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STATISTICAL ANALYSIS OF 'STRUCTURAL  
CHANGE'  
AN ANNOTATED BIBLIOGRAPHY

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## FOREWORD

Within the framework of the Economic Structural Change Program, a cooperative research activity of IIASA and the University of Bonn, FRG, a project is carried out on "Statistical and Econometric Identification of Structural Change"; the project involves studies on the formal aspects of the analysis of structural changes. On the one hand, they include statistical methods to detect non-constancies, such as stability tests, detection criteria, etc., and on the other hand, methods which are suitable for models which incorporate non-constancy of the parameters, such as estimation techniques for time-varying parameters, adaptive methods, etc.

The present paper provides a documentation of the state of the art in the form of a bibliography.

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**STATISTICAL ANALYSIS OF 'STRUCTURAL CHANGE'  
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## Chapter I: INTRODUCTION

The typical 'structural change' situation is - from the point of view of a statistician - as follows: To cope with a particular economic phenomenon a model is specified, and it is suspected that for different periods of time, or for different spacial regions, different sets of parameter values are needed in order to describe the reality adequately; the 'change point' which separates these periods, or regions, is unknown. Questions that arise in this context include: Is it necessary to assume that the parameters are changing? When, or where, does a change occur or - if it takes place over a certain period of time - what is its onset and duration? How much do parameters before and after the change differ? What type of model is appropriate in a particular situation (e.g., two-phase regression, stochastic parameter models)?

Non-constancy of the parameters is an essential element of 'structural change'. This non-constancy of the parameters can appear as an inadequacy of the model which is specified to represent the phenomenon in question; diagnostic checking methods can be applied to identify such non-constancies. On the other hand, parameter variability can be incorporated in the model.

References included in this bibliography concentrate on two topics:

- (1) Detection of non-constancy of parameters in regression and time series models.
- (2) Statistical analysis of models with time-varying parameters.

The first group of references deals mainly with the change point problem in the context of regression models. Constancy of a sequence of random variables is related to the analysis of residuals which might be performed in order to detect non-constancy of the regression parameters; therefore, papers are also included which discuss the analysis of parameter

constancy of (time-ordered) sequences of random variables. Several papers discuss the analysis of constancy of parameters of time series models.

The second group of references is concerned with estimation procedures for regression models with time-varying parameters. These papers are of interest because time-varying parameter models might be appropriate for model specification in the presence of non-constancy. Also, such parameterizations can be used to detect instability in the coefficients. Some papers are included which discuss forecasting problems in the situation of non-constant parameters. No or nearly no weight is given some topics which are related to those mentioned above, viz., continuous sampling inspection, heteroscedasticity, analysis of non-constancy of time-series parameters in the frequency domain, and disequilibrium models. The reasons for this limitations lie partly in the subjects, partly in the fact that our efforts had to be restricted.

The close connection of questions of model stability with economic problems leads us to discuss briefly what is known under 'structural change' among economists. In economics this notion is not clearly defined. However, a notion related to 'structural change' which, in the context of a linear dynamic model, is clearly defined, is the concept of stability. It refers to the dominant root of the characteristic equation of the system: The system is stable if the dominant root lies within the unit circle (cf. Theil & Boot, 1962; Oberhofer & Kmenta, 1973). This concept, however, is of little help for defining 'structural change' if it is accepted that 'structural change' implies non-constant relations between elements (variables) of the system. Economists speak about structural change not only in this rather concrete sense but also if there are substantial changes in certain characteristics, e.g., the mean, of the endogenous variables of the system. Consequently, the borderline between structural change and stability is not strict, the notion 'structural change' is not well-defined, and questions



concerning the theoretical motivation of structural change, its measurability, and others, cannot be discussed properly. An attempt to clarify the subject within an economic framework has been made by Westlund (1985).

Most references included in this bibliography were published in methodological (statistical and econometric) journals; only a few were taken from economic journals. In these papers typical problems which arise in the context of modelling real economic phenomena are rarely discussed. For example, what implies shortness of time series? How can special patterns of parameter changes be treated, particularly slowly moving parameters? Also, very few papers could be found which deal with non-linear or multi-equation models.

Although both of us are responsible for this bibliography, the 'mining' for references was divided: P.Hackl was concerned with papers that discuss analysis of constancy in sequences of random variables, in regression models, and in time series models; A.Westlund supplied the references that refer to the estimation of regression models with time-varying parameters. Our work is partially based on four bibliographies which delivered about 60 % of the references cited here: Shaban (1980), Hinkley (1980), Johnson (1977), and Johnson (1980). Most of the remaining papers appeared after these bibliographies were published, a fact that indicates the still growing interest in this subject. Papers who mainly deal with applications were not incorporated, except papers which were published in methodological journals. We don't claim that this bibliography is complete; we are grateful for further references and suggestions which would help make a future edition more complete.

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## **Chapter II: LIST OF PAPERS**

The list contains some 300 references to research papers. Each entry is annotated by one or more codes which refer to the subject-matter of the paper. The references are arranged in the alphabetic order of its (first) author.

The entries are constructed as follows: After the author's (or authors') names the year of publication is indicated; this is followed by the above-mentioned subject-matter codes. For each separate set of authors the entries are listed chronologically. Entries with more than one author are supplemented by entries corresponding to all other authors except the first one: Each of these supplemental entry consists of an author's name and of a reference to the original entry.

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Intervention analysis and multiple time series.  
Biometrika, 7, 73-78.
- Abraham, B., Minder, C.E. (1982) <3.8> 2  
A time series model with random coefficients.  
Comm. Statist., Theory and Methods, 11, 1381-1391.
- Abraham, B., Wei, W.W.S. (1979) <4.5> 3  
Inferences in a switching time series.  
ASA, Proc. Business Econ. Statist. Section, 354-358.
- Abrams, K.M. see also  
237 Royston, J.P., Abrams, R.M. (1980)
- Akkinä, K.R. (1974) <3.1;C> 4  
Application of random coefficient regression models to the  
aggregation problem.  
Econometrica, 42, 369-375.
- Ali, M.M., Giaccotto, C. (1982) <1.1;NE> 5  
The identical distribution hypothesis for stock market prices -  
location- and scale-shift alternatives.  
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A note on a random coefficients model.  
Intern. Econ. Rev., 19, 793-796.
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A family of models involving straight lines and concomitant expon.  
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Biometrics, 31, 303-310.
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Repeated measurements on autoregressive processes.  
J. Amer. Statist. Assoc., 73, 371-378.
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Sequential life tests for the exponential distribution with  
changing parameter.  
Technometrics, 8, 217-227.
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Alternative estimators of the determinants of inter-regional  
migration.  
ASA, Proc. 1976 Annual Meeting, 217-219.
- Athans, M. (1974) <3.3> 12  
The importance of Kalman filtering methods for economic systems.  
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295 Watts, D.G., Bacon, D.W. (1974)
- Bacon, D.W., Watts, D.G. (1971) <2.4, 2.5; A> 13  
Estimating the transition between two intersecting straight  
lines.  
Biometrika, 58, 525-534.
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147 Johnson, R.A., Bagshaw, M. (1974)
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The effect of serial correlation on the performance of CUSUM  
tests II.  
Technometrics, 17, 73-80.
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Sequential detection of a drift change in a Wiener process.  
Comm. Statist., 4, 767-796.
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Sequential procedures for detecting parameter changes in a  
time-series model.  
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The use of MOSUMs for quality control.  
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An extension of the MUSUM technique for quality control.  
Technometrics, 22, 1-7.
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The application of Hunter's inequality in simultaneous testing.  
Biometr. J., 27, 43-46.
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 Biometrika, 65, 243-251.
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 Econometrica, 44, 167-184.
- Cooley, T.F., Rosenberg, S., Wall, K.D. (1977) <3.3> 67  
 A note on optimal smoothing for time varying coefficient problems.  
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- Cooper, J.P. (1973) <2.6, 3.8> 68  
 Time-varying regression coefficients: a mixed estimation approach and operational limitations of the general Markov structure.  
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- Davis, P.S. see also  
209 Parhizgari, A.M., Davis, P.S. (1978)
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- Draper, N.R., Guttman, I., Lipow, P. (1977) <2.8> 75  
All-bias designs for spline functions, joined at the axes.  
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- Dufour, J.-M. (1982) <2.1; C> 76  
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Chapter III: LIST OF AUTHORS BY SUBJECT MATTER CODE

SUBJECT-MATTER CODE = 0.1	
Cnapman, P.	1
Eubank, R.L.	1
Hinkley, D.V.	1
Johnson, L.W.	2
Poirier, D.J.	1
Ranger, G.	1
Shaban, S.A.	1

SUBJECT-MATTER CODE = 1.2	
Abrams, R.M.	1
Aroian, L.A.	1
Bagshaw, M.	3
Barnard, G.A.	1
Bauer, P.	2
Bhattacharyya, G.K.	1
Goldsmith, P.L.	1
Hackl, P.	2
Hines, W.G.S.	1
Hinkley, D.V.	1
Hsu, D.A.	1
Johnson, R.A.	3
Kenett, K.	1
McGilchrist, C.A.	1
Nadler, J.	1
Page, E.S.	3
Pollak, M.	1
Robbins, N.B.	1
Robison, D.E.	1
Royston, J.P.	1
Sanderson, A.C.	1
Segen, J.	1
Sen, P.K.	1
Shiryayev, A.N.	1
Van_Dobben_de_Bruyn, C.S.	1
Woodward, R.H.	1
Woodyer, K.D.	1

SUBJECT-MATTER CODE = 1.1	
Abrams, R.M.	1
Ali, M.M.	1
Bagshaw, M.	3
Bauer, P.	2
Bhattacharyya, P.K.	1
Bhattacharyya, G.K.	2
Chernoff, H.	1
Darkhovshk, B.S.	1
Frierson, D.	1
Gardner, L.A.	1
Giaccotto, C.	1
Goldsmith, P.L.	1
Hackl, P.	2
Hawkins, D.M.	1
Herzberg, A.M.	1
Hickie, J.S.	1
Hines, W.G.S.	1
Hinkley, D.V.	4
Hinkley, E.A.	1
Johnson, R.A.	4
Kander, Z.	1
McGilchrist, C.A.	1
Mustafi, C.K.	1
Nadler, J.	1
Pettitt, A.N.	1
Robbins, N.B.	1
Royston, J.P.	1
Sanderson, A.C.	1
Schechtman, E.	2
Segen, J.	1
Sen, A.	3
Sen, P.K.	2
Shiryayev, A.N.	1
Srivastava, M.S.	3
Talwar, P.P.	1
Van_Dobben_de_Bruyn, C.S.	1
Wolfe, D.A.	1
Woodward, R.H.	1
Woodyer, K.D.	1
Worsley, K.J.	2
Zacks, S.	2

SUBJECT-MATTER CODE = 1.3	
Bhattacharyya, G.K.	1
Farley, J.U.	1
Gentle, J.E.	1
Hinich, M.	1
Hinkley, D.V.	1
Hinkley, E.A.	1
Hsieh, H.K.	1
Hsu, D.A.	2
MacNeill, I.B.	1
Pettitt, A.N.	1
Sanderson, A.C.	1
Segen, J.	1
Sen, P.K.	1
Talwar, P.P.	1

SUBJECT-MATTER CODE = 1.4	
Bhattacharya, P.K.	2
Brockwell, P.J.	1
Chernoff, H.	1
Cobb, G.W.	1
Kumar, K.D.	1
Mustafi, C.K.	1
Nicklin, E.H.	1
Paulson, A.S.	1
Pettitt, A.N.	1
Quandt, R.E.	1
Ramsay, J.B.	1
Schechtman, E.	1
Schmidt, P.	1
Zacks, S.	1

SUBJECT-MATTER CODE = 1.5	
Broemeling, L.O.	4
Diaz, J.	1
Farley, J.U.	1
Heghinian, S.M.	1
Hinich, M.J.	1
Holbert, D.	1
Hsu, D.A.	1
Lee, A.F.S.	1
Menzefricke, U.	1
Smith, A.F.M.	1

SUBJECT-MATTER CODE = 1.6	
Srivastava, T.N.	1

SUBJECT-MATTER CODE = 2.1	
Bauer, P.	1
Beckman, R.J.	1
Brown, R.L.	2
Chow, G.C.	2
Cook, K.J.	1
Desnayes, J.	1
Dufour, J.-M.	2
Durbin, J.	2
El-Shaarawi, A.H.	1
Esterby, S.R.	1
Evans, J.M.	1
Faith, R.	1
Farley, J.U.	2
Feder, P.I.	1
Fisner, F.M.	1
Fisher, G.	1
Freeman, J.M.	1
Garbade, K.	1
Goldfeld, S.M.	2
Hackl, P.	3
Harrison, M.J.	1
Hinich, M.J.	2
Hinkley, D.V.	2
Inselmann, E.H.	1
Irvine, J.M.	1
Lombard, F.	2
MacNeill, I.B.	1
Maronna, R.	1
McAleer, M.	1
McCabe, B.P.M.	1
McGuire, T.W.	1
Picard, U.	1
Ploberger, W.	1
Quandt, R.E.	5
Ramirez, M.M.	1
Rea, J.D.	1
Schneeberger, H.	1
Schweder, T.	1
Sen, P.K.	3
Sprent, P.	1
Tanaka, K.	1
Toyoda, T.	1
Yohai, V.J.	1

SUBJECT-MATTER CODE = 2.2	
Brown, R.L.	2
Durbin, J.	2
Evans, J.M.	1
Lombard, F.	2
Sen, P.K.	1

SUBJECT-MATTER CODE = 2.3	
Bacon, D.W.	1
Bellman, R.	1
Bookstein, F.L.	1
Brannas, K.	1
Brown, R.L.	1
Carleton, W.T.	1
Chow, G.L.	1
Curnow, R.N.	1
Durbin, J.	1
El-Shaarawi, A.H.	1
Esterby, S.R.	1
Evans, J.M.	1
Faith, R.	1
Feder, P.I.	2
Freeman, J.M.	1
Fuller, W.A.	1
Gallant, A.R.	2
Garbade, K.	1
Goldfeld, S.M.	2
Griffiths, D.A.	1
Hawkins, D.M.	1
Heckman, J.J.	1
Hinkley, D.V.	1
Hudson, D.J.	1
Kastenbaum, M.A.	1
Kiefer, N.M.	1
Lerman, P.M.	1
Maddala, G.S.	1
McGee, V.E.	1
Mehta, J.S.	1
Miller, A.J.	1
Park, S.H.	1
Poirier, D.J.	1
Quandt, R.E.	6
Ramsay, J.B.	1
Rao, P.S.E.S.	1
Robison, D.E.	1
Roth, R.	1
Schmidt, P.	1
Schulze, U.	1
Singpurwalla, N.D.	1
Swamy, P.A.V.B.	1
Sylvester, D.L.	1
Trost, R.P.	1
Tsurumi, H.	1
Uhlin, S.	1
Watts, D.G.	1
Wilton, D.A.	1
Worsley, K.J.	1

SUBJECT-MATTER CODE = 2.4	
Bacon, D.W.	1
Blight, B.J.N.	1
Booth, N.B.	1
Broemeling, L.D.	6
Carter, R.L.	1
Chi, A.	1
Chin_Choi, J.H.	2
Cook, D.G.	1
El-Sayyad, G.M.	1
Ferreira, P.E.	1
Holbert, D.	2
Hsu, D.A.	2
Land, M.	1
Mehta, J.S.	1
Moen, D.H.	1
Ohtani, K.	1
Salazar, D.	2
Sheflin, N.	1
Smith, A.F.M.	2
Smith, P.L.	1
Swamy, P.A.V.B.	1
Tsurumi, H.	5
Watts, D.G.	1

SUBJECT-MATTER CODE = 2.5	
Bacon, D.W.	2
Broemeling, L.D.	1
Goldfeld, S.M.	2
Griffiths, D.A.	1
Kiefer, N.M.	1
Land, M.	1
Miller, A.J.	1
Ohtani, K.	1
Poirier, D.J.	1
Quandt, R.E.	3
Ruud, P.A.	1
Salazar, D.	1
Tsurumi, H.	2
Watts, D.G.	2
Wilton, D.A.	1

SUBJECT-MATTER CODE = 2.6	
Amemiya, T.	1
Cooley, I. F.	1
Cooper, J. P.	1
Garbade, K.	1
Prescott, E. G.	1
Tanaka, K.	1

SUBJECT-MATTER CODE = 3.1	
Akkina, K. R.	1
Johnson, K. H.	1
Rao, C. R.	1
Wittink, D. R.	1

SUBJECT-MATTER CODE = 2.7	
Feder, P. I.	1
Fuller, W. A.	1
Gallant, A. R.	2
Kiefer, N. M.	1
Lerman, P. M.	1

SUBJECT-MATTER CODE = 3.2	
Arora, S. S.	1
Bass, F. M.	1
Borjas, G. J.	1
Chaturvedi, A.	1
Choudhry, N. K.	1
Cooley, I. F.	1
Davis, P. S.	1
Dielman, T.	1
Duncan, D. B.	1
Froehlich, B. R.	1
Griffiths, W. E.	1
Hildreth, C.	1
Horn, R. A.	1
Horn, S. D.	1
Houck, J. P.	1
Hsiao, C.	2
Johnson, K. H.	1
Kiefer, N. M.	1
Mehta, J. S.	1
Mishra, G. D.	1
Murthy, G. V. S. N.	1
Nagar, A. L.	1
Nantell, T. J.	1
Parnizgari, A. M.	1
Raj, B.	3
Rao, U. L. G.	1
Sant, D. T.	1
Singh, B.	2
Srivastava, V. K.	2
Swamy, P. A. V. B.	3
Ullah, A.	2
Upadhyaya, S.	1
Wittink, D. R.	1
Wright, R. L.	1

SUBJECT-MATTER CODE = 2.8	
Cox, M. G.	1
Curnow, R. N.	1
Draper, N. R.	1
Ertel, J. E.	1
Eubank, R. L.	1
Feder, P. I.	1
Fowlkes, E. B.	1
Gutnery, S. B.	1
Guttman, I.	1
Lipow, P.	1
Park, S. H.	1
Poirier, D. J.	2
Wold, S.	1

SUBJECT-MATTER CODE = 2.9	
Broemeling, L. D.	1
Land, M.	1



SUBJECT-MATTER CODE = 3.3	
Athans, M.	1
Baudin, A.	1
Belsley, D. A.	2
Brannas, K.	3
Bucy, K. S.	1
Cooley, T. F.	1
Duncan, D. B.	1
Eklöf, J. A.	1
Enns, P. G.	1
Freebairn, J. W.	1
Hatanaka, M.	1
Horn, S. D.	1
Katman, R. E.	2
Kuh, E.	1
Little, J. D. C.	1
McWhorter, A.	2
Nadeau, S.	1
Narasimham, G. V. L.	1
Otter, P. W.	1
Rausser, G. C.	1
Rosenberg, B.	2
Sarris, A. H.	1
Simonds, R. R.	1
Spivey, W. A.	1
Stenlund, K.	1
Wall, K. D.	1
Westlund, A.	4
Wrobleski, W. J.	2

SUBJECT-MATTER CODE = 3.5	
Cooley, T. F.	4
DeCanio, S. J.	1
Laumas, G. S.	3
Mehra, Y. P.	1
Parson, L. J.	1
Prescott, E. G.	2
Schultz, R. L.	1
Simos, E. D.	1
Sunder, S.	1

SUBJECT-MATTER CODE = 3.6	
Bowman, H. W.	1
Broemeling, L. D.	1
Chi, A.	1
Cook, D. G.	1
Fearn, T.	1
Hanssens, D. M.	1
LaPorte, A. M.	1
Liu, L.-M.	2
Mehta, J. S.	1
Rosenberg, B.	1
Salazar, D.	1
Shiba, T.	1
Smith, A. F. M.	1
Smith, P. L.	1
Swamy, P. A. V. B.	1
Tsurumi, H.	1

SUBJECT-MATTER CODE = 3.4	
Choudhry, N. K.	1
Dent, W. T.	1
Hiltbreth, C.	1
Johnson, L. W.	1
Kiefer, N. M.	1
Mehra, R. K.	1
Nagar, A. L.	1
Neider, J. A.	1
Norberg, R.	1
Pagan, A. R.	1
Raj, B.	1
Rosenberg, B.	2
Rubin, H.	1
Singh, B.	1
Swamy, P. A. V. B.	1

SUBJECT-MATTER CODE = 3.7	
Baudin, A.	1
Bretschneider, S. I.	2
Carbone, R.	3
Longini, R. L.	3
Nadeau, S.	1
Westlund, A.	1

SUBJECT-MATTER CODE = 3.8	
Abraham, B.	1
Bennett, R. J.	1
Burnett, T. D.	1
Cooper, J. P.	1
Ghazal, G. A.	1
Guthrie, D.	1
Mahajan, L. S.	1
Mahajan, Y. L.	1
Mikhail, W. M.	1
Minder, C. E.	1
Raj, B.	1
Rosenberg, B.	1
Swamy, P. A. V. B.	1
Wimmer, G.	1

SUBJECT-MATTER CODE = 4.3	
Anderson, T. W.	1
Bagshaw, M.	1
Johnson, R. A.	1
Ledolter, J.	1
Nicholls, D. F.	1
Quinn, B. G.	1

SUBJECT-MATTER CODE = 4.4	
Bucy, R. S.	1
Kalman, R. E.	2

SUBJECT-MATTER CODE = 3.9	
Broemeling, L. D.	2
Kahl, D. R.	1
Land, M.	1
Ledolter, J.	1
Swamy, P. A. V. B.	1
Tinsley, P. A.	1
Westlund, A.	1

SUBJECT-MATTER CODE = 4.5	
Abraham, B.	1
Booth, N. B.	1
Salazar, D.	1
Smith, A. F. M.	1
Wei, W. W. S.	1

SUBJECT-MATTER CODE = 4.1	
Bagshaw, M.	2
Hsu, D. A.	1
Johnson, R. A.	2
Miller, R. B.	1
Sanderson, A. C.	1
Segen, J.	1
Wichern, D. W.	1

SUBJECT-MATTER CODE = 4.6	
Balmer, D. W.	1
Franzini, L.	1
Harvey, A. C.	1

SUBJECT-MATTER CODE = 4.2	
Basseville, M.	1
Benveniste, A.	1
Hawkins, D. M.	1
Sanderson, A. C.	1
Segen, J.	1

SUBJECT-MATTER CODE = 4.8	
Abraham, B.	1
Box, G. E. P.	2
Tiao, G. C.	2

## Appendix: THE SUBJECT-MATTER CODES

### A.1 Introduction

The entries in the List of Papers (Chapter II) are annotated according to their subject-matter. The corresponding codes consist of two digits which are separated by a period. The first digit indicates the following areas of statistical methodology:

0. General
1. Analysis of Constancy in a Sequence of Random Variables Ordered by Time
2. Analysis of Constancy in Regression Models
3. Estimation of Regression Models with Time-Varying Parameters
4. Analysis of Constancy in Time Series Models

Each entry is annotated by up to four codes. In addition, the following code letters are used to qualify the subject-matter in more detail:

- A Asymptotic Properties
- B Bayesian Methods
- C Comparison of Procedures
- E Examples, Numerical Illustrations
- M Multivariate Procedures
- N Non-Parametric Methods
- P Parametric Methods
- R Robustness
- S (Monte Carlo) Simulation Results
- T Tables, Charts
- U Univariate Procedures
- V Computational Methods
- X Non-Bayesian Methods

References annotated to concern analysis of constancy in

sequences of random variables (1.x), in regression models (2.x), and in time series models (4.x) concentrate on methods to detect non-constancies in the respective models. The remaining references (3.x) discuss the analysis of regression models with time varying parameters. The short descriptions of the several subject-matter codes given in the next section are not intended to be complete.

## **A.2 Annotated List of the Subject-Matter Codes**

### **0. General**

0.1 Bibliography, survey.

### **1. Analysis of Constancy in a Sequence of Random Variables**

1.1 Test for a change in the expectation. The change can be sudden or can continue over a certain period of time; the variance can be known or unknown.

1.2 Sequential test procedures for non-constancy.

1.3 Test for a change of parameters other than the mean or for a change of the whole distribution.

1.4 Estimation concerning the change-point; estimation of the distribution parameters; sample theoretic approach.

1.5 Bayesian inference concerning the change-point and/or the distribution parameters.

1.6 Estimation procedures concerning other parameters than the expectation in the presence of non-constancy.

### **2. Analysis of Constancy in Regression Models**

2.1 Test procedures for non-constancy of regression coefficients of linear regression models. The disturbance variance can be constant or can change also in time.

2.2 Sequential test procedures for the detection of non-constancy.

2.3 Inference concerning the linear regression model in the presence of non-constancy; sample theoretic approach. Methods for estimating the unknown change-point, distributional properties of such an estimate, and inference on the regression model parameters may be treated.

2.4 Bayesian inference in linear regression models in the presence of non-constancy.

2.5 Special switching mechanisms.

2.6 Regression models with time-varying parameters. The mechanism of variation is assumed to be in action during the whole time of observation and may be deterministic or stochastic.

2.7 Inference concerning non-constancy of non-linear regression models.

2.8 Methods of inference for models based on spline functions.

2.9 Forecasting under non-constancy.

### **3. Estimation of Regression Models with Time-Varying Parameters**

3.1 Ordinary least-squares estimation.

3.2 Generalized least-squares estimation (including the Hildreth-Houck and Swamy procedures).

3.3 Filtering and smoothing procedures.

3.4 Maximum likelihood estimation.

3.5 The varying parameter (VPR) procedure.

3.6 Bayesian estimation.

3.7 Adaptive estimation (AEP) procedures.

3.8 Other procedures.

3.9 Forecasting procedures in the presence of non-constant parameters.

### **4. Analysis of Constancy in Time Series Models**

4.1 Test procedures for non-constancy of the mean and/or variance in ARIMA models.

4.2 Sequential test procedures for the detection of non-constancy of an ARIMA model.

4.3 Test procedures for non-constancy of parameters different from mean and variance in ARIMA models.

4.4 Estimation of parameters of an ARIMA model in the presence of non-constancy; sample theoretic approach.

4.5 Bayesian inference concerning the parameters of an ARIMA model in the presence of non-constancy.

4.6 Inference for models different from ARIMA models.

4.7 Forecasting under non-constancy.

4.8 Inference concerning time dependence of (partially) known structure. Test and parameter estimation procedures; the non-constancy is assumed to have a known onset and/or form (cf. intervention analysis).

**A.3 Number of Papers for Each Subject-Matter Code**

Code Number	Code Number	Code Number	Code Number
1.1 60	2.1 60	3.1 4	4.1 9
1.2 35	2.2 8	3.2 42	4.2 5
1.3 15	2.3 57	3.3 38	4.3 6
1.4 15	2.4 37	3.4 16	4.4 3
1.5 13	2.5 21	3.5 15	4.5 5
1.6 1	2.6 6	3.6 17	4.6 3
	2.7 6	3.7 11	4.7 -
	2.8 14	3.8 14	4.8 5
	2.9 2	3.9 8	