the hypothesis that they are equal in magnitude and opposite in sign was tested and could not be statistically rejected. The adoption of this hypothesis in the model leads to considerably higher t-statistics than those estimated for each of the variables individually (as a comparison of the estimated parameters in the restricted and unrestricted columns for commercial traffic show).

An important point to note with respect to the estimated price elasticities for letter traffic by content type is that, again as in VM, they differ substantially by

communication type. In particular, the econometric models indicated that commercial (mainly transactional) letter communications has the lowest price elasticity (of around -0.1 to -0.2) and social letter mail has a higher price elasticity of demand than transactional mail but it is still quite inelastic (around -0.5). The direct mail estimated price elasticity reported in table 2 of a little under unity (-0.9) lies towards the middle of the range of the two estimates contained in VM (that is, -0.7 and -1.4)[14]. This finding is as expected, since the maximum likelihood methodology used to derive the content traffic data combined information from the two survey sources used by VM. The high estimated price elasticity of direct mail relative to other types of letter communications is consistent with the findings of Thress (2006) and Santos and Lagao (2001).

Table 2: Addressed Inland Letter Content Traffic Per Household Model: Estimated Long Run Elasticities and Time Trends[1]

	Social	Commercial mail[4]		Direct mail	Total Traffic[5]	
		Unrestricted	Restricted		Unrestricted	Restricted
Economic activity[2]	ns	0.98 (7.7)*	1.02 (25.7)*	1.98 (4.9)*	1.10	1.14
Own price tariff index[3]	-0.52 (-4.3)*	-0.17 (-1.2)	-0.12 (-3.9)*	-0.92 (-2.2)*	-0.35	-0.31
Quality of service	0.44 (5.4)*	0.34 (5.5)*	0.33 (6.4)*	ns	0.28	0.27
Price of telecommunications index[3]	na	0.11 (2.1)*	0.12 (-3.9)*	ns	0.08	0.09
Proportion of Internet advertising expenditure	Na	na	Na	-2.33 (-6.8)*	-0.47	-0.47
Time trend estimates	Pre 2003 ns	Pre 2002 ns	Pre 2002 ns	Pre 1997 2.0% (2.3)*	Pre 1997 0.4%	Pre 1997 0.4%
	Post 2003 -4.1% (-9.3)*	Post 2002 -2.6% (-8.6)*	Post 2002 -2.6% (-9.0)*	Post 1997 -3.8% (-4.2)*	Post 2003 -3.0%	Post 2003 -3.0%
Net impact of "unexplained" time trends per annum at end of estimation period	-4.1%	-2.6%	-2.6%	-1.8%	-2.6%	-2.6%
Rsq adjusted	0.880	0.995	0.995	0.995		
Reg. SE	0.028	0.014	0.014	0.022		
DW	1.76	1.53	1.49	2.29		
Diagnostic tests (p-values)						
Serial Correlation[6]	0.57	0.38	0.35	0.44		
Heteroscedasticity[7]	0.39	0.28	0.25	0.82		
Normality[8]	0.41	0.91	0.88	0.07		
Reset[9]	0.11	0.98	0.79	0.96		
Chow test[10]	0.26	0.11	0.10	0.10		

Notes:

1 T-statistics reported in brackets and * indicates the parameters were statistically significant at 5%significance level.

2 Refers to Gross Domestic Product (GDP).

3 Deflated by the all items retail prices index.

4 The hypothesis that the own-price elasticity and the telecommunication price elasticities were equal and opposite in sign in the commercial equation was tested and could not be rejected. The commercial estimates imposing this hypothesis are reported in the "restricted" column of results and the freely estimated parameters not imposing this hypothesis is reported in the "unrestricted" column.

5 The total traffic estimated long run elasticities and parameters were calculated by weighting the estimated coefficients of each traffic content stream by their respective volume share in 2007/08.

6 This is a test for 1st order autocorrelation.

7 Refers to White's test for heteroscedasticity.

8 Refers to the Jarque-Bera test for normality in the residuals.

9 Refers to Ramsey's RESET test of functional form misspecification.

10 Refers to Chow's predictive failure test from 2005/06 onwards. Note that for the direct mail and commercial mail equations used to undertake the Chow test the dummy variable associated with 2006/07 was not considered in the regressions.

In order to examine the extent to which the results reported in table 2 depend on the importance placed on the two surveys used to derive time series for letter traffic by content type, two sensitivity tests were undertaken. Although both surveys are considered to be of a high standard, and purely to test the possible impact if one survey were to be considered superior to the other, in the first sensitivity, it was assumed that the information provided by the CPS was incorporated as if it was twice as reliable as that provided by the MCS

and the second sensitivity assumed the opposite[15]. The estimated direct mail price elasticities resulting from these two sensitivities were -0.9 and -1.1 respectively. This suggests that, with both survey sets considered to be of a high standard, a reasonable estimate of the price elasticity for total direct mail over the estimation period is around -1.

The estimated time trend impacts reported in table 2 suggest that there was a decline in the trend rate of social and commercial traffic from around 2003/04 and 2002/03 respectively and that this slowdown was of the scale of about 4% and 2½% per annum respectively[16]. The timing coincides with the sharp increase in the number of firms and individuals with broadband connections in the UK. It is likely that this combined with advances in Internet enabled technology has resulted in continuing substitution of social and commercial letter traffic.

The impact of e-substitution on direct mail resulting from the emergence of the internet and, in particular, "paid-for-search" advertising can be estimated using the coefficient of the proportion of internet advertising expenditure reported in table 2. For example, multiplying the average change in the proportion of internet advertising expenditure over the period 2005/06 to 2007/08 (4 percentage points per annum) by the long-run coefficient reported in table 2 suggests that internet related e-substitution could have reduced direct mail traffic volumes by an average of around 9% per annum during this period[17]. However, independent of the influence of internet advertising, it is likely that the high rates of direct mail growth experienced in the UK in the 1980s and 1990s would have eventually slowed down in order to stabilise its share of advertising spend within overall marketing budgets. The decline in the post

1997 direct mail time trend term effects reported in table 2 is consistent with this hypothesis.

3.3 Using the Letter Traffic by Content Model to Assess Prospects for Mail Trends

The estimated parameters reported in table 2 can be used as a starting point to assess the prospects for traffic growth in the UK in the near future if e-substitution effects are projected to be broadly in line with those in the recent past. As a first step in such an exercise it is necessary to make assumptions regarding the future values for all of the explanatory variables in the model including those for e-substitution. As an illustrative example, assume GDP growth in the UK were to be equal to 2% per annum; household growth were to be 1% per annum; the share of internet advertising expenditure were to continue to increase by 4 percentage points per annum; real telecommunication prices were to decline by around 5% per annum; real letter prices and quality of service were to be unchanged; and time trend terms were to continue in line with the estimates in table 2.

These assumptions together with the estimated parameters reported in table 2 would imply that social letter communications would decline by around 3% per annum; commercial (mainly transactional) letter traffic communications would be broadly flat; and direct mail traffic would decline by around 6% per annum. In total, this would suggest that if the impact of e-substitution as well as the other coefficients in the model were to remain broadly stable at around 2007/08 levels, then total letter traffic in the UK would decline by around 2% per annum in the near to medium term for the assumptions in this illustrative example[18]. However, the increase in the share of Internet advertising expenditure will slow down at some point in the future. If this initially were to

increase by, say, between only 1% and 2% per annum, while the assumptions for all the other factors remained as above, then direct mail demand would be expected to recover from a highly negative growth rate. In this illustrative example, this would reduce the rate of decline in the demand for letter traffic overall in the UK, and possibly even stabilise it.

Unfortunately, the impact of e-substitution in the medium to long term future on the demand for letter traffic is uncertain and clearly may change from the effects experienced over the recent past. As discussed by Nikali (2008), e-substitution is not a single process but reflects the effects of many technologies each with its own s-shaped diffusion curve. As some technologies mature others, perhaps as yet unknown, may impact on letter traffic in the future such that "the curve for substitution is reminiscent of a large corrugated s-curve" (Nikali, 2008, p91). For example, pressures to reduce business costs and concerns with the environment are exerting downward pressure on the demand for transactional letters (which is the largest category of letter mail in the UK and many other countries) and perhaps also on the extent to which direct mail will recover as the increase in Internet advertising expenditure slows down. If, the decline in transactional letter mail over the future were to take place at a faster rate than in the past, then the e-substitution impacts contained in the model reported in table 2 would underestimate the extent to which transactional mail letter communication will be substituted by electronic and digital forms of communication.

It is important that projections of mail volumes attempt to reflect these uncertainties regarding the quantitative impact of e-substitution in future years through risk and sensitivity analysis as well as adjustments to projections for

factors that, as yet, have not entered time series of past trends. It is likely that the factors affecting future demand for mail may be better understood through using a model of letter demand that is based on letter content types than models that focus on the demand for mail differentiated by speed of delivery or presortation levels. Therefore, while there may be some uncertainty associated with individual year estimates for letter traffic volumes by content type, model based projections that are augmented with off-model additional net trend adjustments (ANTAs) based on an analysis of demand by content type may provide a more informed framework for forecasting mail volume trends into the future. This approach is consistent with that developed in Feve et al (2010) where it is recommended that information priors (such as ANTAs) should be used to augment econometric models when forecasting the demand for letter mail in a changing and evolving market environment.

4. SUMMARY AND CONCLUSIONS

Structural changes in the communications market are having different impacts on different types of letter communications. However, many postal operators' information systems, including those in the UK, tend to focus on the types of products sold, which mainly reflect speed of delivery and presortation discounts, and not the type of communication purchased by customers. In order to understand better the factors influencing the total demand for letters and improve forecasting in an evolving market environment, it is important to understand the key drivers underpinning the demand for different types of letter communications.

However, there is a lack of good quality data on letter traffic by content type in most countries. This paper attempts to bridge the information gap in the UK by developing the framework developed in VM and combining actual total traffic

data with survey information to derive estimates for letter traffic volumes by content type. Estimates for three letter content types -social, commercial (mainly transactional) and direct mail- were derived using two sources of incomplete but overlapping survey data. In order to extend the analysis in VM, this paper has used maximum likelihood estimation techniques to combine information from different survey sources to obtain a single data set for UK delivered traffic segmented into the three content types. This data set was then used to estimate econometric time series models of the demand for letter traffic by content type. The results were consistent with those in VM and the econometric estimates in this paper can be viewed as a set of *best* central estimates that lie within a range of potential estimates.

The elasticities contained in section 3 of the paper provide insights into the relative importance of the key drivers for different types of letter communications in the UK. In particular, it is estimated that the elasticity of demand for commercial (mainly transactional) letter traffic with respect to economic activity is, approximately, unity and that direct mail is twice as sensitive to the economic cycle as commercial letter traffic. In contrast social letter traffic was found to be invariant to the economic cycle. Direct mail was estimated to be the most price sensitive segment of letter traffic, with an estimated price elasticity of around -1. Both commercial and social mail price elasticities were found to be considerably less sensitive to price changes. E-substitution impacts were estimated to affect all three content types. For example, over the three years between 2005/06 to 2007/08 the econometric models estimate that e-substitution was reducing the demand for: direct mail by at least 9% per annum[19]; social letter mail by around 4% per annum; and commercial (mainly transactional) letter traffic by around 2½% per annum.

The econometric results reported in this paper can be viewed as a starting point in considering future prospects for letter traffic volumes in the UK. While the impact of economic factors (including prices) appears to be comparatively stable, the significant impacts of e-substitution on mail volumes remain uncertain. In such an environment, it is important that projections of mail volumes attempt to reflect these uncertainties through risk and sensitivity analysis as well as adjustments to projections for factors that are, as yet, not reflected in time series of past trends. Over time, as new outcome data on the evolving mail market environment becomes available off-model sensitivity analysis of this kind can be updated and risks re-assessed. Such an approach is set out formally in Feve et al (2010) and the model set out in the current paper in terms of traffic by content type can be viewed as being fully consistent with that wider framework.

NOTES

* The analysis contained in this paper reflects the views of the authors and not necessarily those of Royal Mail Group.

[1] Except where otherwise stated, the analysis in this paper refers solely to addressed inland mail volumes and does not consider developments in unaddressed or international mail volumes.

[2] See Hooper et al (2008 p 43-44).

[3] See appendix for further details on the two surveys. Note that the UK financial year runs from April to March of the following year.

[4] Veruete-McKay et al (2010) used information from the MCS and CPS to derive two alternative estimates for content traffic data for social, commercial (mainly transactional) and direct mail traffic. They refer to the two different traffic estimates as those obtained using Method 1 and Method 2. Method 1 was based primarily on information available from the MCS and then used the CPS to complete the data set where data were not available from the MCS (for example, on access). In contrast, Method 2 primarily focused on information available from the CPS and then used information available from the MCS to complete the data set where data were not available from the CPS (for example, business-to-business segments).

[5] Royal Mail data on addressed inland letter traffic covers both Royal Mail traffic that is delivered end-to-end and access traffic that is handled by competitors who give this mail back to Royal Mail to deliver. There is a small amount

of addressed inland letter traffic that is not included in the surveys but it is deemed to be too small to materially affect our results.

[6] The 10 sender-receiver segments that the MCS provides information on (as shown in Table 1) are: 4 for social mail (P2P, P2B, B2P, B2B); 2 for direct mail (B2P, B2B); 4 for commercial mail (P2P, P2B, B2C, B2B).

[7] The 8 categories of mail that the CPS provides information on (as shown in Table 1) are: 2 for social mail sent by persons (P2P, P2B); 1 for direct mail ((B2P); 3 for commercial mail (P2P, P2B, B2P); and 2 for access mail (direct mail B2P and commercial B2P).

[8] In particular, changes in MCS content shares were linked to the 2002/03 maximum likelihood estimated content shares to derive time series data going back to 1980/81.

[9] The model was estimated using EVIEWS5.

[10] More general specifications including lags and leads were tested using dynamic OLS estimation methods suggested by Saikkonen (1991) and popularised by Stock and Watson (1993). However, specifications including no leads and no lags were preferred on the basis of statistical criteria.

[11] Where real prices in the paper refer to nominal prices deflated by the all items retail prices index.

[12] The data on Internet advertising expenditure are consistent with the data sources and definitions contained in WARC (2008).

[13] All the diagnostic tests are passed at the 5% level of significance. However, it should be noted that the Heteroskedasticity and Ramsey Reset tests are strictly not valid when I (1) variables (such as economic activity) are included in regression models of this type (see Gerrard and Godfrey, 1998). In addition to the Chow forecast test for parameter stability, CUSUMQ and CUSUMQ Squared tests were also undertaken and they did not indicate any clear evidence of parameter instability.

[14] The estimated direct mail price elasticity in Veruete-McKay et al (2010) using Method 1 (which primarily used information from the MCS) was -1.4 and that using Method 2 (which primarily used information from the CPS) was -0.7.

[15] The sensitivities for estimating content traffic data followed the same methodology as that outlined in section 2 except that the sample sizes used to combine the two surveys were amended to reflect the desired weights.

[16] A number of time trends were tested around this time period. The adoption of the 2002/03 and 2003/04 time trends were informed by the Akaike information criterion (AIC) and the Schwarz criterion (SC).

[17] This estimate is consistent with results reported in Soteri et al (2009).

[18] Note that the figure of around -2% per annum is derived from a weighted average of the illustrative example projections for social letter communications (-3%), commercial (mainly transactional) letter traffic (0%) and direct mail (-6%).

[19] The e-substitution impact of 9% per annum is based only on the impact of the share of Internet advertising variable. If the time trend variable in the direct mail equation is also considered to be a proxy for e-substitution this would add a further negative impact of around 2% per annum. However, if the direct mail time trend impact to some extent reflects factors relating to the slow down in direct mail growth from 1997 onwards due to market saturation factors, it can be argued that this should not be fully considered to be an e-substitution impact.

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APPENDIX: ROYAL MAIL SURVEY DATA

Information on the contents of Royal Mail letter traffic is available from two different surveys: the Mail Characteristics Survey (MCS) and the Consumer Panel Survey (CPS).

The MCS is a random unclustered survey of around 0.7 million consumers and businesses. This survey attaches a questionnaire card to randomly selected envelopes and has a response rate of around one in six. Data collection takes place at all mail centres (MC) and distribution centres (DC). This means that end to end (E2E) mail traffic is covered in the MCS, with the exception of products such as Response Mail, Special Delivery and Cleanmail Advance (3% of total E2E mail in 2007/08). However, the MCS

excludes information on downstream access volumes. Traffic data by type of contents is available from 1980/81 from the MCS. Also this survey records up to five different detailed content types for a specific envelope and allocated a prioritisation routine to identify the "primary" content. This eliminates double counting of contents within the envelope.

The CPS is a weekly survey diary and covers a panel of around 1,000 households with a national representation. This survey is weighted by socioeconomic group, household size and age. The weights are updated every two years. The CPS has the important feature that provides some information on downstream access traffic. However, it does not capture information on business-to-business traffic.

Since neither of the two surveys is fully comprehensive of total letter traffic, information from both was used to derive letter content time series data for addressed inland mail volumes. Traffic data by content types (and disaggregated by flows of senders and receivers) from the MCS and CPS on a financial year basis from 2002/03 to 2007/08 were used to estimate shares of content types of total inland addressed traffic. Due to the longer time span of data available from the MCS its content category definitions were adopted to derive content shares for total UK letter traffic.

LETTER TRAFFIC DEMAND IN THE UK: AN ANALYSIS BY PRODUCT AND ENVELOPE CONTENT TYPE*

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1. INTRODUCTION AND BACKGROUND

Addressed inland letter traffic volumes in the UK have been in decline for a number of years. Until around 2002 UK mail volumes tended to move in line with economic and demographic growth[1]. Since then, however, first growth rates and then mail volumes have declined despite the UK economy exhibiting robust rates of economic growth until 2007. The sharp contraction in economic activity after 2008 exacerbated this decline. The extent to which letter traffic volumes are likely to continue to decline and the degree to which this may be offset by an improvement in the economic environment or factors within postal operators' control (such as prices and quality of service), are important questions facing postal policy makers.

In order to better inform evidence based analysis of the postal industry in the UK this paper uses econometric time series techniques to shed light on the main drivers of letter demand. In particular, the paper updates the Nankervis et al. (2002) study of the demand for letters disaggregated by high level product streams and also provides new insights to the literature by examining the demand for UK letters by analysing trends in the content of mail envelopes.

The impact on letter volumes from developments related to the economy, electronic substitution and price changes are likely to vary across different postal service products and types of mail. This paper identifies and provides quantitative estimates of the key factors that influence the demand for letters in the UK using two data sets. The first analyses the demand for total letter traffic volumes using information on three Royal Mail Group product streams (First Class non-presort, Second Class non-presort and Other (mainly presort) traffic). The second examines the demand for letters by three content types (social, commercial (mainly transactional) and direct mail).

There is a long tradition of modelling letter traffic demand using time series data. Previous studies in the UK, France and Finland have concentrated on total letter demand or the demand for services differentiated by their expected time of delivery (First and Second Class services) or single piece versus bulk mail services[2]. In the

* The analysis contained in this chapter reflects the views of the authors and not necessarily those of Royal Mail Group.

[1] The analysis in this paper refers solely to addressed inland mail volumes and does not consider developments in unaddressed mail volumes.

[2] See Boldron et al. (2010), Florens et al. (2002), Nankervis et al. (2002), Nikali (2001, 2008), and Soteri et al. (2009)

USA much of the differentiation in mail is by content type and single piece versus bulk or "worksharing" specifications[3]. The current study, by utilising two segmentations of the same traffic data series, provides updated estimates of UK demand elasticities for products differentiated by service specification and also, for the first time, demand elasticities by letter content.

Section 2 describes the time series data for the product and content traffic streams used to model the demand for letters in the UK. Section 3 sets out the estimation methodology and reports the results of the modelling of letter product streams. Section 4 reports the results of modelling letter demand by content type. Section 5 compares the two sets of results and highlights new insights into the demand for UK letter demand using this dual data lens approach. Finally, section 6 provides a summary and conclusions.

2. ADDRESSED INLAND LETTER TRAFFIC TRENDS IN THE UK

Using data from 1976Q4 to 1999Q1, Nankervis et al. (2002) modelled the demand for UK addressed inland letter traffic as a function of economic activity, the number of households, prices, quality of service and time trends, the latter variables requiring interpretation to identify possible developments, for example, in electronic substitution. Two notable features of the results of this study were: firstly, the total traffic unit long run elasticities for the number of households and economic activity; and secondly a low total traffic price elasticity underpinned by larger own and cross price letter product elasticities reflecting substitution between the product streams.

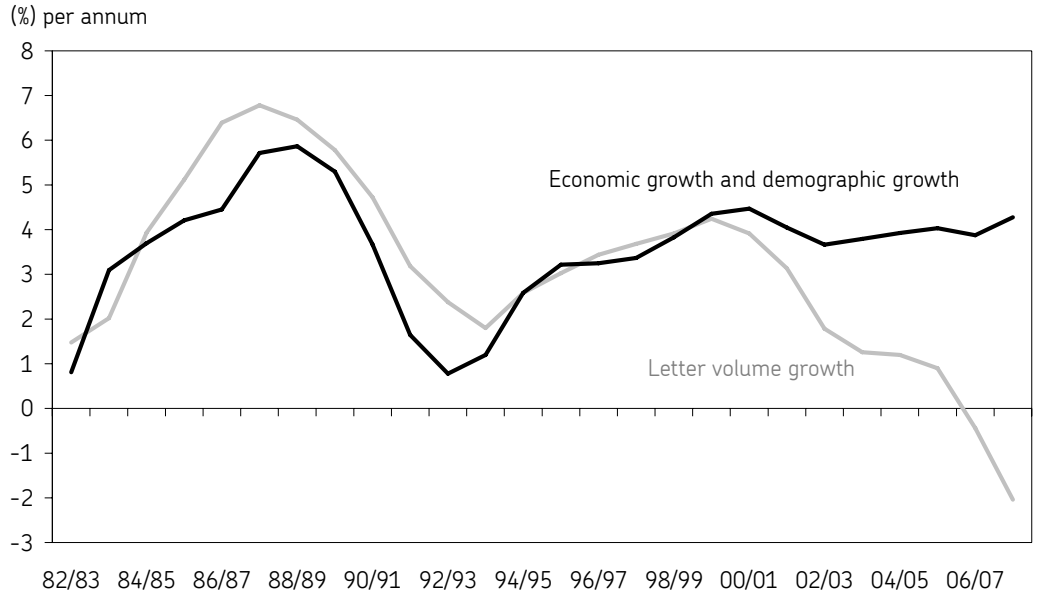
Figure 1 displays a time series for UK total addressed inland letter traffic growth. This shows that historically addressed inland letter traffic in the UK has tended to move in line with the economy and demographic trends. It should be noted that while Nankervis et al. (2002) found other factors, such as mail prices and the price of substitute products to have statistically significant effects on UK mail volumes, their impact on letter volumes have historically been of relatively less importance. However, after around 2002 this pattern no longer appears to have held. This has led to a debate amongst postal administrations and by postal regulators and policy makers as to whether a relationship with economic activity and demographic trends continues to exist or, alternatively, whether this relationship has become more complex and multi-dimensional in nature and so more difficult to detect using simple graphics.

The communication industry is changing rapidly in response to technological advances. The increasing speed and declining cost of electronic forms of communication is leading to the replacement of paper based communications. But to what extent is this driving down mail volumes and what type of mail will be affected to a greater or lesser degree? Furthermore, from a business and policy perspective, are there factors within the control of postal operators and policy

[3] See Thress (2006).

makers to counter such substitution? This paper uses time series econometric techniques to shed some light on these questions.

Figure 1: UK Addressed Inland Mail Traffic Trends Versus Economic and Demographic Growth Trends, 1982/83 to 2007/08



Source: Data from National Statistics, Experian, Royal Mail Group.

Note: (1) Letter traffic growth rates adjusted for number of working days. (2) Economic growth refers to gross domestic product (GDP) growth weighted by letter demand. (3) Data in chart refer to three year moving averages.

Following Nankervis et al. (2002) the current paper models the demand for total addressed inland letter traffic by traffic streams. In particular, total Royal Mail delivered traffic data is disaggregated into three high level product categories of mail: First Class non-presort mail; Second Class non-presort mail; and Other (mainly presort traffic)[4]. These three streams of traffic also broadly align to those used in previous UK econometric studies[5]. The main difference between the definition of product streams in this paper and previous studies relates to the treatment of downstream access volumes. For example, in the data set used in Soteri et al. (2009) access volumes in 2004/05 were negligible and in 2005/06, the final year of the time series, accounted for only 6% of total addressed inland letter traffic. This small amount of access traffic was assumed to have almost all switched from Royal Mail's bulk end-to-end products and therefore included in the Other (mainly presort) category.

[4] The First and Second Class non-presort traffic streams have a next working day and within three working days delivery specification respectively. They include the following single-piece priced addressed inland Royal Mail products: Stamp, Meter, PPI, Cleanmail and estimates for non customer presorted downstream access traffic. Other (mainly presort) traffic includes the following addressed inland Royal Mail products: Mailsort, Walksort, Packetpost, Presstream, Response Services, USO Parcels, Large Mail Order Returns (LMOR), Tracked, Heavyweight and estimates for customer presorted downstream access traffic.

[5] See Nankervis et al. (2002), Cazals et al. (2008) and Soteri et al. (2009).

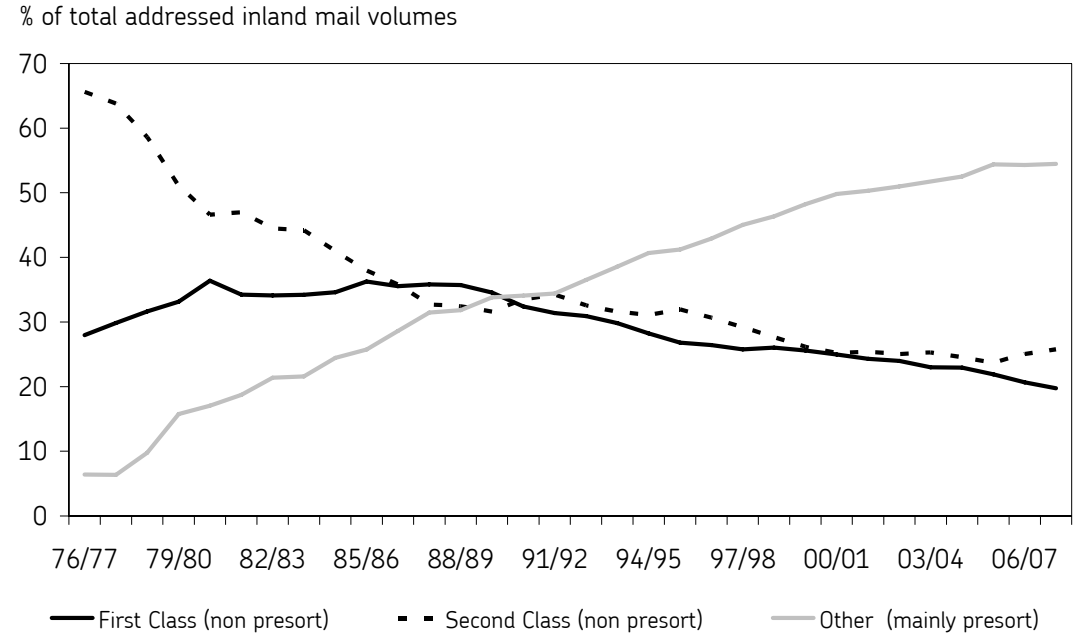
The data period used to undertake the econometric analysis in the current study extends to 2008Q1 and covers UK data up to and including the UK financial year 2007/08. Downstream access volumes delivered by Royal Mail amounted to over 4bn items and accounted for around one-fifth of total letter traffic in 2007/08. Ideally, it would have been better to model access traffic as a separate traffic stream. However, while competition in the UK mail market is still evolving and the number of time series data points for access are limited (only 16 quarterly data points were available up to 2008Q1), it is not possible to estimate a robust econometric time series model for access traffic.

The methodology adopted to handle access traffic in this paper was to include access traffic that mail senders presort prior to handing it to a Royal Mail competitor (or in some cases handed directly to Royal Mail to deliver[6]) in the Other (mainly presort) category, and traffic that is not presorted in the non-presort categories. Estimates by Royal Mail were used to quantify the non-presort and presort categorisation of access traffic. In these estimates a negligible quantity of First Class mail senders had switched to downstream access; a considerable proportion of presorted volumes had switched to access traffic (the vast majority of which is estimated to originate from the Royal Mail Mailsort product range); and a considerably smaller proportion of Second Class non-presort volumes had switched to access[7]. This approach is consistent with using external information to better inform the econometric modelling and is consistent with the approach to updating model parameter estimates in Fève et al. (2010).

Figure 2 shows that there has been a long-term trend away from using both First and Second Class non-bulk letter services towards using bulk presorted services. Proportionately, discounts earned for presorting mail remained broadly unchanged for much of the period reported in figure 2. Following the introduction of work-sharing discounts in the UK in the late 1970s and more extensively in the 1980s, the migration of non-presort traffic would, in general, have reflected one-off changes in relative prices. The main beneficiaries of these services in the early years would have been very large mailers. However, over time smaller scale senders will also have benefited as a result of advances in technology that have lowered the cost of presorting letters.

[6] A number of customers have access contracts directly with Royal Mail ("customer direct access").
[7] In particular, it is estimated that almost all access traffic in 2004/05 and 2005/06 was presorted traffic. For 2006/07 this figure was estimated to be over 80% and in 2007/08 around 80%.

Figure 2: Addressed Inland Letter Volume Product Category Shares, 1976/77 to 2007/08



Source Royal Mail Group

being felt from the late 1980s onwards when fax, and then email and internet usage, developed. Conversely, presort traffic levels should have benefited initially from switching from public tariff services, but, over time, this benefit should have dissipated as the relative magnitude of non-presort traffic declined. In addition, advances in technology which helped to reduce the cost of acquiring and interrogating marketing databases for direct mail campaigns in the 1980s initially boosted bulk letter volumes. However, two decades later, advances in technology have created an alternative and relatively lower cost direct marketing medium in the form of internet "paid-for-search" advertising[8] that is competing with direct mail letter communications and other advertising media for business advertising budgets[9].

In order to obtain further insights into the demand drivers for addressed inland letter traffic, and, in particular, factors underpinning the impact of esubstitution, an examination of letter volume trends by content type was also undertaken. The absence of sales data by content type led to the use instead of two Royal Mail surveys: the Mail Characteristics Survey (MCS) and the Consumer Panel Survey (CPS). However, neither of these sources provided a fully comprehensive survey of total letter traffic and information from both was required to derive time series data for addressed inland mail. In particular, although available from 1980/81 the MCS did not cover the recent development of access traffic and the CPS was available only from 1998/99 and did not cover business-to-business (B2B) mail.

[8] That is, adverts triggered by key "searchwords".
[9] See Soteri et al. (2009).

Given the information gaps of both surveys, two data methods were adopted to derive estimates of content based traffic volumes. Data method 1 focussed firstly on the MCS and used the CPS to inform elements of traffic not covered by the MCS. In contrast, data method 2 started with the CPS and used the MCS to inform gaps in its survey coverage. Given the shorter time period for which CPS content data was available, it was not possible to use method 2 alone to derive content time series that are long enough to undertake robust time series econometrics. However, a continuous time series data set going back to 1980/81 was derived by splicing this data series to MCS content share estimates.

The estimated shares of addressed inland letter traffic by content type using the two data methods yielded broadly similar results. For example, in 2007/08 both methodologies estimate that: direct mail accounted for around 20% of total letter traffic; commercial mail for a little over 70%; and social mail for between 6% and 8%. Figure 3 shows the estimated content volume annual growth rates per working day for the period 1981/82 to 2007/08. Note that, prior to 2001/02 data method 2 used the method 1 share estimates to derive long run time series data (as outlined above) and therefore the annual growth rates reported in figure 3 prior to this time period are almost identical.

In terms of directional trends, figure 3 shows that for commercial mail both data methods estimated rates of growth were negative after 2005/06. Prior to then, commercial mail volumes grew strongly in the mid 1980s, and between 1982/83 to 1989/90 averaged around 5%. It is clear that commercial traffic volumes have been somewhat cyclical, as the low or negative growth rates in the early 1980s, 1990s and 2000s show. Both data methods estimated that social letter volume growth rates were mainly negative from around 2002/03 onwards. Data method 2 suggests a more accentuated decline in the social mail volume trend during the period between 2003/04 and 2007/08 in comparison to data method 1. However, this is more likely to be related to changes in the definition of social traffic in the CPS than changes in the actual trend of social mail volumes. By contrast, during the early 1980s, social mail volumes grew on average by around 2% annually and then declined, but fluctuated considerably, in the early 1990s. Subsequently, social mail volumes tended to display mainly positive rates of growth, until around 2002/03.

Figure 3: Mail Volume Growth Rates by Content Type Using Data Method 1 and 2, 1981/82 to 2007/08

Note: Data refers to year-on-year growth rates in UK Financial years (FY) adjusted for the number of working days. For example, UK FY 2007/08 refers to the data period April 2007 to March 2008.

In the case of direct mail traffic, figure 3 shows that both data methods estimated that the trend rate of volume growth slowed down from around 2000/01 onwards. Furthermore, both data methods indicated that direct mail volumes exhibited considerable declines in individual years from 2003/04 onwards. However, it should be noted, that while some clear changes in the direct mail letter content trend can be discerned from the two time series data, there is considerable variation in individual year-on-year growth rates. This is to be expected, given the reliance on survey data, which contains elements of sampling error, random noise and differences in the nature of the surveys themselves. The large difference between the method 1 and 2 direct mail growth rates in 2006/07 is likely to be due to such factors. For example, method 1 suggests that direct mail increased in 2006/07 by around 10% while Method 2 suggested a decline of around 5%. Direct mail volume growth appears to be highly cyclical and its trend rate of growth has declined over time. For example, direct mail volumes increased by double digit growth rates during the 1980s when the UK economy was growing strongly and direct mail was a relatively new advertising medium. But it exhibited a sharp contraction around the time of the recession of the early 1990s. As the economy recovered from this, so did the demand for direct mail but the rate of growth was somewhat lower than in the previous decade.

The time series data for volume trends by content type suggest a number of important points should be borne in mind when using and interpreting content volume data. Three points to note in particular are: survey data can be used to derive reasonable estimates of the magnitude of the relative share of letter traffic by content type; high level trend estimates of content shares can be used to derive time series estimates of content volumes, and there is some statistical noise associated with content traffic growth rates in individual years.

3. AN ECONOMETRIC ANALYSIS OF UK LETTER TRAFFIC DEMAND USING ROYAL MAIL DELIVERED PRODUCT DATA

3.1 Estimation methodology

The modelling of demand for addressed inland letter traffic volumes by product stream in the current study followed a similar estimation methodology to Nankervis et al. (2002). In summary, the modelling comprised of three relationships, one for each of the following product categories: First Class non-presort traffic; Second Class non-presort traffic; and Other (mainly presort) traffic[10]. The demand relationships were estimated using single equation econometric time series error correction models and the long run coefficients entering the error correction models for each of the three traffic streams were estimated using Dynamic OLS (DOLS) models of the following form[11]:

$$q_{it} = A_i^{'} D_{it} + \Pi_i^{'} x_{it}^{I} + \sum_{k=-m_i}^{k=m_i} C_{ik}^{'} \Delta x_{i,t-k}^{I} + \sum_{k=0}^{k=m_i} F_{ik}^{'} x_{i,t-1-k}^{0} + \eta_{it} \qquad (1)$$

where lower case letters for Q_{it} and X_{it} denote logarithms of variables in time period t. X^{I}_{it} is a subset of X_{it} variables integrated of order 1 (that is, are I(1)) and X^{0}_{it} is a subset of X_{it} variables integrated of order 0 (that is, are I(0))[12]. The Δ is the difference operator (e.g. $\Delta x_{it} = x_{it} - x_{it-1}$). The variable Q_i denotes the volume of traffic per working day for stream i (i=1,2,3); where i=1 refers to First Class non-presort traffic; i=2 to Second Class non-presort; i=3 to Other (mainly presort) traffic. The variable X_{it} denotes a vector of explanatory variables corresponding to each traffic stream i. The vector of explanatory variables X_{it} included the number of households (H), economic activity weighted by letter demand (Y), real letter tariff price indices for product i (P_i), the quality of letter service delivery (QoS), the real price of traditional non-mail advertising media substitutes (PA) and the proportion of internet advertising expenditure relative to total advertising expenditure (PIA). Also, initially included in X_i were a number of variables linked to technology trends, such as the proportion of households with access to the internet and broadband

[10] The model was estimated using the econometric package EVIEWS5.

[11] See Stock and Watson (1993) and Saikkonen (1991).

[12] In particular, X^0 contains real mail tariff price indices (that is mail prices deflated by the UK Retail Prices Index) which were estimated to be I(0) around a trend. Since mail prices in the UK have been subject to an RPI-X price control formula since 2003 and previous to this prices were periodically updated broadly in line with inflationary pressures, it is perhaps not surprising that the mail tariff indices deflated by the RPI were found to be I(0).

and real telecommunication prices. D_{it} is a vector of deterministic variables which includes a constant, seasonal dummies and a number of time trends. Π_i is a vector of long-run coefficients where A_i, C_{ik} and F_{ik} are vectors of coefficients for each of the product sub-models and η_{it} is a random disturbance term.

The time series nature of the Q_i variables and most of the variables included in X_i exhibit non-stationarity and a single cointegrating vector was found to exist for each of the three DOLS models estimated using (1). The values of m_i were chosen on the basis of statistical information criteria[13]. The resulting estimators for the long-run coefficients Π are therefore said to be superconsistent and these estimates were incorporated into general error correction models for each of the three broad product categories. The individual product models were then estimated using a general to specific product modelling methodology, where the general error correction models were of the following form:

$$\Delta q_{it} = \alpha_i' D_{it} + \theta_i(q_{i,t-1} - \hat{\Pi}_i' x^I_{i,t-1}) + \lambda_i x^0_{i,t-1} + \sum_{k=1}^{n_i} \theta_{ik} \Delta q_{i,t-k} + \sum_{k=0}^{n_i} \varphi_{ik} \Delta x^I_{i,t-k} + \varepsilon_{it} \quad (2)$$

where α, θ, λ and Φ are coefficients and lower case variables are in natural logarithmic form.

3.2 Addressed inland letter traffic model by product stream: econometric estimates

The estimated equations for the addressed inland letter traffic model by broad product stream (ILTMP), after deleting insignificant variables and setting the long run elasticities for the number of households to unity[14], are reported in table 1. The estimated parameters have reasonably high t-statistics and the reported diagnostic tests suggest that the ILTMP is statistically sound[15]. Furthermore, the error correction terms, which include I(1) variables, have high t-statistics in each of the three models from which it is concluded that these variables cointegrate[16]. This conclusion is also supported by Johansen cointegration tests.

[13] In particular, Akaike's Information Criterion (AIC) and Schwarz's Bayesian Criterion (SBC).

[14] A unit long-run elasticity hypothesis could not be rejected.

[15] In addition, plots of the recursive estimates of the coefficients of key variables in each of the product sub-models and cusum and cusum-squared tests suggest that the estimated coefficients in ILTMP are relatively stable and do not exhibit parameter instability. These tests, along with the Chow tests for predictive failure reported in table 1 indicate that parameter values are relatively stable and the estimated coefficients in ILTMP are statistically robust.

[16] See Ericsson and MacKinnon (2002).

Table 1. Addressed Inland Letter Traffic Model by Product Stream: (ILTMP)

Estimated Coefficients and Diagnostic Tests

First Class [a]			**Second Class** [a]			**Other class** [a]		
Dependent variable $\Delta(q_{1t}-h_t)$			Dependent variable $\Delta(q_{2t}-h_t)$			Dependent variable $\Delta(q_{3t}-h_t)$		
Estimation method least squares			Estimation method least squares			Estimation method least squares		
	Estimated coefficients	**T-value**		**Estimated coefficients**	**T-value**		**Estimated coefficients**	**T-value**
$ECT1_{t-1}$*	-0.30	-4.7	$ECT2_{t-1}$*	-0.49	-8.2	$ECT3_{t-1}$*	-0.87	-8.9
T87 [b]	-0.003	-3.8	T75 [b]	-0.007	-7.7	pia_{t-1}	-1.52	-6.4
T02 [b]	-0.005	-4.3	T87 [b]	0.004	6.3	T83 [b]	0.011	8.9
p_{1t-1}	-0.23	-2.7	p_{1t-1} [c]	0.15		T97 [b]	-0.010	-7.6
p_{2t-1}	0.10	1.9	p_{2t-1} [c]	-0.15				
			qos_{t-1}	0.25	4.3			
Δy_t	0.91	2.4	Δyt	1.03	2.8	Δyt	1.06	2.0
			Δqos_t	0.22	5.0			
Rsq adjusted	0.83		Rsq adjusted	0.94		Rsq adjusted	0.80	
Reg. SE	0.030		Reg. SE	0.032		Reg. SE	0.031	
Durbin Watson	2.1		Durbin Watson	2.2		Durbin Watson	2.1	
Estimation Period 1975 Q4 - 2008 Q1			Estimation Period 1975 Q3 - 2008 Q1			Estimation Period 1983 Q1 - 2008 Q1		
* ECT1 = $q_{1t} - h_t - 1.65y_t$			* ECT2 = $q_{2t} - h_t - 0.65y_t$			* ECT3= $q_{3t} - h_t - 1.10y_t - 0.44(pa_t - p_{3t})$		
Diagnostic Tests [d]			**Diagnostic Tests** [d]			**Diagnostic Tests** [d]		
	P values			**P values**			**P values**	
Serial correlation	0.28		Serial correlation	0.33		Serial correlation	0.24	
Heteroskedasticity	0.89		Heteroskedasticity	0.08		Heteroskedasticity	0.35	
Normality	0.45		Normality	0.81		Normality	0.38	
Reset	0.32		Reset	0.80		Reset	0.69	
Chow	0.41		Chow	0.88		Chow	0.06	

(a) The estimated models also included deterministic variables such as constant, seasonal dummy and time trends, which were statistically significant at the 5% level.

(b) Refers to a time trend variable starting in the first calendar quarter of the year referred to after the term T.For example, T87 refers to a time trend variable equal to to: 1 in 1987 Q1, 2 in 1987 Q2; ... & 85 in 2008 Q1 and equal to zero for all other quarters.

(c) The Slutsky-Schultz symmetry constraint between First and Second Class traffic was tested using a simultaneous cross equation Wald-test restriction. The Wald test statistic indicated that this restriction was statistically valid and imposed in the model. In addition, the own and cross price elasticities in the Second Class equation were tested to be equal and opposite in magnitude. Again this restriction could not be rejected via statistical tests and was imposed in the model.

(d) The reported diagnostic tests refer to the estimated models prior to the imposition of the cross equation restrictions between First and Second Class models noted in (a):

The Serial Correlation test is a Lagrange multiplier (LM) test of up to 4th order autocorrelation.

The Normality test is based on a test of skewness and kurtosis of residuals.

The Heteroskedasticity is based on the regression of squared residuals on fitted values.

The Reset test used one fitted term

The predictive failure test is Chow 's test with a breakpoint set at 2005Q2

The econometric results reported in table 1 were used to derive the estimated long run elasticities and time trend effects reported in table 2 for ILTMP [17]. The long run elasticities for total addressed inland letter traffic volumes were calculated by aggregating each of the three product stream long run parameters by their respective share of total traffic[18]. The magnitudes of the estimated long run elasticities are, in general, broadly consistent with the results reported in Nankervis

[17] For variables contained in the error correction term the long run elasticities are their imposed coefficients multiplied by -1. For variables not contained in the error correction term, their long run estimated coefficients are obtained by dividing a particular variables' regression coefficient by the error correction term contained within the same regression and then multiplying by -1. In order to express the long run time trend impacts from the quarterly model in percentage terms per annum, their estimated coefficients have been multiplied by 400.

[18] The parameters for total traffic were obtained by weighting each of the individual product stream parameter estimates by their volume weights in 2007/08.

et al. (2002) despite extending the estimation period to include an additional 36 quarters of data.

Table 2: Addressed Inland Letter Traffic per Household Product Model (ILTMP): Long Run Elasticities and Time Trend Impacts

	Long-Run Elasticities ILTMP			
	Total traffic[1]	First Class non-presort	Second Class non-presort	Other traffic (mainly presort)
Economic activity (Y)	1.09	1.65	0.65	1.10
First Class non-presort price[2] (P_1)	-0.07	-0.77	0.31	ns
Second Class non-presort price[2] (P_2)	-0.01	0.33	-0.31	ns
Other (mainly presort) price[2] (P_3)	-0.24	ns	ns	-0.44
Quality of Service[3]	0.13	ns	0.52	ns
Price of non-mail advertising[2] (PA)	0.24	ns	ns	0.44
Proportion of internet advertising spend (PIA)	-0.95	na	na	-1.75
Net impact of "unexplained" time trends (% p.a.)[4]	1987-2001 0.7%	1987-2002 -3.8%	1975-1987 -5.4%	1983-1997 5.2%
	Post 2002 -2.4%	Post 2002 -10.9%	Post 1987 -2.5%	Post 1997 0.7%

Note:
1. Total traffic estimated elasticities and time trend effects were calculated by weighting the estimated coefficients in each of the traffic streams by their by their respective traffic volume share in 2007/08.
2. Deflated by the all items Retail Prices Index
3. Refers to Royal Mail First Class quality of service for Stamp and Meter traffic
4. Estimates refer to the total long run impact of the time trends reported in table 1. For example, the First Class post 2002 impact refers to the combined impact of the long-run estimates related to T87 and T02.
na denotes not applicable
ns denotes not statistically significant at 5% level

Similarly, the addition of a further eight quarters of data to the Other traffic model produced results that were similar to Soteri et al. (2009). The elasticity of demand for total letter traffic with respect to economic activity is again estimated to be close to unity and again varies considerably across streams. In particular, similar to previous results, First Class non-presort traffic is estimated to have a relatively high long run economic activity elasticity of around 1.7 while the estimate for Other (mainly presort) traffic is a little over unity and, again, economic activity is estimated to have the weakest impact on Second Class non-presort letter traffic.

The estimated impact of First and Second Class prices on mail volumes exhibits similar properties to those reported in Nankervis et al. (2002). In particular, the results suggest that First Class non-presort traffic has a relatively high own price long run elasticity of around -0.8 and a cross price elasticity with respect to Second Class traffic of around 0.3. Since the respective shares of these traffic streams is broadly equal, these results suggest that a 1% rise in the price of First Class would lead to a loss in First Class traffic of about 0.8%, of which 0.3% would switch to Second Class traffic, implying that the overall loss to First Class traffic would be about 0.5%. The estimated long run own price elasticity for Second Class traffic is lower than that for First Class, but in this case it is estimated that all this traffic would switch to the First Class stream and the net loss in First and Second Class traffic jointly would be close to zero. Note that a simultaneous equal percentage

increase in First and Second Class prices would imply that these switching effects would largely cancel each other out and yield an overall long run price elasticity for First and Second Class traffic jointly of about -0.2.

The estimated long run price elasticity for Other (mainly presort) traffic is around -0.4. There are no cross-price elasticities estimated for this stream and hence this represents the overall impact on the demand for Other (mainly presort) traffic of changing prices[19]. However, note that it is the price of Other (mainly presort) mail relative to the price of competing modes of advertising that matters (in particular, publishing and TV media) rather than letter prices alone.

The estimated long run quality of service (QoS) elasticity for total letter demand was estimated to be about 0.1. Note that the impact of QoS is found only to be statistically significant in the Second Class stream. This is consistent with an interpretation of "trading up". That is, movements in First Class and Second Class QoS tend to be highly correlated. Hence declines in First Class QoS (and hence of Second Class as well) reduce Second Class mail volumes as some mailers trade up to First Class services to lower the overall effect on them of declining performance. At the same time, some First class traffic is lost in response to the decline in First Class QoS so that the net impact is that the overall decline in mail volumes is accompanied by First Class volumes remaining more or less unchanged but Second Class volumes falling.

The impact of the time trends are perhaps best considered as primarily reflecting the impacts of technology on the demand for mail. The effect of technology on the erosion of mail volumes was explored in a number of ways. For example, model specifications including the proportion of households with internet and broadband access yielded broadly similar results to those reported in table 2. However, statistical criteria (for example, diagnostic test statistics, AIC and SBC information criteria and the standard error of regression) preferred models with time trend break terms. This could reflect the fact that changes in technology are dynamic in nature and unlikely to be reflected within the properties of a single variable or group of variables. For example, it could be the case that, potentially, time trend terms may be a better proxy for the combined and evolving impacts of different technologies, which individually can be modelled as being logistic in their effect on the demand for mail, but over time cumulate to yield "corrugated S-shaped"

[19] The estimated coefficients for the First and Second Class tariff indices were found to be not statistically significant different from zero in the Other traffic equation. The absence of a statistically significant estimated coefficient with respect to First Class prices is likely to reflect a genuine lack of direct substitution between First Class non-presort mail and Other mainly presort traffic. However, in the case of substitution with respect to Second Class mail this is less clear. The large majority of Other traffic is related directly, or indirectly, via discounts to the price of products contained in the Second Class category. Hence, it is not clear whether the lack of statistically significant terms is due to the absence of a relationship or due to the non-identification of a statistically significant coefficient arising from the correlation of the Second Class and Other (mainly presort) price indices.

impacts[20] that are better reflected by time trend terms and/ or time trend break terms[21].

The time trend in the First Class traffic stream reported in table 2 suggests that from around 1987 factors other than those explicitly contained in the model reduced First Class traffic volumes by around 4% per annum, consistent with key developments in communication technology. The negative time trend effect from the late 1980s coincides with the widespread adoption of fax machines, the introduction of bill payments by direct debit and the development of electronic communication and ebusiness services in the 1990s. Furthermore, the increasingly negative trend term after 2002 is consistent with the rapid increase in internet and other electronic technologies substituting for traditional mail communications to the scale of around 11% per annum of the First Class stream.

The net impact of the 'unexplained' time trend in the Second Class model has been to reduce Second Class traffic volumes, although the extent of this reduction has slowed down from 5% per annum up to 1987 to a decline of 3% per annum thereafter. The key driving force accounting for the earlier trend is likely to have been the offering of worksharing discounts and advances in technology over time that have reduced the cost of switching from Second Class non-presort products into Other (mainly presort) mail products. The decline in the negative time trend impact to 3% per annum after 1987 suggests that the pace of such switching slowed and/ or esubstitution effects developed. It is likely that both factors have been at work over this long period but their relative magnitude is uncertain.

In contrast to the First and Second class time trends, the net impact of the time trend variable on Other (mainly presort) traffic has been positive throughout the sample period. Two key factors that are likely to have driven this are the impact of switching from Second Class, as discussed above, and until fairly recently high rates of growth in direct mail traffic. The results reported in table 2 suggest that up to 1997 the time trend impacts accounted for about 5% of growth in presort volumes per annum over and above other factors in the presort model (that is, economic activity, letter prices and non-mail advertising prices) but after 1997 this slowed to less than 1% per annum. The slowdown in the presort time trend is consistent with the rapid advance of electronic billing and banking services which relate to non-direct mail bulk services. However, it is also consistent with a slow down in the Second Class time trend effect, as, over time, the volume of Second Class non-presort traffic switching into the Other (mainly presort) traffic stream must eventually decline as a proportion of the latter.

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[20] See Nikali (2008).

[21] The technology variables tested in the econometric modelling included measures of the number of connections and subscribers to the internet in the UK; the index of broadband internet. connections in the UK; the proportion of adults with access to electronic banking; and the proportion of UK households with access to the internet.

The internet advertising variable (PIA) included in the model can also be considered to be reflecting the impact of substitution on Other traffic volumes. In particular, as noted in section 2, advertising budgets have been increasingly moving online and in particular towards "paid-for-search" advertising[22]. The impact of this variable is estimated to have a statistically significant and large negative effect on Other (mainly presort) traffic mail volumes. Over the three year period 2005/06 to 2007/08 the rapid growth in internet advertising expenditure is estimated to have reduced this stream by almost 7% per annum[23]. If the impact of esubstitution in the Other traffic model is assumed to be approximately equal to the sum of the impacts of the estimated time trends and the proportion of internet advertising, then esubstitution is estimated to have been reducing Other traffic volumes by around 6% per annum. This suggests that similar to the results in Soteri et al. (2009), technology developments in alternative media communications (in particular, the internet) have been exerting substantial downward pressure on bulk mail traffic, and in particular direct mail advertising volumes[24]. However, it is not certain to what extent the internet advertising variable can be assessed to be impacting solely on direct mail if, as is likely to be the case, the profile of this variable is correlated with that for other technologies that are substituting for traditional letter mail.

4. AN ECONOMETRIC ANALYSIS OF UK LETTER TRAFFIC DEMAND BY CONTENT TYPE

4.1 Estimation methodology

To estimate the demand for letters by content type, a similar econometric methodology was used to that in the product model as specified in equation (1). The main difference to the product model estimation methodology was that the coefficients associated with lagged terms of the different explanatory variables corresponding to each traffic content type were statistically not significant. The use of annual data is likely to be a key reason for the absence of lagged terms. The estimated models were therefore of the following form:

$$q_{jt} = A_j^{'} D_{jt} + \Pi_j^{'} x_{jt} + \eta_{jt} \qquad (3)$$

The variable Q_j denotes the volume of traffic per working day for content j (j =1,2,3); where j=1 refers to social mail; j=2 refers to direct mail traffic and j=3 refers to commercial mail. As before, the X_j vector represents a vector of explanatory variables for each traffic content type j. One difference in the explanatory variables is the use of GDP instead of GVA sectors weighted by letter

[22] For example, WARC(2008) reports that in the five year period up to 2007 internet advertising expenditure is estimated to have increased fourteen fold to almost £3bn and account for around 17% of total UK advertising expenditure. Paid-for-search advertising refers to internet adverts triggered by key "searchwords".

[23] This is estimated by multiplying the average change in PIA over the period 2005/06 to 2007/08 (4 per cent per annum) by the long-run coefficient reported in table 2.

[24] See Soteri et al (2009).

demand to estimate the impacts of economic growth on content traffic volumes[25]. The estimates of the parameters in the vector Π_j provide direct estimates for the long run elasticities and parameters for traffic by content type and η_j is a random disturbance term.

4.2 Addressed inland letter traffic model by content type: econometric estimates

Table 3 reports the estimated long run elasticities and time trends for the addressed inland letter traffic model by content type (ILTMC) using data methods 1 and 2. As in the product model, the estimated long run elasticities and time trends for total addressed inland letter traffic volumes were calculated by weighting the long-run parameters for each of the three content types by their respective share of total traffic.

In the majority of cases the estimated parameters reported in table 3 have reasonably high t-statistics (reported in brackets). The only exception was the t-statistic for the estimated price elasticity for commercial mail which is statistically significant using a critical region of around 20%. Given the use of survey data in constructing the data series it is likely that a higher degree of noise is associated with individual parameter estimates and the usual 5% to 10% critical values for comparing t-statistics were relaxed in this case. Given the price variable was correctly signed, it was not deleted from the model. The same diagnostic tests reported for the product model in table 1 are reported for the content model in table 3. In general, similar to the product model, these diagnostic tests suggest the content model is also statistically sound[26]. One point to note with respect to the diagnostic tests is that although the Chow tests were, in general, passed using a significance level of 1%, the estimated content model parameters were less stable than those estimated for the product model. However, given the uncertainty and volatility surrounding the estimated traffic data by content type, this is to be expected.

The estimated models using the two data sets yield broadly similar results although with some exceptions. In particular, the estimated coefficients were very similar for economic activity, quality of service and telephone price impacts and commercial letter tariff prices. By contrast, the estimated coefficients for internet advertising, the time trend estimates and the direct mail price elasticity were somewhat different.

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[25] The generation of mail volumes by content type using survey data includes a high level of noise for individual year estimates. The benefits of using a letter demand sector weighted GVA variable to explain historic behaviour and project mail volumes into the future was therefore considered to be low relative to adopting GDP which is the standard and publicly available indicator of economic activity .

[26] However, it should be noted that the Heteroskedasticity and Ramsey Reset tests are strictly not valid when I(1) variables (such as economic activity) are included in regression models of this type (see Gerrard abd Godfrey, 1998).

Table 3: Addressed Inland Letter Traffic Per Household Content Model (ILTMC): Long Run Elasticities and Time Trend Impacts

	Social	Commercial	Direct	Total Traffic
Method 1 Data Set: Long-Run Elasticities ILTMC				
Economic activity[2] (Y')	ns	0.97 (7.5)	1.87 (4.1)	1.07
Tariff index own price[3] (P)	-0.43 (-3.7)	-0.19 (-1.2)	-1.35 (-2.8)	-0.44
Quality of service (QoS)	0.43 (5.5)	0.34 (5.4)	ns	0.28
Price of telecommunications index[3] (TP)	na	0.10 (2.0)	ns	0.07
Proportion of internet adv. Spend (PIA)	na	na	-1.79 (-4.6)	-0.36
Time trend estimates, %pa	ns	ns	Pre 1997 2.5% (2.5)	Pre 1997 0.5%
	Post 2003 -1.7% (-3.9)	Post 2002 -2.9% (-9.4)	Post 1997 -5.2% (-4.9)	Post 2003 -3.3%
Rsq adjusted	0.853	0.995	0.992	na
Reg. SE	0.027	0.014	0.025	na
DW	1.83	1.52	2.04	na
Diagnostic tests (p-values)				
Serial Correlation[4]	0.683	0.417	0.771	na
Heteroscedasticity[5]	0.322	0.291	0.039	na
Normality[6]	0.583	0.967	0.692	na
Reset[7]	0.105	0.545	0.633	na
Chow[8]	0.82	0.02	0.01	
Method 2 Data Set: Long-Run Elasticities ILTMC				
Economic activity (Y')	ns	0.96 (7.7)	2.04 (4.5)	1.11
Tariff index own price[3] (P)	-0.29 (-2.0)	-0.19 (-1.3)	-0.74 (-1.5)	-0.31
Quality of service (QoS)	0.49 (5.1)	0.36 (6.0)	ns	0.29
Price of telecommunications index[3] (TP)	na	0.12 (2.4)	ns	0.09
Proportion of internet adv. Spend (PIA)	na	na	-3.31 (-8.8)	-0.66
Time trend estimates, %pa	ns	ns	Pre 1997 1.5% (1.5)	Pre 1997 0.3%
	T 2003 -2.8% (-1.5)	T 2002 -1.7% (-6.3)	T 1997 -2.5% (-2.5)	Post 2003 -1.9%
Rsq adjusted	0.941	0.995	0.990	na
Reg. SE	0.032	0.014	0.025	na
Durbin Watson	1.57	1.65	2.25	na
Diagnostic tests (p-values)				
Serial Correlation[4]	0.308	0.544	0.563	na
Heteroscedasticity[5]	0.429	0.043	0.080	na
Normality[6]	0.474	0.768	0.886	na
Reset[7]	0.117	0.720	0.569	na
Chow[8]	0.02	0.26	0.34	

Note:
(1) T-statistics are reported in brackets. (2) Y' refers to Gross Domestic Product (GDP). (3) Deflated by the all items Retail Prices Index. (4) This is a Lagrange multiplier test for 1st order autocorrelation. (5) Refers to White's test for heteroscedasticity. (6) Refers to the Jarque-Bera test for normality in the residuals. (7) Refers to Ramsey's RESET test of functional form misspecification. (8) Refers to Chow's predictive failure test from 2005/06 onwards.

The models estimated using the two data sets suggest that price elasticities vary substantially across content type. While the direct mail price elasticities estimated using data generated by methods 1 and 2 differ in absolute size, their relative order

of magnitude is similar. The estimated price elasticity for commercial traffic (mainly transactional mail) has the lowest value in absolute terms (around -0.2) while social mail is estimated to have a slightly higher price elasticity of demand (around -0.3 to -0.4). Direct mail traffic is considered to possess the highest price elasticity of demand (somewhere in the range of -0.7 to -1.4).

The relatively low price elasticity of demand for commercial (mainly transactional) letter mail may, to some extent, reflect the lower degree of choice open to the large majority of sender-receiver channels for such communications. The low price elasticity could reflect the fact that this type of mail (which includes bills, statements and invoices) is usually sent to a specific named individual or business and, in general, cannot be substituted without additional information about the receiver (such as their email address or mobile telephone number) which in most cases may not be readily available. Furthermore, even if such information were available, the substitution of letter transactions via an electronic alternative would, in most cases, require the prior agreement of the receiver.

In contrast, the low estimated price elasticity of demand for social mail (in the range -0.3 to -0.4) is, in general, more likely to reflect the value that social letter mailers obtain from sending mail such as birthday and Christmas cards rather than factors relating to sender-receiver information.

The relatively high price elasticity estimates for direct mail traffic, which are estimated to be in the range -0.7 to -1.4, is likely to reflect the higher degree of choice that senders of direct mail have with respect to the use of mail and wider range of substitutes in the advertising market. The considerably higher direct mail price elasticities estimated relative to other types of mail are broadly consistent with the findings of other econometric studies. For example, Thress (2006) reports estimated price elasticities for United States Postal Services (USPS) Standard Mail Regular traffic and Standard Mail Enhanced Carrier Route traffic that primarily consist of direct mail traffic, that lie in the range -0.3 to -1.1. In addition, estimates of direct mail price elasticities in Santos and Lagao (2001) range from -0.8 to -2.8, although this study concluded that the lower estimates were likely to be a better approximation of the demand behaviour of firms.

The estimated parameters of ILTMC reported in table 3 suggest that there was a decline in the trend rate of social and commercial traffic around 2003/04 and 2002/03 respectively and that this slowdown was of the scale of about 2% to 3% per annum. While the estimated decline in the trend rate of growth is a little different when using data methods 1 and 2, they are of a similar order of magnitude and the slowdown in the trend rates of growth is estimated to occur around the same time[27]. The timing coincides with the sharp increase in the number of firms and individuals with broadband connections in the UK. It is likely

[27] A number of time trends were tested around this time period. The adoption of starting dates for the time trends was informed by the Akaike information criterion (AIC) and the Schwarz criterion (SC).

that this combined with advances in internet enabled technology has resulted in continuing substitution of social and commercial letter traffic.

The estimated impact of electronic substitution on direct mail resulting from the emergence of the internet, and in particular "paid-for-search" advertising, can be estimated using the coefficients of the PIA variable reported in table 3. For example, multiplying the average change in PIA over the period 2005/06 to 2007/08 (4% per annum) by the long run coefficient reported in table 3 suggests that internet related esubstitution could have reduced direct mail traffic volumes by between 7% to 13% per annum during this period. However, independent of the impact of internet advertising, it is likely that the high rates of technology driven direct mail growth experienced in the 1980s and 1990s would have eventually slowed down in order to stabilise the share of direct mail advertising spend within overall marketing budgets. The decline in the post 1997 direct mail time trend term effects reported in table 3 is consistent with such a hypothesis.

A point to note about the data method 1 and 2 estimates for the share of internet advertising expenditure variable and time trends is the considerable difference in their relative importance. For example, the content model results using data method 1 estimate lower esubstitution impacts for PIA but higher negative time trend estimates post 1997 in comparison with those using data method 2. This perhaps suggests that the econometric estimates may be unable to identify fully the impact of each of these two effects separately but a greater degree certainty can be attached to their combined impact.

5. PERSPECTIVES ON TOTAL ADDRESSED INLAND LETTER TRAFFIC FROM THE PRODUCT AND CONTENT MODELS

Table 4 presents the estimated time trend impacts and long run elasticities for total traffic contained in the addressed inland letter traffic model using product stream data (ILTMP) and contents data (ILTMC) using data methods 1 and 2.

The estimated economic activity elasticities for total traffic in the product and the content models are broadly similar and around unity. The estimated total traffic letter price elasticities are also similar in the two models and lie in the range -0.3 to -0.4, while the quality of service elasticity in the product model is a little smaller compared to those obtained in the content models. However, there are a number of differences between the models. First, the price of non-mail advertising did not appear to be statistically significant in the content model while the price of telecommunication was statistically significant in the content model but did not appear in the product model. Both of these variables have a relatively small effect in their respective models. Second, the impact of the PIA variable, the ratio of internet advertising spend to total advertising expenditure, on mail volumes is somewhat higher in the product model. Third, the net impacts of the unexplained time trends are similar in the product and content models using the data method 1, although this impact is somewhat smaller using data method 2.

The econometric results reported in table 4 can be used to provide some general insights into the recent behaviour of letter traffic volumes and potentially the behaviour of UK total traffic in the future. The econometric analysis of UK total letter traffic using Royal Mail product streams and letter content types suggests that the relationship between total traffic growth rates and economic factors remains important. However, their impact has become more complex to identify as other factors appear to have become significant drivers of letter traffic growth and these are driving a wedge between economic activity and letter traffic growth rates. The long run estimated elasticities reported in table 4 can be used to estimate the scale of this wedge effect, which can perhaps be best ascribed to technology impacts. A quantitative analysis of the impact of esubstitution using the results reported in table 4 suggests the estimated impact of this "technology wedge" reduced total UK letter traffic growth rates by around 5% to 6% per annum[28] on average during the period 2005/06 to 2007/08. This suggests that the declines in UK letter traffic growth rates that took place from around 2003 were the outcome of two quite strong sets of factors pulling in opposite directions. On the one hand economic growth and demographic trends continued to raise the demand for letter traffic as they had in the period before this break but this was more than offset by the development of powerful esubstitution factors that reduced the demand for mail.

Table 4: Long Run Elasticities and Time Trends for Total Traffic Per Household: Comparison of Product and Content models

	Estimated models		
	ILTMP	ILTMC using data method 1	ILTMC using data method 2
Economic activity	1.09	1.07	1.11
Letter price[1]	-0.33	-0.44	-0.31
Quality of Service	0.13	0.28	0.29
Price of non-mail advertising[1]	0.24	ns	ns
Proportion of internet advertising spend	-0.95	-0.36	-0.66
Price of telecommunication[1]	n.s.	0.07	0.09
Net impact of "unexplained" time trends post 2003 (% p.a.)	-2.4	-2.7	-1.0

[1.] Deflated by the all items Retail Prices Index.

[28] The technology wedge estimate was derived as follows: multiply the parameter estimates for the internet share variable by its average change over the past 3 years; add the average rate of growth of real telecommunication prices multiplied by its parameter estimate; add the impact of the time trends.

6. SUMMARY AND CONCLUSIONS

This paper has applied econometric modelling techniques using time series data to quantify the impact of key factors affecting UK letter traffic. The econometric methodology followed is based on a previous study by Nankervis et al. (2002) and has updated the high level product stream estimates in the paper using nine years of additional quarterly data. Furthermore, the paper provides new insights to the literature by examining the demand for UK letters by the contents of mail items using two survey based sources of data. The updated product models produced broadly similar results to those reported in Nankervis et al. (2002) and also Soteri et al. (2009). In particular, with regard to the estimated long run elasticities for economic activity in the product model, these were close to unity and the number of households' elasticity was estimated to be equal to unity. Similar results were found in the content models. The results of adopting this dual lens approach to modelling letter traffic were, in this case, mutually reinforcing. Furthermore, in addition to obtaining updated results on the differences in the effects of economic activity by broad product streams, the content models provided new insights into the different impacts of economic activity by letter content type. For example, direct mail traffic was estimated to be around twice as sensitive to changes in economic conditions than commercial (mainly transactional) traffic, the latter being estimated to have an elasticity approximately equal to unity

The effect of technology on the erosion of mail volumes was explored in a number of ways but most satisfactorily through the share of internet advertising variable and the use of time trends. The product model results suggest that the adverse impact of esubstitution has been predominantly on First Class traffic and Other (mainly presort) traffic. The content traffic models provide further insights into the impact of esubstitution and, in general, are consistent with the product model. For example, the impact of the time trend variables and the share of internet advertising variable in the direct mail models is considerably higher than that for the other content categories and consistent with the large negative impacts estimated for the Other (mainly presort) traffic product model which contains a substantial proportion of direct mail traffic. There are some differences between the individual variables used to proxy esubstitution when applying the two data sets in the content models and also between the product and content models. However, the combined impact of the esubstitution variables on total UK letter traffic are similar, and suggest that such factors exerted downward pressure on total letter traffic growth of around 5% to 6% per annum on average over the period 2005/06 to 2007/08.

The estimated long run price elasticity for total traffic using both the product and content models was estimated to be around -0.3 to -0.4. The product model estimates a considerably higher own price elasticity for First Class non-presort traffic of about -0.8. However, due to switching between First and Second Class non-presort products their combined own-price elasticity is estimated to be around -0.2. The own-price elasticity for Other (mainly presort) traffic was estimated to be

about -0.4. The long-run price elasticities estimated using the content model provided a number of new insights. In particular, the estimated price elasticity for social mail was estimated to be about -0.3 to -0.4 and for commercial (mainly transactional) mail to be around -0.2. By contrast, the direct mail price elasticity was estimated to be considerably higher and lie somewhere in the range -0.7 to -1.4.

The difference between the estimated direct mail price elasticity estimates using the two data sources in the content model reflects, at least in part, data issues associated with allocating UK traffic volumes to content types using survey data. It should be noted that while survey data was used to derive reasonable estimates of directional trends for content traffic, there is some statistical noise associated with movements for individual years. Consequently, this is likely to lead to wider confidence intervals for estimated elasticities. In future research, it may be possible to combine the information available from each survey using statistical techniques to obtain more robust content share estimates. Furthermore, it may be possible to combine such data with product time series data to jointly estimate letter demand elasticities. Given the importance of price elasticities to inform business strategies this could be an important avenue for future research.

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APPENDIX: USING MCS AND CPS SURVEY DATA

The Mail Characteristics Survey (MCS) is a large random survey that obtains information on content types by information from mail receivers via a response card. The response rate for the card is high for surveys of this type (around one in six) as is the survey sample size (around 0.7 million). The MCS covers Royal Mail end-to-end (E2E) traffic (except for Response Mail, Special Delivery and Cleanmail Advance which accounted for around 3% of E2E traffic in 2007/08). The survey excluded downstream access. The Consumer Panel Survey (CPS) is a weekly household survey diary and covered a panel of around 1000 households. This survey therefore excluded business-to-business (B2B) traffic but included access traffic.

Since neither of the two surveys provided a comprehensive survey of total letter traffic, information from both was used to derive letter content time series data for addressed inland mail volumes. Information from the MCS was available on a quarterly basis going back to 1999 and for UK financial years to 1980/81. In contrast, the CPS contained information on a quarterly basis only from 1997 Q3. Due to the longer time span of data available from the MCS its content category definitions were adopted to derive content shares for total UK letter traffic.

The MCS survey recorded up to five different content types for a specific envelope and allocated a prioritisation routine to identify the "primary" content. This eliminated the double counting of contents within the envelope. Since there were no access volumes prior to 2004/05 the MCS covered the large majority of Royal Mail addressed inland mail up to that point in time. However, access volumes increased from a negligible level in 2004/05 to account for around one-fifth of total letter traffic by 2007/08. The MCS therefore excluded an increasing proportion of mail volumes from 2004/05 onwards. In contrast, the CPS which did not include information on B2B mail excluded around a quarter of total inland mail (based on MCS estimates).

Given the substantial information gaps contained in both surveys two different data methods were adopted to derive estimates of content based traffic volumes. Data method 1 used MCS content shares and Royal Mail E2E volumes to derive a content volume time series for Royal Mail E2E traffic and from 2004/05 onwards used CPS to derive estimates for content shares and access volumes. These time series were then aggregated together to provide a single content based traffic volumes series for total addressed inland letter traffic.

Data method 2 derived estimates of content based traffic data by primarily focussing on the CPS and using MCS B2B information to derive content share estimates for 1998/99 onwards. Given the shorter time period for which CPS content data is available, it was not possible to use method 2 alone to derive content time series that is long enough to undertake robust time series econometrics. However, a continuous time series data set going back to 1980/81 was derived by splicing this data series to MCS content share estimates. While data method 2 does not provide a full time series data set for econometric analysis, it generates an alternative set of data that can be used for comparison purposes.