"ESTIMATING DYNAMIC RESPONSE MODELS WHEN THE DATA ARE SUBJECT TO DIFFERENT TEMPORAL AGGREGATION"

Wilfried R. VANHONACKER*

N° 89 / 12

* Wilfried R. VANHONACKER, Associate Professor of Marketing, INSEAD, Fontainebleau, France.

Director of Publication :

Charles WYPLOSZ, Associate Dean for Research and Development

Printed at INSEAD, Fontainebleau, France

ESTIMATING DYNAMIC RESPONSE MODELS WHEN THE DATA ARE SUBJECT TO DIFFERENT TEMPORAL AGGREGATION

ABSTRACT

In estimating response models using secondary data, it can happen that the observations on the variables are subject to different temporal aggregation. Estimating a dynamic model with this type of data is not straightforward, particularly when (a) estimates with good statistical properties are desired, and (b) full use of all information in the data is needed. This paper provides an overview and discussion of the various approaches to the estimation problem when independent variables are observed less frequently than the dependent variable. An investigation of the subset of practical approaches in a numerical framework suggests that one-step estimation procedures which simultaneously estimate the parameters and the missing disaggregated data points should be preferred.

Key Words: TEMPORAL AGGREGATION; PARTIAL ADJUSTMENT MODEL

I. INTRODUCTION

In estimating time-series models, researchers often must rely on observations made available for given and equal time intervals. The researcher generally has little control over the length of these intervals and consequently is faced with matching the data to the theoretically specified model. When the observations on the variables specified in a model are subject to different temporal aggregation, it is not immediately evident how the model should be estimated. The purpose of this paper is to review various approaches to the problem and to illustrate numerically the relative performance of a number of estimators in a finite sample framework.

The estimation problem is investigated in a specific framework. The analytic results reported are based on a partial adjustment model (PAM) specification which has been used extensively in sales response modeling (see, e.g., Clarke 1976, Vanhonacker 1983),and which finds its theoretical origin in the adaptive expectations literature (Nerlove 1956, 1958, Cagan 1956). The PAM of interest can be expressed as

$$y_{t,i} = \gamma y_{t,i-1} + \delta x_{t,i} + u_{t,i} \tag{1}$$

where $y_{t,i}$ denotes the dependent variable in time period t, i, $x_{t,i}$ denotes an independent predictor for time period t, i, and $u_{t,i}$ denotes the disturbance term in time period t, i. Double subscripts on the variables identify a temporally aggregated observation period t (e.g., quarter, year, etc.) and a temporally disaggregated period i (e.g., week, month, etc.). For example, the subscript t, i could refer to month i in year t.

Relative to other dynamic models, PAM has a simple error structure which enhances analytic tractability. Specifically, the disturbances $u_{t,i}$ in model (1) are independent. In contrast, most dynamic models derived from distributed lag models (e.g., Koyck models) have correlated disturbances which, in combination with lagged dependent variables, give rise to challenging estimation tasks (for a discussion, see e.g., Johnston 1972,

p.307). Independent disturbances make analytic work with PAM relatively straightforward.

In order to keep the analytic discussion concise and insightful, only a single non-stochastic independent variable is specified in (1). The results obtained for this simple model are directly applicable to models with multiple independent variables as long as the multiple independent variables are orthogonal to one another. The numerical results will provide some insights into the case of multiple, correlated independent variables. Furthermore, the investigation is confined to independent flow variables (e.g., advertising). When stock variables (e.g., price) are specified, the estimation problem becomes very difficult as complex interpolation techniques may be required (see, e.g., Friedman 1962).

Specific focus in this manuscript is on instances where the independent variable is observed less frequently than the dependent variable. In other words, the data available for estimation of model (1) consists of $y_{t,i}$ and

$x_t = \sum_{i=1}^{n} x_{t,i}$ for $i = 1, 2, \ldots, n$ and $t = 1, 2, \ldots, T$.

Given this body of <u>partially</u> aggregated data, how should one estimate the response model to obtain parameter estimates which (a) have good statistical properties, and (b) include all information contained in the data? In answering this question, this study (a) gathers the various approaches to the estimation problem in one place, (b) reviews, compares, and discusses them, and (c) tests a subset of the theoretically appealing and more practical ones in a practically-relevant numerical framework.

II. APPROACHES TO THE ESTIMATION PROBLEM

1. Two-Step Procedures

Two basic avenues exist for solving the estimation problem described above. One avenue consists of two-step procedures which first modify the data and then estimate the model parameters. Another avenue consists of one-step procedures which perform both tasks simultaneously. Figure 1 summarizes the various options available to a researcher faced with estimating a model when data are aggregated at varying levels.

Two-step procedures perform two tasks sequentially. In the first step, the observations on the variables are modified. One set of methods simply aggregates the observations on the response variable up to the aggregated level of the independent variable observations. Another set of methods tries to disaggregate the observations on the independent variable. Both approaches provide final observations on all variables at a common level of temporal aggregation (or disaggregation). In the second step, the model is estimated with an appropriate least squares estimator using the derived data. Some comments are in order with respect to the properties of the derived estimates.

The traditional (but seldom acknowledged) approach to the estimation problem of interest has been to aggregate the $y_{t,i}$ observations up to the x_t level. The process of aggregating observations over time creates four major problems, however, all of which have received attention in the econometrics literature. Temporal aggregation has been shown to: (a) decrease the precision of estimation (Zellner and Montmarquette 1971, Farebrother 1979) and prediction (Amemiya and Wu 1972), (b) decrease the power of traditional regression statistics (Rowe 1976), (c) confound the causal direction of the relationships modeled (Liu 1969), and (d) obscure the relationship between the aggregated model parameters and the parameters of the underlying disaggregated specification, especially in dynamic structures (Mundlak 1961, Moriguchi 1970, Clarke 1976, Weinberg and Weiss 1982, Vanhonacker 1983, 1984). Some approaches have been developed in the sales response modeling literature to derive disaggregated model parameters from aggregated model estimates (see, e.g., Bass and Leone 1983, 1986, Weiss,

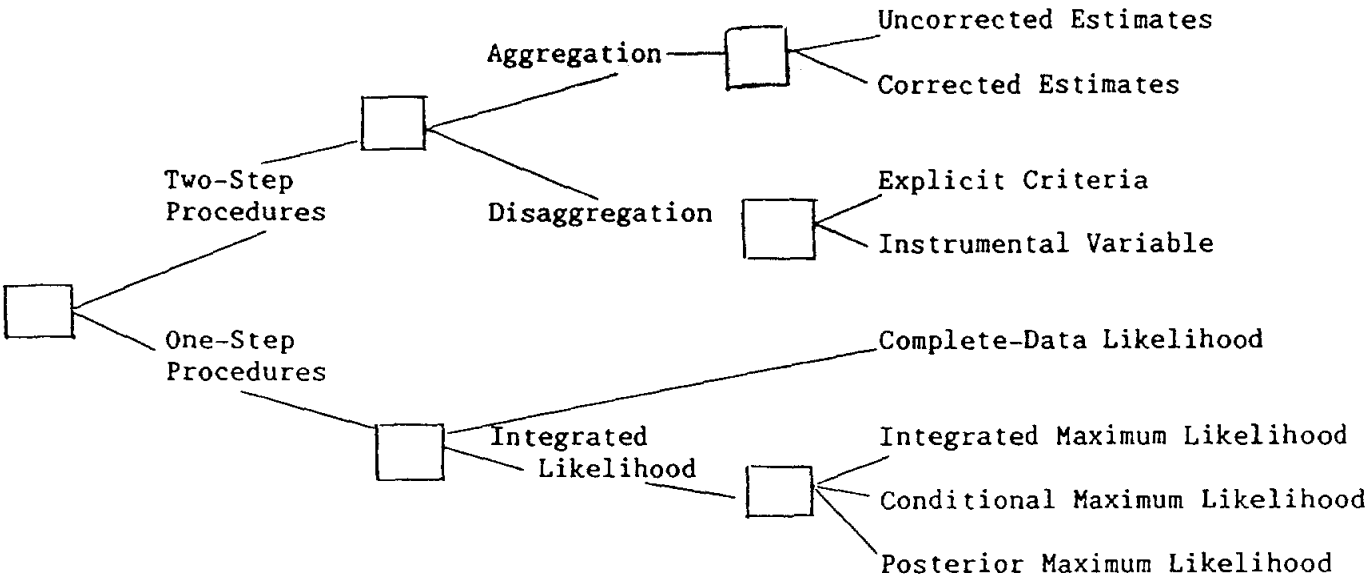

Figure 1

APPROACHES TO ESTIMATING A MODEL
WHEN DATA ARE SUBJECT TO DIFFERENT TEMPORAL AGGREGATION

Weinberg, and Windal 1983, Kanetkar, Weinberg, and Weiss 1986a, 1986b). However, these are merely approximations with unknown statistical properties. Furthermore, since they were not specifically developed for the problem at hand, they don't make full use of all the available data. These difficulties together with the general problems of temporal aggregation suggest that this estimation approach should perhaps be avoided.

The approach of disaggregating the x_t observations is consistent with the current move toward disaggregated modeling and estimation. Two methods exist for disaggregating time-series on a flow variable. One relies on an instrumental variable for which disaggregated data are available. The other derives disaggregated data in accordance with some criterion. Both are discussed here in some detail.

Instrumental variables have received a lot of attention in the econometric literature (Johnston 1972, p. 278). They serve as proxies for variables that are specified in a model. Their selection is governed by a set of criteria which vary depending on the problem dealt with (Judge, Griffiths, Hill, and Lee 1980, p. 531). For the estimation problem investigated here, the instrumental variable should especially be (a) highly correlated with the independent variable, and (b) observed at the same disaggregated level as the dependent variable. Accordingly, the distribution pattern of the observations on the instrument over the disaggregated time periods will be used to break down the aggregated x_t series. In other words, if $z_{t,i}$ denotes an instrument for $x_{t,i}$, an instrumental variable model can be specified as

$$x_{t,i} = \phi z_{t,i} + v_{t,i} \tag{2}$$

which describes the relationship between the instrument and the variable for which it serves as proxy.

When the instrument is highly correlated with the original variable, the derived disaggregated observations on the independent variable will be close to the actual but unobserved series and accurate model parameters can be obtained. Specific approaches on how to disaggregate observations with the use of an instrument are discussed in Chow and Lin (1971, 1976), Dagenais

(1973), and Chang and Liu (1951). The best linear unbiased (BLU) prediction derived by Chow and Lin (1971, 1976) is particularly appealing. Here, the disaggregated observations are derived as

$$\hat{x}_{t,i} = \phi z_{t,i} + \frac{1}{n} (x_t - \phi \dot{z}_t) \tag{3}$$

where $z_t = \sum_{i=1}^{n} z_{t,i}$. Assuming that all $v_{t,i}$ in (2) are independently and identically distributed according to a normal distribution, the predictions are identical to the minimum mean squared error predictions which can be derived in a likelihood framework. With respect to these predictions, two observations question the validity and practicality of this approach in the estimation problem of interest.

First, before the predicted observations can be derived, an estimate of parameter ϕ is needed. A least squares estimate can be obtained from instrumental variable (2) using the <u>aggregated</u> data on x_t and z_t . Accordingly, this aggregated estimate will have the various problems mentioned above.

Second, the selection of instruments in practice is not without difficulty. The validity of an instrument is hard to assess a priori as the lack of observations makes it impossible to test for the criterion of high correlation. Note, however, that a set of dummy variables as instruments often is sufficient to derive efficient estimates of temporally disaggregated data (Chow and Lin 1976). The impact of selecting an inaccurate instrument on the final estimation results will be investigated numerically later. Note, however, that if proxy $z_{t,i}$ is not a good instrument for $x_{t,i}$, the ϕ estimate could be statistically insignificant which would, according to expression (3), result in BLU predictions of equal distribution, or $\hat{x}_{t,i} = (x_t/n)$.

An alternative to instrumental variable models is to derive disaggregated data according to some explicit criterion. Lisman and Sandee (1964) suggest a simple method for deriving disaggregated time-series as a solution to a system of equations. The criteria they investigate are quite arbitrary, however,

and might not always be applicable. Glesjer (1966) extended Lisman and Sandee's work to a method which sequentially narrows the time interval of the data. Improved methods were studied by Boot, Feibes, and Lisman (1967) using minimum squared first difference and second difference criteria. These methods are computationally intensive. Doran (1974) suggests minimizing mean squared errors subject to the constraint that the sum of the disaggregated observations equals the aggregated observations. As his least squares approach requires the knowledge of variance-covariance matrices in the unobserved variables, he can only obtain desirable results for stationary series using some methods popular in time-series analysis. Despite their theoretical elegance, these approaches seem to be ill suited for the partial aggregation estimation problem.

In summary, a variety of two-step procedures exist for sequentially deriving time-series observations and parameter estimates. The latter are all least squares estimates which do not have the traditional statistical properties because they are based on stochastic regressors. Accordingly, the parameter estimates will have at best desirable asymptotic properties (Johnston 1972, p. 267). On most occasions, however, the estimates are inconsistent (Palm and Nijman 1984). Furthermore, recent theoretical work indicates that performing both steps simultaneously can lead to greater efficiency of the parameter estimates (see, e.g., Hsiao 1979). This finding gives rise to one-step approaches.

2. One-Step Procedures

One step procedures are favored over two-step procedures because of potential increases in efficiency. Two basic approaches exist. First, the estimation problem can be viewed as a special case of the missing data problem, and the missing disaggregated data are either integrated out of the likelihood function or estimated simultaneously with the model parameters. Second, the missing disaggregated data are approximated by either an instrumental variable or a prior distribution. Both approaches are discussed in some detail now with attention to their usefulness in the partial aggregation estimation problem.

Estimation with missing observations has received a lot of attention in the econometrics and statistics literatures (Anderson 1957, Beale and Little 1975, Box, Draper, and Hunter 1970, DeGroot and Goel 1980, Dempster, Laird, and Rubin 1977, Dunsmuir and Robinson 1981, Gourieroux and Monfort 1981, Hartley and Hocking 1971, Little and Rubin 1983, Press and Scott 1976, Rubin 1972, 1974, 1976, Stewart and Sorenson 1981, Trawinski and Bargman 1964). Two basic approaches exist: the full (or complete-data) likelihood approach and the integrated likelihood approach.

The full likelihood approach consists of maximizing the complete-data likelihood function with respect to the parameter vector and the disaggregate $x_{t,i}$ for all t and i= 1, 2, ..., n-1 (Rubin 1972, DeGroot and Goel 1980, Press and Scott 1976, Box, Draper, and Hunter 1970). In theory, this approach could be applied to the estimation problem of interest here. However, two difficulties arise. First, in the case of estimation with partially aggregated data the number of parameters increases with the number of observations which makes the approach impractical. Second, the optimal statistical properties of maximum likelihood are obtained only when (a) the number of missing observations tends to zero as the sample size increases, and (b) the observations are missing at random (Rubin 1976). The latter two conditions clearly are not satisfied here which makes the approach statistically non-optimal.

In the integrated likelihood approach, the missing disaggregated observations essentially are integrated out of the complete-data likelihood function (Dempster, Laird, and Rubin 1977, Rubin 1976, Little and Rubin 1983). In contrast to the full likelihood, the number of parameters which need to be estimated is not affected by sample size. However, two caveats remain. First, the evaluation of multiple integrals poses practical problems. Second, as was the case with the complete-data likelihood approach, optimal statistical properties are not obtained as the disaggregated observations on the independent predictor are not missing at random.

Two alternative approaches which are based on integrated likelihood functions can be followed which do secure the optimal properties of maximum likelihood. One approach incorporates an instrumental variable into the likelihood function as a proxy to the unobserved disaggregated series. This

conditional likelihood approach was introduced by Hsiao (1979). Another approach would be to define a Bayesian prior on the distribution of the aggregated predictor and derive posterior model parameter estimates.

The conditional likelihood estimator is consistent and robust in efficiency (Hsiao 1979). Palm and Nijman (1982) show that in a linear model without stochastic regressors, Hsiao's estimator is consistent but less efficient than the joint maximum likelihood estimator of all parameters simultaneously. However, their numerical results show that the inefficiency is very small particularly relative to the inefficiency of the least squares estimators based on temporally aggregated data. Accordingly, the conditional likelihood estimator has in general good asymptotic properties.

Palm and Nijman (1982) also provide an alternative predictor to (3) for the disaggregated predictor series. Their predictor uses all related series. In other words, besides the instrumental variable model (from which (3) is derived), the model itself is incorporated. This prediction is appealing theoretically, but it requires temporally aggregated estimates on the model parameters which can be severely biased and inconsistent. Furthermore, relative to Hsiao's estimator (as discussed shortly) , the estimator is not easily extended to cases where $n > 2$.

Practically, the conditional likelihood approach requires the analytic evaluation of multiple integrals. Hsiao only solved the case of a static model with $n = 2$. For dynamic response model (1), it can be shown that the estimates which are obtained for the disaggregated predictor series (i.e., the $x_{i,t}$'s) are the minimum mean squared error predictions and equal the BLU predictions derived by Doran (1974) discussed above. Furthermore, the ϕ estimate is (a) obtained from temporally aggregated observations on the instrument and the independent variable (i.e., z_t and x_t), and (b) independent of the other parameter estimates. This result indicates a practical extension for $n > 2$. Specifically, for $n > 2$, ϕ could be estimated with the available x_t data, and minimum mean squared error predictions for the independent variable could be derived using expression (3). In order to secure full use of the instrumental variable observations, those independent variable observations should be predicted for time periods which are twice as long as the time

periods of the $y_{t,i}$ data. In a second step, the conditional likelihood procedure for $n = 2$ can be implemented. Note, however, that the suggested extension is only strictly applicable for $n > 2$ but n being a multiple of 2, and that it will result in efficient estimates provided ϕ is estimated efficiently.

Two practical issues come to mind in relation to the conditional likelihood approach. The estimation requires the use of numerical optimization techniques and the selection of an instrument which, as discussed above, is difficult in practice. These potential difficulties raise the possibility of approaching integrated likelihood from an Bayesian perspective using the posterior likelihood.

In the posterior likelihood method, the distribution of the aggregated x_t observations over the disaggregated time periods could be captured in some prior distribution. Maximizing the posterior likelihood function would provide estimates for the parameters of the model and of the prior density. This approach has practical appeal as no instrument needs to be specified. However, a prior density needs to be selected. In general, specifying a prior should be easier than selecting an instrument. For example, a non-informative prior such a uniform distribution (Leamer 1978, p.61) could be used. This prior is very non-committal, is consistent with the Bayes-Laplace principle of insufficient reason (Jeffreys 1961), and in essence coincides with the minimum mean squared error prediction (and, hence, the BLU prediction) when inaccurate instruments are relied upon. Note, furthermore, that from a Bayesian perspective, the conditional likelihood method discussed above is a posterior likelihood approach which uses an instrument as a "dogmatic" prior. Use of such a prior can affect the statistical properties of the derived estimates when the instrument is improper (Leamer 1978).

The posterior likelihood method, currently undeveloped, should be a fruitful avenue for future research as it would retain the optimal properties of maximum likelihood without having to select and justify particular instruments. Its practical value would depend on the feasibility of solving analytically the multiple integrals involved.

In summary, when faced with data subject to different temporal aggregation, a number of alternative methods exist to estimate a dynamic response model. The various approaches with references and some general characteristics are summarized in **Table 1.** As can be observed there and was discussed at length above, these approaches either have no known statistical properties or at best have desirable asymptotic properties. In practice, sample sizes are often limited. Hence, the optimal asymptotic properties are seldom achieved and the question arises of how well these approaches will perform when small samples are available. Furthermore, practical difficulties in identifying a proper instrumental variable often result in the use of inaccurate proxy variables. Hence, the question arises of how well some of these approaches will recover the parameters given inaccurate instruments. These two questions were addressed numerically.

III. SOME NUMERICAL RESULTS

Some of the estimators discussed above have major drawbacks on theoretical grounds. Others are not yet fully developed or they are limited in their applicability. Accordingly, only a subset was investigated. For the two-step procedures, two disaggregated least squares estimators were incorporated. One is based on BLU predictions of the disaggregated predictor series and the other is based on equally distributed predictor series over the disaggregated time periods. Of the one-step procedures, the conditional likelihood estimator and its simple extension were considered. The numerical framework within which these estimators were evaluated is described in Appendix 1.

Four general observations characterize the simulation results. First, the parameter of the lagged dependent variable generally was underestimated and the parameter of the independent variable was over-estimated. This result is consistent with empirical findings on the data interval bias (see, e.g., Vanhonacker 1983, Weinberg and Weiss 1982). Second, the least squares estimates derived from equal distribution and BLU predictions are very similar. This is consistent with the discussion above which indicated that

Table 1

APPROACHES TO ESTIMATING A DYNAMIC RESPONSE MODEL

WHEN DATA ARE SUBJECT TO DIFFERENT TEMPORAL AGGREGATION

	ESTIMATION APPROACH		SOME REFERENCES	GENERAL COMMENTS
Two-Step Procedures	Aggregation of Response Variable Observations	Uncorrected Estimates	Traditional Approach	- Inefficient - Aggregation bias - Do not use all data
		Corrected Estimates	Bass and Leone (1983, 1986) Weiss, Weinberg and Windal (1983) Kanetkar, Weinberg and Weiss (1986a, 1986b)	- Unknown statistical properties - Do not use all data - Non-unique estimates
	Criteria Disaggregation of Independent Variable Observations	Explicit (1964)	Lisman and Sandee criteria Boot, Febies and Lisman (1967) Doran (1974)	- Arbitrary - Unknown statistical properties
		Instrumental Variable	Chow and Lin (1971, 1976) Dagenais (1973) Chang and Liu (1951)	- Instrumental variable selection - Unknown statistical properties
One-Step Procedures	Complete-Data Likelihood		Rubin (1972) DeGroot and Goel (1980) Press and Scott (1976) Box, Draper, and Hunter (1970)	- Number of parameters increases with sample size - No optimal properties of maximum likelihood - Analytically complex
	Integrated Likelihood	Integrated Maximum Likelihood	Dempster, Laird and Rubin (1977) Rubin (1976)	- No optimal properties of maximum likelihood - Analytically complex
		Conditional Maximum ' Likelihood	Hsiao (19779) Palm and Nijman (1982)	- Analytically complex - Instrumental variable selection - Consistent but not most efficient
		Posterior Maximum Likelihood	Currently Undeveloped	- Prior density selection - Analytically complex

the use of poor proxies may lead to insignificant estimates of the parameter ϕ in (2), resulting in BLU predictions which equal a rectangular distribution. Because of the similarity, only the BLU prediction results will be reported hereafter. Third, consistent with intuition, increased temporal aggregation of the independent variable series relative to the response variable series translates into less accurate parameter estimates, particularly when the proxy is poor. Finally, the conditional likelihood estimator (CLE) consistently outperformed the other estimators investigated. For illustrative purposes, Table 2 contains mean squared error results for the two best performing estimators, the disaggregated least squares estimator based on BLU predictions and the conditional likelihood estimator. As can be seen there, in all cells of the design the conditional likelihood estimator performs very well despite its reliance on an inaccurate instrument in some instances.

IV. SUMMARY, CONCLUSIONS, AND DIRECTIONS FOR FUTURE RESEARCH

In estimating dynamic models using secondary data, it often happens that the observations on the variables are subject to different temporal aggregation. Estimating a model with this type of data is not straightforward particularly when (a) estimates with good statistical properties are desired, and (b) full use of all the data is required. This paper provided an overview and discussion of various approaches currently available to solve the estimation problem when independent variables are observed less frequently than the dependent variable.

A distinction was made between two-step and one-step procedures. In the two-step procedures, the data is modified first to arrive at observations with identical aggregation or disaggregation levels. The model parameters are estimated in the second step using traditional least squares. In the one-step procedures, both steps are performed simultaneously in a likelihood framework.

The theoretical discussion of these approaches revealed that all of them at best have desirable asymptotic properties. Furthermore, the one-step procedures are known to be more efficient. The numerical results indicate that estimators which use the temporally disaggregated observations on the

Table 2

MEAN SQUARED ERROR RESULTS[a]

Level of Partial Aggregation[b] (n)	Instrumental Variable Data Pattern ($z_{t,i}$)	Residual Variance in Instrumental Variable Model (σ_v^2)	Sample Size Tn = 60 BLU	Sample Size Tn = 60 CLE	Sample Size Tn = 120 BLU	Sample Size Tn = 120 CLE
n = 2	Linearly Increasing	125.0	0.0010	0.0000	0.0008	0.0000
		12,500.0	0.0063	0.0000	0.0049	0.0000
		1,250,000.0	0.0092	0.0000	0.0056	0.0000
	Random Around Fixed Mean	125.0	0.0020	0.0000	0.0004	0.0000
		12,500.0	0.0073	0.0000	0.0021	0.0000
		1,250,000.0	0.0102	0.0000	0.0052	0.0000
n = 4	Linearly Increasing	125.0	0.0013	0.0000	0.0011	0.0000
		12,500.0	0.0501	0.0001	0.0349	0.0000
		1,250,000.0	0.1188	0.0010	0.0519	0.0008
	Random Around Fixed Mean	125.0	0.0031	0.0000	0.0008	0.0000
		12,500.0	0.0195	0.0001	0.0157	0.0000
		1,250,000.0	0.1247	0.0016	0.0489	0.0010
n = 6	Linearly Increasing	125.0	0.0018	0.0000	0.0011	0.0000
		12,500.0	0.1037	0.0001	0.0488	0.0000
		1,250,000.0	0.2650	0.0013	0.1249	0.0006
	Random Around Fixed Mean	125.0	0.0110	0.0000	0.0023	0.0000
		12,500.0	0.1110	0.0001	0.0245	0.0000
		1,250,000.0	0.2634	0.0015	0.1210	0.0011

a BLU = Best Linear Unbiased Prediction, CLE = Conditional Likelihood Estimation

b Level of aggregation of response variable relative to the independent variable.

response variable and an instrumental variable recover the parameter values much better than those using only the aggregated data or no instrument. In particular, the conditional likelihood estimator provided accurate parameter estimates despite high residual variance in its underlying instrument. Together with their superior asymptotic properties discussed above, this result indicates that one-step approaches to the partial aggregation estimation problem should be preferred in practice irrespective of sample size and even when a valid instrument is hard to obtain.

The favorable results for one-step procedures suggests that a Bayesian extension where the instrument would be replaced with a prior density could become a powerful estimator for the problem of interest and future research efforts should be devoted to the development of such an estimator.

REFERENCES

Amemiya, T. and R. Y. Wu (1972), "Effect of Aggregation of Prediction in the Autoregressive Model," Journal of the American Statistical Association, 67, 628-632.

Anderson, T. W. (1957), "Maximum Likelihood Estimates for a Multivariate Normal Distribution When Some Observations are Missing," Journal of the American Statistical Association, 52, 200-203.

Bass, F. M. and R. P. Leone (1983), "Temporal Aggregation, the Data Interval Bias and Empirical Estimation of Bimonthly Relations from Annual Data," Management Science, 29, 1-11.

Beale, E. M. L., and R. J. Little (1975), "Estimating Micro Relationships From Macro Data: A Comparative Study of Two Approximations of the Brand Loyal Model Under Temporal Aggregation," Journal of Marketing Research, 23 (August), 291-297.

Boot, J. C. G., W. Feibes, and J. H. C. Lisman (1967), "Further Methods of Derivation of Quarterly Figures from Annual Data," Journal of the Royal Statistical Society, Series C, 16, 65-75.

Box, M. J., Draper, N. R., and W. G. Hunter (1970), "Missing Values in Multi-Response Nonlinear Data Fitting," Technometrics, 12, 613-620.

Cagan, P. (1956), "The Monetary Dynamics of Hyper Inflation," in Friedman (ed.), Studies in the Quantity Theory of Money. Chicago, Ill.: Univ. of Chicago Press.

Chang, C. and T. Liu (1951), "Monthly Estimates of Certain National Product Components, 1946-1949," The Review of Economics and Statistics, 33, 219-227.

Chow, G. and A. L. Lin (1971), "The Best Linear Unbiased Interpolation, Distribution, and Extrapolation of Time Series by Related Series," Review of Economics and Statistics, 53, 372-375.

Chow, G. and A. L. Lin (1976), "Best Linear Unbiased Estimation of Missing Observations in an Economic Time Series," Journal of the American Statistical Association, 71, 719-721.

Clarke, D. G. (1976), "Econometric Measurement of the Duration of Advertising Effect on Sales," Journal of Marketing Research, 13, 345-357.

Dagenais, M. G. (1973), "The Use of Incomplete Observations in Multiple Regression Analysis," Journal of Econometrics, 4, 317-328.

DeGroot, M. H., and K. Goel (1980), "Estimation of the Correlation Coefficient from a Broken Random Sample," Annals of Statistics, 8, 264-278.

Dempster, A. P., Laird, N., and D. B. Rubin (1977), "Maximum Likelihood from Incomplete Data via the EM Algorithm," Journal of the royal Statistical Association, 69, 546-554.

Dunsmuir, W., and P.M. Robinson (1981), "Estimation of Time Series Models in the Presence of Missing Data," Journal of the American Statistical Association, 76, 560-568.

Farebrother, R. W. (1979), "Estimation with Aggregated Data," Journal of Econometrics, 10, 43-55.

Friedman, M. (1962), "The Interpolation of Time Series by Related Series," Journal of the American Statistical Association, 57, 729-757.

Glesjer, H. (1966), "Une Méthode d'Evaluation de Données Mensuelles à Partir d'Indices Trimestriels ou Annuels," Cahiers Economiques de Bruxelles, 19, 45-54.

Gourieroux, Ch. and A. Monfort (1981), "On the Problem of Missing Data in Linear Models," Review of Economic Studies, 48, 579-586.

Hartley, H. O., and R. R. Hocking (1971), "The Analysis of Incomplete Data," Biometrics, 27, 783-808.

Hsiao, C. (1979), "Linear Regression Using Both Temporally Aggregated and Temporally Disaggregated Data," Journal of Econometrics, 10, 243-252.

IMSL Library, Edition 8 (1980). Houston, Texas: IMSL.

Jeffreys, H. (1961), Theory of Probability, London, England: Oxford University Press.

Johnston, J. (1972), Econometric Methods, Second Edition. New York, N.Y.: McGraw-Hill.

Judge, G. G., W. E. Griffiths, R. C. Hill, and T.C. Lee (1980), The Theory and Practice of Econometrics. New-York, NY: J. Wiley.

Kanetkar, V., C. B. Weinberg, and D. L. Weiss (1986a), "Recovering Micro Parameters From Aggregate Data for the Kyock and Brand Loyal Models," Journal of Marketing Research, 23 (August), 298-304.

Kanetkar, V., C. B. Weinberg, and D. L. Weiss (1986b), "Estimating Parameters of the Autocorrelated Current Effects Model from Temporally Aggregated Data," Journal of Marketing Research, 23 (November), 379-386.

Leamer, E. E. (1978), Specification Searches, New York, NY: J. Wiley and Sons.

Lisman, J. H. C. and J. Sandee (1964), "Derivation of Quarterly Figures from Annual Data," Journal of the Royal Statistical Society, Series C, 13, 87-90.

Little, R. J., and D. B. Rubin (1983), "On Jointly Estimating Parameters and Missing Data by Maximizing the Complete-Data Likelihood," The American Statistician, 37, 218-220.

Liu, T. C. (1969), "A Monthly Recursive Econometric Model of the United States: A Test of Feasibility," The Review of Economics and Statistics, 51, 1-13.

Moriguchi, C. (1970), "Aggregation Over Time in Macroeconomic Relations," International Economic Review, 11, 427-440.

Mundlak, Y. (1961), "Aggregation Over Time in Macroeconomic Relations," International Economic Review, 2, 154-163.

Nerlove, M. (1956), "Estimates of Elasticities of Supply of Selected Agricultural Commodities," Journal of Farm Economics, Vol. 38, pp. 496-509.

Nerlove, M. (1958), Distributed Lags and Demand Analysis. USDA, Agricultural Handbook No. 14, Washington, June.

Palda, K. S. (1964), The Measurement of Cumulative Advertising Effects, Englewood Cliffs, NJ: Prentice-Hall.

Palm, F. C., and T. E. Nijman (1982), "Linear Regression Using Both Temporally Aggregated and Temporally Disaggregated Data," Journal of Econometrics, 19, 333-1435.

Palm, F. C., and T. E. Nijman (1984), "Missing Observations in the Dynamic Regression Model," Econometrica, 52, 1415-1435.

Press, S. J., and A. J. Scott (1976), "Missing Variables in Bayesian Regression, II," Journal of the American Statistical Association, 71, 366-369.

Rowe, R. D. (1976), "The Effects of Aggregation Over Time on t-Ratios and R^2s," International Economic Review, 17, 751-757.

Rubin, D. B. (1972), "A Non-Iterative Algorithm for Least Sqaures Estimation of Missing Values in any Analysis of Variance Design," Journal of the Royal Statistical Society, Ser. C., 21, 136-141.

Rubin, D. B. (1974), "Characterizing the Estimation of Parameters in Incomplete-Data Problems," Journal of the American Statistical Association, 69, 467-474.

Rubin, D. B. (1976), "Inference and Missing Data," Biometrika, 63, 581-592.

Stewart, W. E., and J. P. Sorenson (1981), "Bayesian Estimation of Common Parameters from Multiresponse Data with Missing Observations," Technometrics, 23, 131-146.

Trawinski, I. M., and R. E. Bargman (1964), "Maximum Likelihood Estimates with Incomplete Data," Annals of Mathematical Statistics, 35, 647-657.

Vanhonacker, W. R. (1983), "Carryover Effects and Temporal Aggregation in a Partial Adjustment Model Framework," Marketing Science, 2, 297-317.

Vanhonacker, W. R. (1984), "Estimation and Testing of a Dynamic Sales Response Model with Data Aggregated Over Time: Some Results for the Autoregressive Current Effects Model," Journal of Marketing Research, 21, 445-455.

Weiss, D. L., C. B. Weinberg, and P. M. Windal (1983), "The Effects of Serial Correlation and Data Aggregation on Advertising Measurement," Journal of Marketing Research, 20, 268-279.

Weinberg, C. B. and D. L. Weiss (1982), "On the Econometric Measurement of the Duration of Advertising Effect on Sales," Journal of Marketing Research, 19, 585-591.

Zellner, A. and C. Montmarquette (1971), "A Study of Some Aspects of Temporal Aggregation Problems in Econometric Analyses," The Review of Economics and Statistics, 11, 444-454.

APPENDIX 1: MONTE CARLO SIMULATION DESIGN

The relative performance of various estimators was evaluated in a Monte Carlo experimental framework. Observations were generated according to equations (1) and (2). Response parameters were fixed as follows: the lagged dependent variable parameter γ was set equal to 0.8, the independent variable parameter γ was set equal to 2.0, and the instrumental variable parameter ϕ was set at 0.9. The random components of the system (i.e., $v_{i,t}$ and $u_{i,t}$) were generated from a multivariate normal distribution using the GGNSM routine of IMSL (IMSL 1980). The variables manipulated in the design are shown in Table 1.1.

With respect to the instrumental variable model (2), two variables were manipulated: the time-series pattern of the observations on the instrument and the variance parameter of the disturbances. For the observations on the instrument, two patterns were considered which together capture a wide variety of possible series. The random distribution around a fixed mean served as a base pattern. The linearly increasing pattern was considered primarily to assess the impact of ignoring systematic variation in the independent variable series (in this case, a trend component). The variance parameter of the disturbances $v_{t,i}$ was varied as a manipulation of (a) instrument accuracy, (b) serial correlation in the disturbances of the instrumental variable model, and (c) multicollinearity if multiple instruments were specified in model (2). All three elements affect the efficiency of the parameter estimates of model (2). All three effects were captured in a single experimental factor as their impact on the estimates of γ and δ in (1) is likely to be similar. Furthermore, it simplifies the experimental design significantly.

The sample sizes for disaggregated observations were set at 60 and 120. Partial aggregation was considered for n equal to 2, 4, and 6. For each cell of the design, 50 replications were performed. Accordingly, all results discussed are mean values for 50 different sets of estimates.

Table 1-1

VARIABLES MANIPULATED IN MONTE CARLO SIMULATION DESIGN

Variable	Levels
1. Observations on Instrumental Variable	- Linearly increasing: $z_{t,i} = z_{t,\ i-1} + 5.0$ - Random around fixed mean: $z_{t,i} = 500.0 + \xi_{t,i}$ with $\xi_{t,i}$ i.i.d. N(0,5)
2. Variance of Disturbances in Instrumental Variable Model (σ_v^2)	- $\sigma_v^2 = 125.0$ - $\sigma_v^2 = 12,500.0$ - $\sigma_v^2 = 1,250,000.0$
3. Number of Disaggregated Dependent Variable Observations (Tn)	- Tn = 120 - Tn = 60
4. Levels of Partial Aggregation (n)	- n = 2 - n = 4 - n = 6

INSEAD WORKING PAPERS SERIES

1986

86/01	Arnoud DE MEYER	"The R & D/Production interface".
86/02	Philippe A. NAERT Marcel WEVERBERGH and Guido VERSWIJVEL	"Subjective estimation in integrating communication budget and allocation decisions: a case study", January 1986.
86/03	Michael BRIMM	"Sponsorship and the diffusion of organizational innovation: a preliminary view".
86/04	Spyros MAKRIDAKIS and Michèle HIBON	"Confidence intervals: an empirical investigation for the series in the M-Competition" .
86/05	Charles A. WYPLOSZ	"A note on the reduction of the workweek", July 1985.
86/06	Francesco GIAVAZZI, Jeff R. SHEEN and Charles A. WYPLOSZ	"The real exchange rate and the fiscal aspects of a natural resource discovery", Revised version: February 1986.
86/07	Douglas L. MacLACHLAN and Spyros MAKRIDAKIS	"Judgmental biases in sales forecasting", February 1986.
86/08	José de la TORRE and David H. NECKAR	"Forecasting political risks for international operations", Second Draft: March 3, 1986.
86/09	Philippe C. HASPESLAGH	"Conceptualizing the strategic process in diversified firms: the role and nature of the corporate influence process", February 1986.
86/10	R. MOENART, Arnoud DE MEYER, J. BARBE and D. DESCHOOLMEESTER.	"Analysing the issues concerning technological de-maturity".
86/11	Philippe A. NAERT and Alain BULTEZ	"From "Lydiametry" to "Pinkhamization": misspecifying advertising dynamics rarely affects profitability".
86/12	Roger BETANCOURT and David GAUTSCHI	"The economics of retail firms", Revised April 1986.
86/13	S.P. ANDERSON and Damien J. NEVEN	"Spatial competition à la Cournot".
86/14	Charles WALDMAN	"Comparaison internationale des marges brutes du commerce", June 1985.
86/15	Mihkel TOMBAK and Arnoud DE MEYER	"How the managerial attitudes of firms with FMS differ from other manufacturing firms: survey results". June 1986.
86/16	B. Espen ECKBO and Herwig M. LANGOHR	"Les primes des offres publiques, la note d'information et le marché des transferts de contrôle des sociétés".
86/17	David B. JEMISON	"Strategic capability transfer in acquisition integration", May 1986.
86/18	James TEBOUL and V. MALLERET	"Towards an operational definition of services", 1986.
86/19	Rob R. WEITZ	"Nostradamus: a knowledge-based forecasting advisor".
86/20	Albert CORHAY, Gabriel HAWAWINI and Pierre A. MICHEL	"The pricing of equity on the London stock exchange: seasonality and size premium", June 1986.
86/21	Albert CORHAY, Gabriel A. HAWAWINI and Pierre A. MICHEL	"Risk-premia seasonality in U.S. and European equity markets", February 1986.
86/22	Albert CORHAY, Gabriel A. HAWAWINI and Pierre A. MICHEL	"Seasonality in the risk-return relationships some international evidence", July 1986.
86/23	Arnoud DE MEYER	"An exploratory study on the integration of information systems in manufacturing", July 1986.
86/24	David GAUTSCHI and Vithala R. RAO	"A methodology for specification and aggregation in product concept testing", July 1986.
86/25	H. Peter GRAY and Ingo WALTER	"Protection", August 1986.
86/26	Barry EICHENGREEN and Charles WYPLOSZ	"The economic consequences of the Franc Poincare", September 1986.
86/27	Karel COOL and Ingemar DIERICKX	"Negative risk-return relationships in business strategy: paradox or truism?", October 1986.
86/28	Manfred KETS DE VRIES and Danny MILLER	"Interpreting organizational texts.
86/29	Manfred KETS DE VRIES	"Why follow the leader?".
86/30	Manfred KETS DE VRIES	"The succession game: the real story.
86/31	Arnoud DE MEYER	"Flexibility: the next competitive battle", October 1986.
86/31	Arnoud DE MEYER, Jinichiro NAKANE, Jeffrey G. MILLER and Kasra FERDOWS	"Flexibility: the next competitive battle", Revised Version: March 1987
86/32	Karel COOL and Dan SCHENDEL	Performance differences among strategic group members", October 1986.

86/33	Ernst BALTENSPERGER and Jean DERMINE	"The role of public policy in insuring financial stability: a cross-country, comparative perspective", August 1986, Revised November 1986.
86/34	Philippe HASPESLAGH and David JEMISON	"Acquisitions: myths and reality", July 1986.
86/35	Jean DERMINE	"Measuring the market value of a bank, a primer", November 1986.
86/36	Albert CORHAY and Gabriel HAWAWINI	"Seasonality in the risk-return relationship: some international evidence", July 1986.
86/37	David GAUTSCHI and Roger BETANCOURT	"The evolution of retailing: a suggested economic interpretation".
86/38	Gabriel HAWAWINI	"Financial innovation and recent developments in the French capital markets", Updated: September 1986.
86/39	Gabriel HAWAWINI Pierre MICHEL and Albert CORHAY	"The pricing of common stocks on the Brussels stock exchange: a re-examination of the evidence", November 1986.
86/40	Charles WYPLOSZ	"Capital flows liberalization and the EMS, a French perspective", December 1986.
86/41	Kasra FERDOWS and Wickham SKINNER	"Manufacturing in a new perspective", July 1986.
86/42	Kasra FERDOWS and Per LINDBERG	"FMS as indicator of manufacturing strategy", December 1986.
86/43	Damien NEVEN	"On the existence of equilibrium in hotelling's model", November 1986.
86/44	Ingemar DIERICKX Carmen MATUTES and Damien NEVEN	"Value added tax and competition", December 1986.

1987

87/01	Manfred KETS DE VRIES	"Prisoners of leadership".
87/02	Claude VIALLET	"An empirical investigation of international asset pricing", November 1986.
87/03	David GAUTSCHI and Vithala RAO	"A methodology for specification and aggregation in product concept testing", Revised Version: January 1987.
87/04	Sumantra GHOSHAL and Christopher BARTLETT	"Organizing for innovations: case of the multinational corporation", February 1987.
87/05	Arnoud DE MEYER and Kasra FERDOWS	"Managerial focal points in manufacturing strategy", February 1987.
87/06	Arun K. JAIN, Christian PINSON and Naresh K. MALHOTRA	"Customer loyalty as a construct in the marketing of banking services", July 1986.
87/07	Rolf BANZ and Gabriel HAWAWINI	"Equity pricing and stock market anomalies", February 1987.
87/08	Manfred KETS DE VRIES	"Leaders who can't manage", February 1987.
87/09	Lister VICKERY, Mark PILKINGTON and Paul READ	"Entrepreneurial activities of European MBAs", March 1987.
87/10	André LAURENT	"A cultural view of organizational change", March 1987
87/11	Robert FILDES and Spyros MAKRIDAKIS	"Forecasting and loss functions", March 1987.
87/12	Fernando BARTOLOME and André LAURENT	"The Janus Head: learning from the superior and subordinate faces of the manager's job", April 1987.
87/13	Sumantra GHOSHAL and Nitin NOHRIA	"Multinational corporations as differentiated networks", April 1987.
87/14	Landis GABEL	"Product Standards and Competitive Strategy: An Analysis of the Principles", May 1987.
87/15	Spyros MAKRIDAKIS	"METAFORECASTING: Ways of improving Forecasting. Accuracy and Usefulness", May 1987.
87/16	Susan SCHNEIDER and Roger DUNBAR	"Takeover attempts: what does the language tell us?, June 1987.
87/17	André LAURENT and Fernando BARTOLOME	"Managers' cognitive maps for upward and downward relationships", June 1987.
87/18	Reinhard ANGELMAR and Christoph LIEBSCHER	"Patents and the European biotechnology lag: a study of large European pharmaceutical firms", June 1987.
87/19	David BEGG and Charles WYPLOSZ	"Why the EMS? Dynamic games and the equilibrium policy regime, May 1987.
87/20	Spyros MAKRIDAKIS	"A new approach to statistical forecasting", June 1987.
87/21	Susan SCHNEIDER	"Strategy formulation: the impact of national culture", Revised: July 1987.
87/22	Susan SCHNEIDER	"Conflicting ideologies: structural and motivational consequences", August 1987.
87/23	Roger BETANCOURT David GAUTSCHI	"The demand for retail products and the household production model: new views on complementarity and substitutability".

87/24	C.B. DERR and André LAURENT	"The internal and external careers: a theoretical and cross-cultural perspective", Spring 1987.
87/25	A. K. JAIN, N. K. MALHOTRA and Christian PINSON	"The robustness of MDS configurations in the face of incomplete data", March 1987, Revised: July 1987.
87/26	Roger BETANCOURT and David GAUTSCHI	"Demand complementarities, household production and retail assortments", July 1987.
87/27	Michael BURDA	"Is there a capital shortage in Europe?", August 1987.
87/28	Gabriel HAVAVINI	"Controlling the interest-rate risk of bonds: an introduction to duration analysis and immunization strategies", September 1987.
87/29	Susan SCHNEIDER and Paul SHRIVASTAVA	"Interpreting strategic behavior: basic assumptions themes in organizations", September 1987
87/30	Jonathan HAMILTON V. Bentley MACLEOD and J. F. THISSE	"Spatial competition and the Core", August 1987.
87/31	Martine QUINZII and J. F. THISSE	"On the optimality of central places", September 1987.
87/32	Arnoud DE MEYER	"German, French and British manufacturing strategies less different than one thinks", September 1987.
87/33	Yves DOZ and Amy SHUEN	"A process framework for analyzing cooperation between firms", September 1987.
87/34	Kasra FERDOWS and Arnoud DE MEYER	"European manufacturers: the dangers of complacency. Insights from the 1987 European manufacturing futures survey, October 1987.
87/35	P. J. LEDERER and J. F. THISSE	"Competitive location on networks under discriminatory pricing", September 1987.
87/36	Manfred KETS DE VRIES	"Prisoners of leadership", Revised version October 1987.
87/37	Landis GABEL	"Privatization: its motives and likely consequences", October 1987.
87/38	Susan SCHNEIDER	"Strategy formulation: the impact of national culture", October 1987.
87/39	Manfred KETS DE VRIES	"The dark side of CEO succession", November 1987
87/40	Carmen MATUTES and Pierre REGIBEAU	"Product compatibility and the scope of entry", November 1987
87/41	Gavriel HAVAVINI and Claude VIALLET	"Seasonality, size premium and the relationship between the risk and the return of French common stocks", November 1987
87/42	Damien NEVEN and Jacques-F. THISSE	"Combining horizontal and vertical differentiation: the principle of max-min differentiation", December 1987
87/43	Jean GABSZEVICZ and Jacques-F. THISSE	"Location", December 1987
87/44	Jonathan HAMILTON, Jacques-F. THISSE and Anita VESKAMP	"Spatial discrimination: Bertrand vs. Cournot in a model of location choice", December 1987
87/45	Karel COOL, David JEMISON and Ingemar DIERICKX	"Business strategy, market structure and risk-return relationships: a causal interpretation", December 1987.
87/46	Ingemar DIERICKX and Karel COOL	"Asset stock accumulation and sustainability of competitive advantage", December 1987.

1988

88/01	Michael LAWRENCE and Spyros MAKRIDAKIS	"Factors affecting judgemental forecasts and confidence intervals", January 1988.
88/02	Spyros MAKRIDAKIS	"Predicting recessions and other turning points", January 1988.
88/03	James TEBOUL	"De-industrialize service for quality", January 1988.
88/04	Susan SCHNEIDER	"National vs. corporate culture: implications for human resource management", January 1988.
88/05	Charles WYPLOSZ	"The swinging dollar: is Europe out of step?", January 1988.
88/06	Reinhard ANGELMAR	"Les conflits dans les canaux de distribution", January 1988.
88/07	Ingemar DIERICKX and Karel COOL	"Competitive advantage: a resource based perspective", January 1988.
88/08	Reinhard ANGELMAR and Susan SCHNEIDER	"Issues in the study of organizational cognition", February 1988.
88/09	Bernard SINCLAIR-DESGAGNé	"Price formation and product design through bidding", February 1988.
88/10	Bernard SINCLAIR-DESGAGNé	"The robustness of some standard auction game forms", February 1988.
88/11	Bernard SINCLAIR-DESGAGNé	"When stationary strategies are equilibrium bidding strategy: The single-crossing property", February 1988.

88/12	Spyros MAKRIDAKIS	"Business firms and managers in the 21st century", February 1988
88/13	Manfred KETS DE VRIES	"Alexithymia in organizational life: the organization man revisited", February 1988.
88/14	Alain NOEL	"The interpretation of strategies: a study of the impact of CEOs on the corporation", March 1988.
88/15	Anil DEOLALIKAR and Lars-Hendrik ROLLER	"The production of and returns from industrial innovation: an econometric analysis for a developing country", December 1987.
88/16	Gabriel HAWAWINI	"Market efficiency and equity pricing: international evidence and implications for global investing", March 1988.
88/17	Michael BURDA	"Monopolistic competition, costs of adjustment and the behavior of European employment", September 1987.
88/18	Michael BURDA	"Reflections on "Wait Unemployment" in Europe", November 1987, revised February 1988.
88/19	M.J. LAWRENCE and Spyros MAKRIDAKIS	"Individual bias in judgements of confidence", March 1988.
88/20	Jean DERMINE, Damien NEVEN and J.F. THISSE	"Portfolio selection by mutual funds, an equilibrium model", March 1988.
88/21	James TEBOUL	"De-industrialize service for quality", March 1988 (88/03 Revised).
88/22	Lars-Hendrik RÖLLER	"Proper Quadratic Functions with an Application to AT&T", May 1987 (Revised March 1988).
88/23	Sjur Didrik FLAM and Georges ZACCOUR	"Equilibres de Nash-Cournot dans le marché européen du gaz: un cas où les solutions en boucle ouverte et en feedback coïncident", Mars 1988
88/24	B. Espen ECKBO and Herwig LANGOHR	"Information disclosure, means of payment, and takeover premia. Public and Private tender offers in France", July 1985, Sixth revision, April 1988.
88/25	Everette S. GARDNER and Spyros MAKRIDAKIS	"The future of forecasting", April 1988.
88/26	Sjur Didrik FLAM and Georges ZACCOUR	"Semi-competitive Cournot equilibrium in multistage oligopolies", April 1988.
88/27	Murugappa KRISHNAN Lars-Hendrik RÖLLER	"Entry game with resalable capacity", April 1988.
88/28	Sumantra GHOSHAL and C. A. BARTLETT	"The multinational corporation as a network: perspectives from interorganizational theory", May 1988.
88/29	Naresh K. MALHOTRA, Christian PINSON and Arun K. JAIN	"Consumer cognitive complexity and the dimensionality of multidimensional scaling configurations", May 1988.
88/30	Catherine C. ECKEL and Theo VERMAELEN	"The financial fallout from Chernobyl: risk perceptions and regulatory response", May 1988.
88/31	Sumantra GHOSHAL and Christopher BARTLETT	"Creation, adoption, and diffusion of innovations by subsidiaries of multinational corporations", June 1988.
88/32	Kasra FERDOWS and David SACKRIDER	"International manufacturing: positioning plants for success", June 1988.
88/33	Mihkel M. TOMBAK	"The importance of flexibility in manufacturing", June 1988.
88/34	Mihkel M. TOMBAK	"Flexibility: an important dimension in manufacturing", June 1988.
88/35	Mihkel M. TOMBAK	"A strategic analysis of investment in flexible manufacturing systems", July 1988.
88/36	Vikas TIBREVALA and Bruce BUCHANAN	"A Predictive Test of the NBD Model that Controls for Non-stationarity", June 1988.
88/37	Murugappa KRISHNAN Lars-Hendrik RÖLLER	"Regulating Price-Liability Competition To Improve Welfare", July 1988.
88/38	Manfred KETS DE VRIES	"The Motivating Role of Envy : A Forgotten Factor in Management, April 88.
88/39	Manfred KETS DE VRIES	"The Leader as Mirror : Clinical Reflections", July 1988.
88/40	Josef LAKONISHOK and Theo VERMAELEN	"Anomalous price behavior around repurchase tender offers", August 1988.
88/41	Charles WYPLOSZ	"Assymetry in the EMS: intentional or systemic?", August 1988.
88/42	Paul EVANS	"Organizational development in the transnational enterprise", June 1988.
88/43	B. SINCLAIR-DESGAGNE	"Group decision support systems implement Bayesian rationality", September 1988.
88/44	Essam MAHMOUD and Spyros MAKRIDAKIS	"The state of the art and future directions in combining forecasts", September 1988.
88/45	Robert KORAJCZYK and Claude VIALLET	"An empirical investigation of international asset pricing", November 1986, revised August 1988.
88/46	Yves DOZ and Amy SHUEN	"From intent to outcome: a process framework for partnerships", August 1988.

88/47	Alain BULTEZ, Els GIJSBRECHTS, Philippe NAERT and Piet VANDEN ABEELE	"Asymmetric cannibalism between substitute items listed by retailers", September 1988.
88/48	Michael BURDA	"Reflections on 'Vait unemployment' in Europe, II", April 1988 revised September 1988.
88/49	Nathalie DIERKENS	"Information asymmetry and equity issues", September 1988.
88/50	Rob VEITZ and Arnoud DE MEYER	"Managing expert systems: from inception through updating", October 1987.
88/51	Rob VEITZ	"Technology, vork, and the organization: the impact of expert systems", July 1988.
88/52	Susan SCHNEIDER and Reinhard ANGELMAR	"Cognition and organizational analysis: who's minding the store?", September 1988.
88/53	Manfred KETS DE VRIES	"Vhatever happened to the philosopher-king: the leader's addiction to pover, September 1988.
88/54	Lars-Hendrik RÖLLER and Mihkel M. TOMBAK	"Strategic choice of flexible production technologies and velfare implications", October 1988
88/55	Peter BOSSAERTS and Pierre HILLION	"Method of moments tests of contingent claims asset pricing models", October 1988.
88/56	Pierre HILLION	"Size-sorted portfolios and the violation of the random valk hypothesis: Additional empirical evidence and implication for tests of asset pricing models", June 1988.
88/57	Wilfried VANHONACKER and Lydia PRICE	"Data transferability: estimating the response effect of future events based on historical analogy", October 1988.
88/58	B. SINCLAIR-DESGAGNE and Mihkel M. TOMBAK	"Assessing economic inequality", November 1988.
88/59	Martin KILDUFF	"The interpersonal structure of decision making: a social comparison approach to organizational choice", November 1988.
88/60	Michael BURDA	"Is mismatch really the problem? Some estimates of the Chelvood Gate II model vith US data", September 1988.
88/61	Lars-Hendrik RÖLLER	"Modelling cost structure: the Bell System revisited", November 1988.
88/62	Cynthia VAN HULLE, Theo VERMAELEN and Paul DE VOUTERS	"Regulation, taxes and the market for corporate control in Belgium", September 1988.
88/63	Fernando NASCIMENTO and Wilfried R. VANHONACKER	"Strategic pricing of differentiated consumer durables in a dynamic duopoly: a numerical analysis", October 1988.
88/64	Kasra FERDOWS	"Charting strategic roles for international factories", December 1988.
88/65	Arnoud DE MEYER and Kasra FERDOWS	"Quality up, technology down", October 1988.
88/66	Nathalie DIERKENS	"A discussion of exact measures of information assymetry: the example of Myers and Majluf model or the importance of the asset structure of the firm", December 1988.
88/67	Paul S. ADLER and Kasra FERDOWS	"The chief technology officer", December 1988.

1989

89/01	Joyce K. BYRER and Tawfik JELASSI	"The impact of language theories on DSS dialog", January 1989.
89/02	Louis A. LE BLANC and Tawfik JELASSI	"DSS software selection: a multiple criteria decision methodology", January 1989.
89/03	Beth H. JONES and Tawfik JELASSI	"Negotiation support: the effects of computer intervention and conflict level on bargaining outcome", January 1989.
89/04	Kasra FERDOWS and Arnoud DE MEYER	"Lasting improvement in manufacturing performance: In search of a nev theory", January 1989.
89/05	Martin KILDUFF and Reinhard ANGELMAR	"Shared history or shared culture? The effects of time, culture, and performance on institutionalization in simulated organizations", January 1989.
89/06	Mihkel M. TOMBAK and B. SINCLAIR-DESGAGNE	"Coordinating manufacturing and business strategies: I", February 1989.
89/07	Damien J. NEVEN	"Structural adjustment in European retail banking. Some viev from industrial organisation", January 1989.
89/08	Arnoud DE MEYER and Hellmut SCHÜTTE	"Trends in the development of technology and their effects on the production structure in the European Community", January 1989.
89/09	Damien NEVEN, Carmen MATUTES and Marcel CORSTJENS	"Brand proliferation and entry deterrence", February 1989.
89/10	Nathalie DIERKENS, Bruno GERARD and Pierre HILLION	"A market based approach to the valuation of the assets in place and the growth opportunities of the firm", December 1988.

89/11	Manfred KETS DE VRIES and Alain NOEL	"Understanding the leader-strategy interface: application of the strategic relationship interview method", February 1989.