"EXPONENTIAL SMOOTHING: THE EFFECT OF INITIAL VALUES AND LOSS FUNCTIONS ON POST-SAMPLE FORECASTING ACCURACY"

by

Spyros MAKRIDAKIS*
and
Michèle HIBON**

N° 91/23/TM
(Revision of 90/46)

* Research Professor of Decision Sciences and Information Systems, INSEAD, Boulevard de Constance, Fontainebleau 77305 Cedex, France.

** Research Associate at INSEAD Boulevard de Constance, Fontainebleau 77305 Cedex, France.

Printed at INSEAD,
Fontainebleau, France.

EXPONENTIAL SMOOTHING: THE EFFECT OF INITIAL VALUES AND LOSS FUNCTIONS ON POST-SAMPLE FORECASTING ACCURACY

Spyros MAKRIDAKIS and Michèle HIBON

INSEAD Fontainebleau France

EXPONENTIAL SMOOTHING: THE EFFECT OF INITIAL VALUES AND LOSS FUNCTIONS ON POST-SAMPLE FORECASTING ACCURACY

ABSTRACT

This paper describes an empirical investigation aimed at measuring the effect of different initial values and loss functions (both symmetric and asymmetric) on the post-sample forecasting accuracy. The 1001 series of the M-competition are used and three exponential smoothing methods are employed. The results are compared over various types of data and forecasting horizons and validated with additional data. The paper concludes that contrary to expectations, post-sample forecasting accuracies are not affected by the type of initial values used or the loss function employed in the great majority of cases.

Exponential smoothing methods are widely used in many industrial applications including production planning, production scheduling and inventory control (Brown, 1959; Brown, 1963; Brown, 1967; Gardner, 1985; Holt et al., 1960; Johnson and Montgomery, 1974; Makridakis and Wheelwright, 1989, Winters, 1960). Although extremely simple and easy to model, such methods have been found by many studies to be as accurate as more complex and statistically sophisticated alternatives (Groff, 1973; Chatfield, 1978; Koehler and Murphree, 1988; Makridakis and Hibon, 1979; Makridakis et al., 1982; Martin and Witt, 1989). Furthermore exponential smoothing methods are robust, easy to program, require a minimum of historical data while the cost of running them on the computer is the smallest of all available alternatives.

The purpose of this paper is to empirically investigate the effect of various initial values and loss functions on the post-sample forecasting accuracy of three of the most widely used (Single, Holt's and Dampened) exponential smoothing methods. The fourth widely used method (Winters') was not utilized as empirical findings have shown to produce forecasts very similar to those of Holt's (see Markridakis et al, 1982). The first part of the paper reviews the literature and provides the reasoning for undertaking this study. The second part describes the methodology used and formulates various hypotheses to be studied. The third part presents and analyses the results. There is a concluding section which discusses the implications of the findings, validates such findings with another set of data provided by Fildes (1989) and presents possible avenues for further research.

LITERATURE REVIEW AND REASONS FOR UNDERTAKING THIS STUDY

Since the introduction of exponential smoothing methods the question of how to initialize the first smoothed value(s) has always been posed (Cogger, 1973; McClain, 1981; Taylor, 1981; Wade, 1967). Several alternatives have been proposed in the literature, but there is little advice on which of these alternatives to use (see Chatfield and Yar, 1988). The most common among them are the following (see Appendix for more details):

1. Least Square Estimates: The historical data available is used to estimate ordinary least square estimates of the initial value(s) (Brown, 1959). In practice this is the most widely used approach for computing them.

2. Backcasting: The data is inverted and forecasting starts using the most recent data and going backwards forecasting the less recent ones. The forecast, or smoothed values, at

period 1 are then used as initial values to start the usual forecasting (Ledolter and Abraham, 1984).

3. Training Set: The data is divided into two parts. The first part (usually the smaller of the two) is used to estimate the initial values for the exponential smoothing equation(s) used with the second part where the final forecasts (see Makridakis et al., 1983) are being based.

4. Convenient Initial Values: Some convenient values can be used to initialize the smoothing equation(s). For instance, the first data value can be used to initialize the level, while the difference between the first and the second actual value (or the average of the second minus the first and third minus the fourth) can be used to initialize the trend. (Makridakis and Wheelwright, 1978).

5, 6 and 7 Zero Values: The initial values can be all set to zero, or alternatively one can be set to zero and the other(s) can be initialized using one of the alternatives described above. This set of values(s) can be used as benchmarks to judge the improved accuracy of approaches 1 to 4 above. Although it seems an unreasonable alternative it provides an advantage in terms of large initial errors which force the estimated values to approach the actual ones much faster than alternative initialization procedures.

Because of the widespread applications of exponential smoothing methods even small reductions in their forecasting errors can bring big improvements in terms of lower costs and/or better customer services (Gardner, 1990a). At present few guide-lines and no empirical evidence exist to help users decide upon the best initialization procedure (see Chatfield and Yar, 1988; Gardner, 1985). The present study aims to provide such empirical evidence and propose guide-lines, if any exist, for selecting appropriate initialization approaches.

Forecasting and, in general, statistical models can be optimized using a number of loss functions such as linear, quadratic, or higher order. The rationale behind such choice is that the negative consequence of forecasting errors are not necessarily proportional. Thus higher order loss functions which penalize bigger errors, in a quadratic or cubic fashion, are used. On the other hand, when forecasting errors are considered to be proportional then a linear loss can be used. As in the case of initial values there is not much help or empirical evidence to guide the choice of the best loss function to optimize a model's parameters (Cogger, 1979; Granger, 1969; Montgomery and Johnson, 1976), although, in practice the great majority of computer programs employ a quadratic loss that minimizes the sum of square errors when a model is fitted to historical data.

Eight loss functions have been used from those eight the MAD, MAPE, Median and MSE have been suggested and/or used as loss functions with MSE being the most popular one. The cubic power is rarely used while those of 1.5, 2.5 and 4th power have never, in our knowledge, been utilized. Nevertheless they were included in order to study the sensitivity of the results under as wide a range of loss functions as possible. The aim of this paper is to study the influence of all loss functions (both those actually used and theoretical alternatives) in terms of the three exponential smoothing methods utilized in the present study. The obvious purpose of interest is whether or not post-sample forecasting accuracy can be improved by the appropriate choice of a loss function.

Finally, the effects of non-symmetric loss-functions are investigated as in practice the cost of negative errors (i.e., underestimating demand) is usually considered more critical than that of positive ones (i.e., overestimating demand). Although alternative forms of modeling non-symmetric loss functions might be possible in the present paper our purpose is to simply determine the influence of non-symmetric losses on the post-sample forecasting errors and suggest guide-lines, if any exist, in using non-symmetric loss functions to balance the cost of negative versus positive forecasting errors.

EXPERIMENTAL DESIGN AND METHODOLOGY

The three (Single, Holt's and Dampened) most commonly used exponential smoothing method were selected for the study (see Appendix for a description of the models involved). Seven types of initial values (see last section and Appendix) were used for Holt's and Dampened smoothing and five for Single. In addition eight optimization criteria (loss functions) were employed. They range from a linear to a fourth power one (see Appendix). The optimization of the model parameter(s) was done using *a grid search algorithm* which found the optimal smoothing constants through finer and finer searches around a global optimum initially identified through the grid search. In total 56 possibilities were tested for each of the three smoothing methods. A non-symmetric loss function was also applied by weighting positive errors less than negative ones. Such weighting was done at five levels (.35, .50, .65, .80, .95) while computing the model fitted errors. Consequently the post sample forecasting accuracy of each horizon and method was recorded and compared to that of symmetric optimization

The methodology employed consisted of using the 1001 series of the M-Competition (see Makridakis et al., 1982) for each of the applicable possibilities. The procedure used was exactly the same as utilized in the M-Competition. This means that when a data series was seasonal its values were first deseasonalized using the classical decomposition method (the post-sample forecasting accuracy when seasonal series were deseasonalized using other decomposition approaches were not different than those of the classical decomposition, (Makridakis et al., 1982), a forecasting model was subsequently estimated and forecasts from this model obtained. Finally, these forecasts were reseasonalized using the seasonal indices found by the classical decomposition method. If the data series was not seasonal the model was estimated directly on the original data and forecasts were directly found. Following the above-mentioned procedure, optimal model parameters were estimated and subsequently used to forecast for periods 1, 2, ... , m (where m=6 for yearly data, m=8 for quarterly data and m=18 for monthly data). These forecasts were then compared to the actual values (known but obviously not used in developing the forecasting model) so as to compute the post-sample forecasting errors for each of the m forecasting horizons. Three post-sample accuracy measures were computed from such errors: the Mean Absolute Deviations (MAD), the Mean Absolute Percentage Errors (MAPE) and the Mean Square Errors (MSE). These accuracy measures were calculated separately for yearly, quarterly and monthly data and were also summarized for all data and forecasting horizons. Similarly, the same accuracy measures were also computed when a non-symmetric loss function was used to optimize the parameter(s) in the model fitting phase.

The approach used in this study is not different to that of real life applications where m forecasts are made at period t (present) even though their accuracy can only be found in the future when the actual data becomes available.

The hypotheses to be tested were the following:

A. If μ_o is the average post-sample accuracy when the initial values are found by ordinary least squares (prevalent approach) and when the optimization is done by a quadratic loss function (prevalent approach), then

$$H_o : \mu_o = \mu_i$$
$$H_A : \mu_o \neq \mu_i$$

where μ_i is the average post-sample accuracy of an alternative initialization procedure.

B. If μ_o is the average post-sample accuracy when a quadratic loss function (prevalent approach) is used to obtain optimal model parameters and when ordinary least squares (prevalent approach) is employed to initialize the first value(s), then

$$H_o : \mu_o = \mu_j$$
$$H_A : \mu_o \neq \mu_j$$

where μ_j is the average post-sample accuracy of an alternative loss function.

C. If μ_o is the average post-sample accuracy when the initial values are found by ordinary least squares and the optimization is done through a quadratic loss function, then

$$H_o : \mu_o = \mu_{ij}$$
$$H_A : \mu_o \neq \mu_{ij}$$

where μ_{ij} denotes post sample accuracies for specific forecasting horizons, averages of such horizons (e.g., short, medium, long), specific types of data (e.g., monthly, quarterly, yearly) or length of the time series.

PRESENTATION AND ANALYSIS OF THE RESULTS

Table 1 shows the MAPE of the best and worst initialization alternatives together with that of least square estimates (the most widely used approach) for various forecasting horizons. The optimization alternative used was that of minimizing a symmetric quadratic (MSE) loss function. As it can be seen in Table 1 the differences in average forecasting accuracy between the best and worst alternatives are extremely small. Moreover, if these differences are tested to determine if they are due to random influences or to real causes (i.e., test the hypotheses A and B) it is concluded that they are random (i.e., statistically non-significant) for Single and Dampened exponential smoothing as well as for short (periods 1 to 6) forecasting horizons for Holt's. The statistical testing was using both parametric and non-parametric methods. The same results can be observed in Table 2 which shows the MAPE of the best and worst symmetric optimization alternative together with that of the MSE (the most widely used approach) for various forecasting horizons when the initialization approach employed was that of ordinary least squares. None of the differences are statistically significant except for those of Holt's for longer than six forecasting horizons.

INSERT TABLES 1 AND 2 ABOUT HERE

In conclusion, there is no evidence from the empirical results to reject the null hypotheses stated in A and B except in the case of Holt's smoothing for periods longer than six horizons.

The same conclusions can be drawn when the data are separated into yearly, quarterly and monthly. All of the observed differences when various initial approaches and loss functions are used are extremely small and none are statistically significant at the 5% level or below except in the case of Holt's smoothing for periods longer than six horizons. Table 3, for instance, shows the results of an analysis of variance for yearly data ($m=6$ for such data) when Dampened smoothing was used. None of the differences between initialization procedures (columns), optimization criteria (rows) or their interaction is statistically significant (the smallest P-value is equal to 0.34). When the same analysis of variance is conducted for Holt's smoothing the only statistically significant difference comes from the horizon effect.

INSERT TABLE 3 ABOUT HERE

Table 4 summarizes the MAPE for the best and worst alternatives for the various initialization values *and* loss functions. 'B' on the top right corner of each box means 'Best' among the horizontal alternatives (i.e., optimization criteria) while 'W' signifies 'Worst'. Similarly, 'B' and 'W' on the left, lower corner of each box means 'Best' and 'Worst' alternative among the vertical ones (i.e., initialization values). Table 4(a) presents the results of Single smoothing, 4(b) presents those of Holt's while 4(c) presents those of Dampened.

The differences in Table 4(a) are extremely small (the largest is only 0.3%) and none of them are statistically significant. Moreover, none of the alternatives perform *consistently* "best" or "worst" in terms of the initialization and optimization alternatives experimented with.

The differences in Table 4(b) are considerably bigger than those in Table 4(a). Moreover, almost all differences between the best and worst alternatives are statistically significant (at least at the 5% level). In addition the median is consistently the worst optimization approach while power 1.5 or 2 (MSE) is consistently the best. Among the different initialization alternatives the best results are found when both initial values are set to zero, except in one case where the best result is when only one of the two is set to zero.

Differences in Table 4(c) are less consistent than those in Table 4(b). The loss function which does best most of the time is that of MAPE while the corresponding 'best' for initialization is that of least square estimates and convenient values. Furthermore, the great majority of differences are not statistically significant.

There are no consistent results that hold across Tables 4(a), 4(b), and 4(c). Thus, hypotheses C cannot be always rejected from the experimental findings. In Single smoothing, Table 4(a), the best results are found when the loss function is the median and the worst the fourth power. There is no best initialization procedure although the worst is when the first value is set to zero. However, it must be emphasized that all differences are extremely small and statistically not significant. In Holt's smoothing, Table 4(b), the worst loss function is the median (the opposite of Table 4(a)) and the best is the 1.5 power in all but one case when the 2nd power (MSE) provides the best results. In terms of initial values the best post-sample accuracies are found when the first values are both set to zero, except in one case when only one of the two is set to zero. The worst results are when convenient values are used to initialize.

For Dampened smoothing, Table 4(c), the results are closer to those of Single. Thus the worst loss function is the fourth power (although not in all cases), the worst initialization is with zero values (not in all cases) while the best is found with convenient values (again not in all cases). The great majority of differences are extremely small and statistically non-significant (in Single smoothing the differences are even smaller and none are statistically significant).

Tables 5 shows results similar to those of Table 4 except the post-sample accuracy is that of MAD instead of MAPE. Concerning Single smoothing the differences in post-sample MADs are extremely small and statistically non-significant as was the case in Table 4(a). However, there are no other consistent patterns between Tables 4(a) and 5(a). For instance, in Table 5(a) there is a consistent improvement in post-sample MAD when the model parameters are optimized through higher power (2.5, 3, or 4) loss functions while in

Table 4(a) this is not the case. Similarly, the initial values that provide the most accurate results are not the same in Tables 4(a) and 5(a).

In Holt's smoothing the differences in MADs are bigger, however higher power loss functions do not improve the results. Moreover, the median continues to be the worst optimization alternative while the 1.5 or 2 power the best. There is also consistency in initialization procedures where the results of Table 4(b) and 5(b) are similar. Thus, setting both initial values at zero provides the best results most of the time while the worst results are found when the initialization is done through a training set.

Finally, there is little consistency between Tables 4(c) and 5(c) - Dampened smoothing. In Table 5(c) the best optimization criterion is power 1.5 in all but one case, while in Table 4(c) the best was MAPE (in all but two cases). Finally, there is no initialization procedure which is consistently best in Table 5(c) while the best in 4(c) was that of convenient values (in all but two cases).

Thus, it can be concluded that few consistent results can be reported between Tables 4 (a) and 4 (c) and 5 (a) and 5 (c). That is whatever, if anything, influences post-sample MAPEs does not consistently influence MADs. This is not, however, the case with Tables 4 (b) and 5 (b) - referring to Holt's smoothing - where the results are fairly consistent.

INSERT TABLE 5 ABOUT HERE

Although, the authors are well aware of the problems of using MSE over many series of unequal values they also computed post-sample accuracies using such measure in order to provide a complete range of results and anticipate possible criticism that a widely-used measure such as the MSE was not used. As it could be expected, the values found were large and extremely unstable. The averages were often reduced by a factor of 10,000 by excluding as few as six series. Given the large number of series and forecasting horizons involved (almost 14,000 in total) such large fluctuations make the use of MSE inappropriate as a comparative measure (see Chatfield, 1988). Furthermore, no consistent or insightful results could be deduced by examining the various tables of post-sample MSE values even when large errors were excluded. This is why tables using MSEs are not reported in this paper.

The non-symmetric optimization was done using ordinary least square estimates for initial values and a quadratic (MSE) loss function. Five levels of non-symmetric losses were used by adding to the sum 35%, 50%, 65%, 80% or 95% of the square error at period t, when such error was positive while adding the entire square error when it was negative (see Appendix for more details). As usual the parameter(s) that minimized the sum of square errors were chosen and were used to make m forecasts and subsequently compute the post-sample accuracies.

The differences in post-sample accuracies when a non-symmetric loss function was used were extremely small for *all three* exponential smoothing methods. In Single smoothing the great majority of such differences were in the second decimal. In Holt's smoothing there were some small improvements in post-sample accuracies for longer than twelve forecasting horizons when the non-symmetric loss function, at the 35% level, was used. However, such differences were not statistically significant while the best overall results were *still* obtained when a symmetric loss function was employed. In Dampened smoothing the best overall results were found with a non-symmetric loss function at the 50% level. Furthermore, for twelve or longer forecasting horizons the improvements were considerably larger than those of Single or Holt's smoothing *and* consistent; however, they were *not* statistically significant.

Discussion

The purpose of this paper is not to enter into the debate of which accuracy measure is the most appropriate or what is the value of empirical competitions. Such issues have been debated elsewhere (Chatfield, 1988; Fildes and Makridakis, 1990; Zellner, 1986; Armstrong and Lusk, 1983). Instead, it aims at investigating the issues of the various initial values proposed in the literature and the entire range of possible loss functions. At the same time, the authors are well aware that relative measures such as MAPE are more appropriate when averaging over many series and this is why MAPEs were used to express the results in all tables except 5 which uses MAD.

At the same time MSE were also computed for reasons of completeness. If the median and the fourth power are excluded as loss functions to base the optimization of model parameters few consistent or statistically significant differences can be found in post-sample forecasting accuracies whether such accuracies are measured in terms of MAPE, MAD or MSE. Moreover, no consistent patterns could be found when MAPEs, MADs or MSEs criteria were used to optimize the model's parameters and MAPEs, MADs or MSEs measures were employed to compute post-sample accuracies. Thus, there was no correspondence between the type of loss function used during the model fitting and the accuracy measure employed to compute the post-sample errors.

These results are surprising. In the forecasting literature the initialization procedure and the optimization criteria have been considered to influence post-sample forecasting accuracies. It has been also advocated that there must be a correspondence between the loss function used in the model fitting and the corresponding post-sample accuracy used to measure forecasting errors (Zellner, 1986).

From a practical point of view the prevalent approaches of using MSE as a loss function and ordinary least square estimates to initialize the starting values seems adequate as the differences between such approaches and the best of the alternatives are small and statistically non-significant, in the great majority of cases. Furthermore, as these approaches (MSE as the loss function and least square estimates for initialization) are easy to program and require little computer time to apply there is no motivation to change them. On the other hand, it makes no sense to consider more elaborate alternatives such as backcasting for initial values or medians for optimizing the model's parameter(s) since such alternatives are more difficult to program and require more computer time when used to obtain forecasts.

In addition to the various results reported in the last section several other hypotheses were tested during our study. For instance we found that *sample size did not exhibit any consistent influence on the magnitude of post-sample forecasting errors or the choice of the best initialization or optimization alternatives.* This finding is consistent of that reported in Makridakis and Hibon (1979) and, is no doubt, due to the fact that the pattern of the series changes even abruptly in some cases. In addition, if frequency distributions of the differences in post-sample errors between the various approaches were made it was found that the great majority of them were less than 1% - this was in particular true with Single and Dampened smoothing. Furthermore, no obvious patterns of such differences could be deduced and no important factors could be found that could explain the larger than 1% errors.

Another hypothesis tested was whether a specific set of initial values or loss functions was best for yearly, quarterly or monthly data. But again no consistent conclusion that hold among the three methods could be reached. Similarly, no forecasting horizons could be better predicted than others by the appropriate choice of specific initial values or loss functions.

The practical implications of our study suggest that there are few benefits, if any, in attempting to find optimal ways to initialize the values of exponential smoothing methods (at least the three we studied). Moreover, the choice of a best loss function is of no consequence as long as the median and the fourth power are excluded. As Gardner (1990, b) explained "the reason that starting values and loss functions don't make any difference is that the optimal smoothing parameter(s) found *compensate* for various starting values and different loss functions". However, we must emphasize that our results apply to the average of forecasts that have been found mechanically (i.e., using an automatic approach) without studying each series separately to determine what the best initial values or loss function. In our view additional research will be required to determine if our findings also apply when single series are studied and optimized individually (e. g., see Chatfield, 1978; Chatfield and Yar, 1988).

Our findings suggest that the prevalent approach of initializing by ordinary least squares and optimizing by a quadratic loss (MSE) function provide satisfactory results which, on average when the methods are run mechanically, cannot be improved in any consistent way that holds constant across methods, data types, forecasting horizons or sample sizes. These conclusions are both good and bad news. The good news is that exponential smoothing methods (and in particular Simple and Dampened) are easy, accurate and robust forecasting techniques that can be readily used across a wide range of actual forecasting applications. The bad news is that theoretical expectations do not seem to hold empirically for reasons that are not always clear apart from saying that the pattern of series is changing. Thus, research efforts must concentrate on better understanding such reasons and in developing alternative methods and approaches that can more accurately predict real life time series whose pattern, we know, change over time. Somehow it must be possible to beat Single smoothing for longer forecasting horizons and Dampened for shorter and medium ones. Moreover, research efforts must be directed in better understanding the effects of one-period-ahead versus two, three, ... , m-period optimization and their consequence on post-sample forecasting accuracy (Makridakis, 1990). Finally, more research needs to be done to better understand the lack of consistency between various loss functions used in model optimization and the resulting post-sample accuracies. For instance, one would have expected a correspondence between the type of loss function used in model fitting and the best results found when post-sample accuracies were measured in the same fashion; however, none were found in our study. Finally, additional work is needed to determine whether or not our findings also apply to single series when an expert forecaster attempts to minimize post-sample errors.

Validation

An interesting question in all types of empirical work is whether or not the results found can be generalized and can also hold with other types of data. In order to validate the generality of the findings it was therefore decided, after the present results were found, to test the various possibilities we experimented in this study with the data of Fildes (1989) Such data are *not* at all similar to those of the M-Competition. They consist of 261 monthly series all coming from a Single source (AT&T). Moreover, all series exhibit a strong negative trend and include little or no seasonality.

Table 6 present the best and worst alternatives for the Fildes data. The similarities between the results shown in Table 6 and the corresponding ones in Table 5 which uses the M-Competition data is considerable as far as Single and Holt's smoothing are concerned. That is the magnitude of the difference between the various experimental cases is very similar while the best and the worst alternatives are practically the same. With Dampened smoothing the best initialization procedure, for the Fildes data, most of the time, was that of the least squares (this was not so with the M-Competition data) while there was no loss function which provided in a consistent way the best or the worst results as it was also the case with the M-Competition data (see Table 6).

Conclusion

This study has shown few differences in post sample forecasting accuracies when different initialization values and optimization (loss) functions have been used. In addition non-symmetric loss functions did not change in any statistically significant fashion the post-sample results. Apart from the conclusion that the median and the fourth power produced inferior results, no other pervasive finding holds across the experimental possibilities tested. Finally, concerning the differences observed the biggest ones were for longer than six forecasting horizons and were mostly concentrated to Holt's exponential smoothing. All differences between the various experimental cases in Single smoothing were small and statistically insignificant while the magnitude of those very few of Dampened which were statistically significant was a small fraction of those of Holt's.

The practical implications of this study suggest dropping existing concerns about initial values and loss functions at least when the various methods are run on a push bottom basis and instead concentrating on more important issues affecting post-sample forecasting accuracy such as optimizing for more than one-step-ahead forecasting horizons and using actual post-sample measures to base the model selection process.

To allow replication and/or extensions of the present study both the M-Competition and the Fildes data can be obtained at no cost by writing to Spyros Makridakis at INSEAD.

REFERENCES

Armstrong, J. C. and Lusk, E. J., *"Commentary on the Makridakis Time Series Competition (M-Competition)"*, Journal of Forecasting, 2 (1983), 259-311.

Brown, R. G., *Statistical Forecasting for Inventory Control*, New York: McGraw-Hill, 1959.

Brown, R. G., *Smoothing, Forecasting and Prediction of Discrete Time Series*, Englewood Cliffs, NJ: Prentice-Hall, 1963.

Brown, R. G., *Decision Rules for Inventory Management*, New York: Holt, Rinehart and Winston, 1967, Part 2.

Chatfield, C., 'The Holt-Winters forecasting procedure', *Applied Statistics*, **27**(1978), 264-279.

Chatfield, C., 'Apples, Oranges and Mean Square Error', *International Journal of Forecasting*, **4**(1988), 515-518.

Chatfield, C., and Yar, M., "Holt-Winters Forecasting: Some Practical Issues", *The Statistician*, 37 (1988), 129-140.

Cogger, K. O., 'Extensions of the fundamental theorem of exponential smoothing', *Management Science*, **19**(1973), 547-554.

Cogger, K. O., 'Time Series Analysis and Forecasting with an Absolute Error Criterion', *TIMS Studies in Management Science*, **12**(1979), 189-201.

Fildes, R., 'Evaluation of Aggregate and Individual Forecast Method Selection Selection Rules' *Management Science*, 35(1989), 1056-1965.

Fildes, R., and Makridakis, S., "Forecasting and Loss Functions", *International Journal of Forecasting*, ((1988), 545-550.

Gardner, E. S., 'Exponential Smoothing: The State of the Art', *Journal of Forecasting*, **4**(1985), 1-28.

Gardner, E. S., 'Evaluating Forecasting Performance in Inventory Control Systems', *Management Science*, 36(1990 a), 490-499.

Gardner, E. S., Private Correspondence, (1990 b)

Gardner, E. S. and McKenzie, E., 'Forecasting Trends in Time Series', *Management Science*, 31(1985), 1237-1246.

Granger, C. W. J., 'Prediction with a generalized cost of error function', *Operational Research Quarterly*, **20**(1969), 150-161.

Groff, G . K., 'Empirical comparison of models for short-range forecasting', *Management Science*, **20**(1973), 22-31.

Harrison, P. J., 'Exponential smoothing and short-term sales forecasting', *Management Science*, **13**(1967), 821-842.

Holt, C. C., et al., *Planning Production, Inventories, and Work Force*, Englewood Cliffs, NJ: Prentice-Hall, 1960, Chapter 14.

Johnson, L. A. and Montgomery, D. C., *Operations Research In Production Planning, scheduling, and inventory Control*, New York: Wiley, 1974.

Koehler, A.B. and Murphree, E.S., 'A Comparison of Results from State Space Forecasting with Forecasts from the Makridakis Competition', *International Journal of Forecasting*, **4**(1988), 45-58.

Ledolter, J. and Abraham, B., 'Some comments on the initialization of exponential smoothing', *Journal of Forecasting*, **3**(1984), 79-84.

Makridakis, S., 'A New Approach to Times Series Forecasting', *Management Science*, **36**(1990), 505-512

Makridakis, S. and Wheelwright, S. C., *Forecasting Methods for Management* (5th ed), New York, Wiley, 1989.

Makridakis, S. and Wheelwright, S. C., *Interactive Forecasting: Univariate and Multivariate Methods* (2nd ed), San Francisco: Holden-Day, 1978.

Makridakis, S. and Hibon, M., 'Accuracy of forecasting : an empirical investigation (with discussion)', *Journal of the Royal Statistical Society (A)*, **142**(1979), 97-145.

Makridakis, S., Anderson, A., Carbone, R., Fildes R., Hibon, M., Lewandowski R., Newton, J., Parzen, R., and Winkler, R., 'The accuracy of extrapolation (time series) methods: results of a forecasting competition', *Journal of Forecasting*, **1**(1982), 111-153.

Makridakis, S., Wheelwright, S. C. and McGee, V., *Forecasting: Methods and Applications* (2nd edn), New York: Wiley, 1983.

Martin, C.A., and Witt, S.F., 'Forecasting Tourist Demand: A Comparison of the Accuracy of Several Quantitative Methods", *International Journal of Forecasting*, **5**(1989), 7-20.

McClain, J. O., 'Restarting a forecasting system when demand suddenly changes', *Journal of Operations Management*, **2**(1981), 53-61.

Montgomery, D. C. and Johnson, L. A., *Forecasting and Time series Analysis*, New York: McGraw-Hill, 1976.

Taylor, S. G., 'Initialization of exponential smoothing forecasts', *AIIE Transactions*, **13**(1981), 199-205.

Wade, R. C., 'A technique for initializing exponential smoothing forecasts', *Management Science*, **13**(1967), 601-602.

Winters, P. R., 'Forecasting sales by exponentially weighted moving averages', *Management Science*, **6**(1960), 324-342.

Zellner, A., 'A Tale of Forecasting 1001 Series: The Bayesian Knight Strikes Again', *International Journal of Forecasting*, **2**(1986), 491-494.

APPENDIX

A. Exponential Methods Used

Single

$e_t = X_t - \hat{X}_{t-1}(1)$

where X_t is the actual data at period t and
$\hat{X}_{t-1}(1)$ is the one-step-ahead forecast at period t-1 for period t.

$S_t = S_{t-1} + \alpha e_t$
where α is the smoothing constant whose value is $0 \leq \alpha \leq 1$

and $\hat{X}_t(m) = S_t$

where the maximum m is six for yearly data, eight for quarterly and eighteen for monthly

Holt's Smoothing

$e_t = X_t - \hat{X}_{t-1}(1)$

$S_t = S_{t-1} + T_{t-1} + \alpha e_t$

$T_1 = T_{t-1} + \beta e_t$

where β is a smoothing constant whose value is $0 \leq \beta \leq 1$

and $\hat{X}_t(m) = S_t + mT_t$

Dampened Trend

$e_t = X_t - \hat{X}_{t-1}(1)$

$S_t = S_{t-1} + \phi T_{t-1} + \alpha e_t$

$T_t = \phi T_{t-1} + \beta e_t$

$$\hat{X}_t(m) = S_t + \sum_{i=1}^{m} \phi^i T_t$$

B. Initial values used

1. Least Square Estimates

For Single exponential smoothing the initial value S_1 was found as :

$$S_1 = \frac{\sum_{t=1}^{n} X_t}{n}$$

where n is the number of historical data available.

For Holt's and dampened exponential smoothing S_1 and T_1 are found as :

$$T_1 = \frac{n\sum_{t=1}^{n} tX_t - \sum_{t=1}^{n} t\sum_{t=1}^{n} X_t}{n\sum_{t=1}^{n} t^2 - \left(\sum_{t=1}^{n} t\right)^2}$$

and

$$S_1 = \frac{\sum_{t=1}^{n} X_t}{n} - T_1\frac{\sum_{t=1}^{n} t}{n}$$

This initialization approach is referred to as the "prevalent" one as it is the most widely used in forecasting applications (Brown, 1959; Johnson and Montgomery, 1974).

2. Backcastings

The data is inverted and the most recent data value becomes period 1 while the least recent (i.e., period 1) becomes the last one (i.e., period n). Consequently the values of S_1, or S_1 and T_1 are found as above and the appropriate equation(s) is(are) used to forecast. The last values of S_n, or S_n and T_n are used for initial estimates in the regular forecastings except that the sign of the value of T_n is reversed. Thus, in Single smoothing

$$S_1 = S_n$$

while in Holt's and Dampened

$$S_1 = S_n$$
$$T_1 = T_n$$

3. Training set

The data is separated into two sets (the first set makes up one third of the historical data while the second makes up the remaining two thirds). The initial values for S_1 or S_1 and T_1 for the training set are found as in 1 above.

If f is the last period of the training (first) set then the values of the S_1 or S_1 and T_1 for the remaining data are found as:

$S_1 = S_f$

or

$S_1 = S_f$
$T_1 = T_f$

4. Convenient values

The value of S_1 or S_1 and T_1 are simply set as follows :

$S_1 = X_1$

or

$S_1 = X_1$
$T_1 = (X_2 - X_1 + X_4 - X_3) / 2$

5. Zero values

The initial values are set as follows:

$S_1 = 0$

or

$S_1 = 0$
$T_1 = 0$

6. Zero Value (for Holt's and Dampened smoothing only)

$S_1 = 0$
T_1 = Least square estimate (see 1 above).

7. Zero value (for Holt's and Dampened smoothing only)

S_1 = Least square estimate (see 1 above)
$T_1 = 0$

C. Symmetric Loss Functions

The one-period-ahead forecasting errors e_t were computed as :

$e_t = X_t - \hat{X}_{t-1}$ (1)

Consequently the smoothing parameters α, α and β, or α, β and φ were chosen in such a way as to minimize the corresponding model fitting loss function outlined below :

I Mean Absolute Deviation (MAD)

$$\frac{\sum_{t=1}^{n} |e_t|}{n}$$

II Mean Absolute Percentage Error (MAPE)

$$\frac{\sum_{t=1}^{n} \frac{|e_t|}{X_t}}{n}$$

III Median Absolute Percentage Error (Median)

The middle value (median) when all absolute percentage errors were arranged from the smallest to the largest.

IV Mean Square Error (MSE)

$$\frac{\sum_{t=1}^{n} e_t^2}{n}$$

V 3th Power

$$\frac{\sum_{t=1}^{n} |e_t|^3}{n}$$

D. Non-Symmetric Loss Functions

The prevalent initialization procedure (least square estimates see 1 above) and the prevalent optimization function (MSE, I above) were used with the following non-symmetric loss functions.

$$\frac{\sum \psi e_t^2}{n}$$

where $\psi = 1$ when $e_t > 0$

and $\psi = c$ when $e_t < 0$

where c took the values of 0.35, 0.50, 0.65, 0.80 and 0.95.

TABLE 1

COMPARISON OF INITIALIZATION

OPTIMIZATION BY MSE

			FORECASTING HORIZONS						
			1	3	6	8	12	18	Average (All horizons)
All Data	SINGLE	Least Squares (1)	8.7	13.3	19.7	18.0	16.9	26.1	17.0
		Best: Convenient (4)	8.5	13.1	19.4	17.9	16.9	26.1	16.9
		Worst: zero (5)	8.8	13.2	19.6	18.4	16.9	25.8	17.0
All Data	HOLT	Least Squares (1)	8.7	12.9	21.3	22.7	21.3	33.6	19.8
		Best: Both zero (5)	8.6	12.5	19.4	20.6	19.4	34.8	18.7
		Worst: Convenient (4)	8.8	13.4	22.1	25.4	26.0	42.5	22.8
All Data	DAMPEN	Least Squares (1)	8.5	12.4	18.5	18.1	17.2	27.4	17.0
		Best: Convenient (4)	8.4	12.5	18.7	18.2	17.2	27.5	17.0
		Worst: Both zero (5)	8.7	12.9	19.2	18.8	17.2	27.1	17.3

TABLE 2

COMPARISON OF OPTIMIZATION

INITIALIZATION BY PREVALENT VALUES

			FORECASTING HORIZONS						
			1	3	6	8	12	18	Average (All horizons)
All Data	SINGLE	MSE	8.7	13.3	19.7	18.0	16.9	26.1	17.0
		Best: MEDIAN	8.6	13.0	19.4	17.9	16.8	25.9	16.9
		Worst: e_t^3	8.7	13.4	19.8	18.0	16.9	26.1	17.0
All Data	HOLT	MSE	8.7	12.9	21.3	22.7	21.3	33.6	19.6
		Best: MSE	8.7	12.9	21.3	22.7	21.3	33.6	19.6
		Worst: MEDIAN	9.5	15.5	24.6	28.3	33.0	50.0	27.6
All Data	DAMPEN	MSE	8.5	12.4	18.5	18.1	17.2	27.4	17.0
		Best: MAPE	8.7	12.2	18.6	17.8	17.5	24.8	16.8
		Worst: MEDIAN	8.5	12.4	19.1	19.3	17.9	26.7	17.4

TABLE 3: TWO-WAY ANALYSIS OF VARIANCE

Source	Sum of Squares	d.f.	Mean Square	Computed F-value	p-value
Columns	2266.	5.	453.	.87	.498
Rows	2940.	5.	587.	1.13	.340
Row X Col	1199.	25.	47.	.09	1.000
Error	3062580.	5904.	519.		
TOTALS	3068990.	5939.			

165 series of yearly data with DAMPEN-Trend Method
Average Error on 6 Forecasting Horizons

Horizontal values: Errors for each OPTIMIZATION criteria
Vertical values: Errors for each STARTING VALUE

THE DIFFERENCES ARE NOT STATISTICALLY SIGNIFICANT

TABLE 4(a): SINGLE SMOOTHING, AVERAGE MAPE FOR ALL FORECASTING HORIZONS AND TIME SERIES

Initial Values	Symmetric loss functions				
	I	II	III	IV	V
	MAD	MAPE	MEDIAN	MSE 2nd power	Cubic power
Least square estimates	16.9^{B}	16.9^{B}	${}_{W}16.9^{B}$	${}_{W}17.0^{W}$	17.0^{W}
2 Backcasting	16.9	${}_{B}16.8$	${}_{B}16.7^{B}$	${}_{B}16.9$	17.0^{W}
3 Training set	16.9	${}_{B}16.8^{B}$	16.8^{B}	${}_{W}17.0$	${}_{W}17.1$
4 Convenient values	${}_{B}16.8^{B}$	${}_{B}16.8^{B}$	16.8^{B}	${}_{B}16.9$	${}_{B}16.9$
5 s=0, or s=0 and t=0	${}_{W}17.0$	${}_{W}17.1^{W}$	${}_{W}16.9^{B}$	${}_{W}17.0$	17.0

"B" at the upper, right hand side of each box signifies Best while "W" signifies Worst accuracy.
"B" at the lower, left hand side of each box signifies Best, while "W" signifies Worst accuracy.

TABLE 4(b): HOLT'S SMOOTHING, AVERAGE MAPE FOR ALL FORECASTING HORIZONS AND TIME SERIES					
	Symmetric loss functions				
Initial Values	I	II	III	IV	V
	MAD	MAPE	MEDIAN	MSE 2nd power	Cubic power
1 Least square estimates	19.8 B	19.9	27.6 W	19.8 B	20.3
2 Backcasting	20.7	21.5	27.8 W	20.3 B	21.6
3 Training set	21.4	22.8	30.5 W	20.8 B	22.5
4 Convenient values	W 23.5	W 23.6	W 29.6 W	W 22.8 B	W 24.8
5 s=0, or s=0 and t=0	B 19.0	B 18.9	27.0 W	B 18.7 B	B 19.7
6 s=0 t=least square	19.1	19.1	27.1 W	18.9 B	B19.7
7 s=least square T=0	19.2 B	19.3	B 26.8 W	21.8	5.0

"B" at the upper, right hand side of each box signifies Best while "W" signifies Worst accuracy.
"B" at the lower, left hand side of each box signifies Best, while "W" signifies Worst accuracy.

TABLE 4(c): DAMPENED SMOOTHING, AVERAGE MAPE FOR ALL FORECASTING HORIZONS AND TIME SERIES					
	Symmetric loss functions				
Initial Values	I	II	III	IV	V
	MAD	MAPE	MEDIAN	MSE 2nd Power	Cubic Power
1 Least square estimates	16.9	16.8^{B}	17.4^{W}	$_{B}17.0$	$_{B}17.2$
2 Backcasting	17.0	$_{B}16.7^{B}$	17.4	17.1	17.3
3 Training set	17.0^{B}	17.0^{B}	17.4	17.3	17.4
4 Convenient values	$_{B}16.8$	$_{B}16.7^{B}$	17.4	$_{B}17.0$	$_{B}17.2$
5 s=0, or s=0 and t=0	$_{W}17.3$	$_{W}17.2^{B}$	$_{W}17.7^{W}$	$_{W}17.3$	17.4
6 s=0 t=least square	17.1^{B}	$_{W}17.2$	17.6^{W}	17.1^{B}	$_{B}17.2$
7 s=least square T=0	16.9^{B}	17.1	$_{B}17.3$	17.2	$_{W}17.5$

"B" at the upper, right hand side of each box signifies Best while "W" signifies Worst accuracy.
"B" at the lower, left hand side of each box signifies Best, while "W" signifies Worst accuracy.

TABLE 5(a): SINGLE SMOOTHING, AVERAGE MAD FOR ALL FORECASTING HORIZONS AND TIME SERIES (Values have been divided by 1000)					
Initial Values	Loss functions				
	I	II	III	IV	V
	MAD	MAPE	MEDIAN	MSE 2nd power	Cubic power
1 Least square estimates	15.4	15.5^{W}	15.3	$_{W}15.4$	$_{W}15.4$
2 Backcasting	15.4^{W}	15.4^{W}	$_{B}15.1$	15.3	$_{B}15.0^{B}$
3 Training set	$_{B}15.3^{W}$	$_{B}15.2$	15.3^{W}	$_{B}15.2$	$_{B}15.0$
4 Convenient values	15.5^{W}	15.4	15.5^{W}	15.3	$_{B}15.0$
5 s=0, or s=0 and t=0	$_{W}15.6^{W}$	$_{W}15.6^{W}$	$_{W}15.6^{W}$	$_{W}15.4$	15.1

"B" at the upper, right hand side of each box signifies Best while "W" signifies Worst accuracy.
"B" at the lower, left hand side of each box signifies Best, while "W" signifies Worst accuracy.

TABLE 5(b): HOLT's SMOOTHING, AVERAGE MAD FOR ALL FORECASTING HORIZONS AND TIME SERIES
(Values have been divided by 1000)

Initial Values	Loss functions				
	I	II	III	IV	V
	MAD	MAPE	MEDIAN	MSE 2nd power	Cubic power
1 Least square estimates	12.4^{B}	13.2	${}_{B}17.3^{W}$	12.4^{B}	15.1
2 Backcasting	11.9	${}_{B}12.7$	21.9^{W}	11.8^{B}	${}_{W}15.8$
3 Training set	${}_{W}15.5$	${}_{W}18.7$	${}_{W}28.1^{W}$	${}_{W}14.3^{B}$	14.9
4 Convenient values	13.6	15.6	23.5^{W}	11.7^{B}	14.4
5 s=0, or s=0 and t=0	${}_{B}11.3^{B}$	12.9	20.4^{W}	${}_{B}11.5$	${}_{B}13.9$
6 s=0 t=least square	12.2^{B}	13.6	22.8^{W}	12.2^{B}	14.7
7 s=least square T=0	13.0^{B}	13.9	18.6^{W}	13.6	${}_{B}13.9$

"B" at the upper, right hand side of each box signifies Best, while "W" signifies Worst accuracy.
"B" at the lower, left hand side of each box signifies Best, while "W" signifies Worst accuracy.

TABLE 5(c): DAMPENED SMOOTHING, AVERAGE MAD FOR ALL FORECASTING HORIZONS AND TIME SERIES (Values have been divided by 1000)					
Initial Values	Loss functions				
	I	II	III	IV	V
	MAD	MAPE	MEDIAN	MSE 2nd power	Cubic power
1 Least square estimates	13.4	14.9 W	14.2	B 12.2 B	12.9
2 Backcasting	13.3	14.3	14.4 W	12.8 B	W 13.2
3 Training set	13.5	B 13.2	15.8 W	13.1 B	13.1 B
4 Convenient values	B 13.2	14.3	W 18.7 W	12.9 B	W 13.2
5 s=0, or s=0 and t=0	13.6	W 15.6 W	15.1	12.4 B	12.9
6 s=0 t=least square	13.9	14.8	B 15.0 W	12.6 B	B 12.4
7 s=least square T=0	W 15.0	15.3 W	B 15.0	W 14.1	13.0 B

"B" at the upper, right hand side of each box signifies Best, while "W" signifies Worst accuracy.
"B" at the lower, left hand side of each box signifies Best, while "W" signifies Worst accuracy.

TABLE 6(a): SINGLE SMOOTHING, AVERAGE MAPE FOR ALL FORECASTING HORIZONS AND TIME SERIES					
Initial Values	FILDES DATA				
	I	II	III	IV	V
	MAD	MAPE	MEDIAN	MSE 2nd power	Cubic power
Least square estimates	18.1	18.1	18.1	18.2	18.2
2 Backcasting	18.1	18.1	18.2	18.1	18.2.
3 Training set	18.1	17.9	18.1	18.1	18.1
4 Convenient values	18.1	17.9	18.2	18.1	18.2
5 s=0, or s=0 and t=0	18.1	18.1.	18.1	18.1	18.1

"B" Best and "W" Worst are practically the same.

TABLE 6(b): HOLT'S SMOOTHING, AVERAGE MAPE FOR ALL FORECASTING HORIZONS AND TIME SERIES

FILDES DATA					
Initial Values	I	II	III	IV	V
	MAD	MAPE	MEDIAN	MSE 2nd power	Cubic power
1 Least square estimates	9.1 B	12.4 W	B 11.5	9.7	10.4
2 Backcasting	8.8 B	12.5	17.1 W	9.2	10.3
3 Training set	8.9 B	10.2	18.0 W	10.1	10.7
4 Convenient values	9.6 B	W 12.7	W 20.0 W	10.3	10.5
5 s=0, or s=0 and t=0	W 18.1	11.6 B	16.9	W 18.9	W 19
6 s=0 t=least square	B 7.3 B	9.3	15.4 W	B 8.2	B 8.8
7 s=least square T=0	10.4	B 9.0	17.7 W	8.9 B	9.6

"B" at the upper, right hand side of each box signifies Best while "W" signifies Worst accuracy.
"B" at the lower, left hand side of each box signifies Best, while "W" signifies Worst accuracy.

TABLE 6(c): DAMPENED SMOOTHING, AVERAGE MAPE FOR ALL FORECASTING HORIZONS AND TIME SERIES					
	FILDES DATA				
Initial Values	I	II	III	IV	V
	MAD	MAPE	MEDIAN	MSE 2nd Power	Cubic Power
1 Least square estimates	12.6	13.4	13.6^{W}	$_{B}$10.4	$_{B}$9.4^{B}
2 Backcasting	$_{B}$12.5	$_{B}$13.2.	13.8^{W}	12.6	13.5
3 Training set	14.3^{W}	13.9	$_{W}$14.3^{W}	13.3	10.8^{B}
4 Convenient values	13.4^{W}	$_{B}$13.2	$_{B}$13.1	12.3	13.4^{W}
5 s=0, or s=0 and t=0	$_{W}$18.0	$_{W}$17.4	13.9^{B}	$_{W}$18.1^{W}	18.0
6 s=0 t=least square	$_{W}$18.0	$_{W}$17.4	13.9^{B}	$_{W}$18.1	$_{W}$18.2
7 s=least square T=0	15.0^{W}	14.3	$_{B}$13.1	12.6	11.5

"B" at the upper, right hand side of each box signifies Best while "W" signifies Worst accuracy.
"B" at the lower, left hand side of each box signifies Best, while "W" signifies Worst accuracy.

INSEAD WORKING PAPERS SERIES

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 RÖLLER	**"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 inter-organizational 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 TIBREWALA 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-DESGAGNÉ	**"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,	**"Asymmetric cannibalism between substitute items listed by retailers"**, September 1988.

	Philippe NAERT and Piet VANDEN ABEELE	
88/48	Michael BURDA	**"Reflections on 'Wait unemployment' in Europe, II"**, April 1988 revised September 1988.
88/49	Nathalie DIERKENS	**"Information asymmetry and equity issues"**, September 1988.
88/50	Rob WEITZ and Arnoud DE MEYER	**"Managing expert systems: from inception through updating"**, October 1987.
88/51	Rob WEITZ	**"Technology, work, 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	**"Whatever happened to the philosopher-king: the leader's addiction to power,** September 1988.
88/54	Lars-Hendrik RÖLLER and Mihkel M. TOMBAK	**"Strategic choice of flexible production technologies and welfare 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 walk 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-DESGAGNÉ 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 Chelwood Gate II model with 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 WOUTERS	**"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 new 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-DESGAGNÉ	**"Coordinating manufacturing and business strategies: I"**, February 1989.
89/07	Damien J. NEVEN	**"Structural adjustment in European retail banking. Some view 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.
89/12	Wilfried VANHONACKER	**"Estimating dynamic response models when the data are subject to different temporal aggregation"**, January 1989.
89/13	Manfred KETS DE VRIES	**"The impostor syndrome: a disquieting phenomenon in organizational life"**, February 1989.
89/14	Reinhard ANGELMAR	**"Product innovation: a tool for competitive advantage"**, March 1989.
89/15	Reinhard ANGELMAR	**"Evaluating a firm's product innovation performance"**, March 1989.
89/16	Wilfried VANHONACKER, Donald LEHMANN and Fareena SULTAN	**"Combining related and sparse data in linear regression models"**, February 1989.
89/17	Gilles AMADO, Claude FAUCHEUX and André LAURENT	**"Changement organisationnel et réalités culturelles: contrastes franco-américains"**, March 1989.
89/18	Srinivasan BALAK-RISHNAN and Mitchell KOZA	**"Information asymmetry, market failure and joint-ventures: theory and evidence"**, March 1989.
89/19	Wilfried VANHONACKER, Donald LEHMANN and Fareena SULTAN	**"Combining related and sparse data in linear regression models"**, Revised March 1989.
89/20	Wilfried VANHONACKER and Russell WINER	**"A rational random behavior model of choice"**, Revised March 1989.
89/21	Arnoud de MEYER and Kasra FERDOWS	**"Influence of manufacturing improvement programmes on performance"**, April 1989.
89/22	Manfred KETS DE VRIES and Sydney PERZOW	**"What is the role of character in psychoanalysis?"** April 1989.
89/23	Robert KORAJCZYK and Claude VIALLET	**"Equity risk premia and the pricing of foreign exchange risk"** April 1989.
89/24	Martin KILDUFF and Mitchel ABOLAFIA	**"The social destruction of reality: Organisational conflict as social drama"** zApril 1989.

89/25	Roger BETANCOURT and David GAUTSCHI	"Two essential characteristics of retail markets and their economic consequences" March 1989.
89/26	Charles BEAN, Edmond MALINVAUD, Peter BERNHOLZ, Francesco GIAVAZZI and Charles WYPLOSZ	"Macroeconomic policies for 1992: the transition and after", April 1989.
89/27	David KRACKHARDT and Martin KILDUFF	"Friendship patterns and cultural attributions: the control of organizational diversity", April 1989.
89/28	Martin KILDUFF	"The interpersonal structure of decision making: a social comparison approach to organizational choice", Revised April 1989.
89/29	Robert GOGEL and Jean-Claude LARRECHE	"The battlefield for 1992: product strength and geographic coverage", May 1989.
89/30	Lars-Hendrik ROLLER and Mihkel M. TOMBAK	"Competition and Investment in Flexible Technologies", May 1989.
89/31	Michael C. BURDA and Stefan GERLACH	"Intertemporal prices and the US trade balance in durable goods", July 1989.
89/32	Peter HAUG and Tawfik JELASSI	"Application and evaluation of a multi-criteria decision support system for the dynamic selection of U.S. manufacturing locations", May 1989.
89/33	Bernard SINCLAIR-DESGAGNÉ	"Design flexibility in monopsonistic industries", May 1989.
89/34	Sumantra GHOSHAL and Nittin NOHRIA	"Requisite variety versus shared values: managing corporate-division relationships in the M-Form organisation", May 1989.
89/35	Jean DERMINE and Pierre HILLION	"Deposit rate ceilings and the market value of banks: The case of France 1971-1981", May 1989.
89/36	Martin KILDUFF	"A dispositional approach to social networks: the case of organizational choice", May 1989.
89/37	Manfred KETS DE VRIES	"The organisational fool: balancing a leader's hubris", May 1989.
89/38	Manfred KETS DE VRIES	"The CEO blues", June 1989.
89/39	Robert KORAJCZYK and Claude VIALLET	"An empirical investigation of international asset pricing", (Revised June 1989).
89/40	Balaji CHAKRAVARTHY	"Management systems for innovation and productivity", June 1989.
89/41	B. SINCLAIR-DESGAGNE and Nathalie DIERKENS	"The strategic supply of precisions", June 1989.
89/42	Robert ANSON and Tawfik JELASSI	"A development framework for computer-supported conflict resolution", July 1989.
89/43	Michael BURDA	"A note on firing costs and severance benefits in equilibrium unemployment", June 1989.
89/44	Balaji CHAKRAVARTHY and Peter LORANGE	"Strategic adaptation in multi-business firms", June 1989.
89/45	Rob WEITZ and Arnoud DE MEYER	"Managing expert systems: a framework and case study", June 1989.
89/46	Marcel CORSTJENS, Carmen MATUTES and Damien NEVEN	"Entry Encouragement", July 1989.
89/47	Manfred KETS DE VRIES and Christine MEAD	"The global dimension in leadership and organization: issues and controversies", April 1989.
89/48	Damien NEVEN and Lars-Hendrik RÖLLER	"European integration and trade flows", August 1989.

89/49	Jean DERMINE	**"Home country control and mutual recognition"**, July 1989.
89/50	Jean DERMINE	**"The specialization of financial institutions, the EEC model"**, August 1989.
89/51	Spyros MAKRIDAKIS	**"Sliding simulation: a new approach to time series forecasting"**, July 1989.
89/52	Arnoud DE MEYER	**"Shortening development cycle times: a manufacturer's perspective"**, August 1989.
89/53	Spyros MAKRIDAKIS	**"Why combining works?"**, July 1989.
89/54	S. BALAKRISHNAN and Mitchell KOZA	**"Organisation costs and a theory of joint ventures"**, September 1989.
89/55	H. SCHUTTE	**"Euro-Japanese cooperation in information technology"**, September 1989.
89/56	Wilfried VANHONACKER and Lydia PRICE	**"On the practical usefulness of meta-analysis results"**, September 1989.
89/57	Taekwon KIM, Lars-Hendrik RÖLLER and Mihkel TOMBAK	**"Market growth and the diffusion of multiproduct technologies"**, September 1989.
89/58 (EP,TM)	Lars-Hendrik RÖLLER and Mihkel TOMBAK	**"Strategic aspects of flexible production technologies"**, October 1989.
89/59 (OB)	Manfred KETS DE VRIES, Daphna ZEVADI, Alain NOEL and Mihkel TOMBAK	**"Locus of control and entrepreneurship: a three-country comparative study"**, October 1989.
89/60 (TM)	Enver YUCESAN and Lee SCHRUBEN	**"Simulation graphs for design and analysis of discrete event simulation models"**, October 1989.
89/61 (All)	Susan SCHNEIDER and Arnoud DE MEYER	**"Interpreting and responding to strategic issues: The impact of national culture"**, October 1989.
89/62 (TM)	Arnoud DE MEYER	**"Technology strategy and international R&D operations"**, October 1989.
89/63 (TM)	Enver YUCESAN and Lee SCHRUBEN	**"Equivalence of simulations: A graph approach"**, November 1989.
89/64 (TM)	Enver YUCESAN and Lee SCHRUBEN	**"Complexity of simulation models: A graph theoretic approach"**, November 1989.
89/65 (TM, AC, FIN)	Soumitra DUTTA and Piero BONISSONE	**"MARS: A mergers and acquisitions reasoning system"**, November 1989.
89/66 (TM,EP)	B. SINCLAIR-DESGAGNÉ	**"On the regulation of procurement bids"**, November 1989.
89/67 (FIN)	Peter BOSSAERTS and Pierre HILLION	**"Market microstructure effects of government intervention in the foreign exchange market"**, December 1989.

<u>1990</u>

90/01 TM/EP/AC	B. SINCLAIR-DESGAGNÉ	**"Unavoidable Mechanisms"**, January 1990.
90/02 EP	Michael BURDA	**"Monopolistic Competition, Costs of Adjustment, and the Behaviour of European Manufacturing Employment"**, January 1990.
90/03 TM	Arnoud DE MEYER	**"Management of Communication in International Research and Development"**, January 1990.
90/04 FIN/EP	Gabriel HAWAWINI and Eric RAJENDRA	**"The Transformation of the European Financial Services Industry: From Fragmentation to Integration"**, January 1990.
90/05 FIN/EP	Gabriel HAWAWINI and Bertrand JACQUILLAT	**"European Equity Markets: Toward 1992 and Beyond"**, January 1990.

90/06 FIN/EP	Gabriel HAWAWINI and Eric RAJENDRA	**"Integration of European Equity Markets: Implications of Structural Change for Key Market Participants to and Beyond 1992"**, January 1990.
90/07 FIN/EP	Gabriel HAWAWINI	**"Stock Market Anomalies and the Pricing of Equity on the Tokyo Stock Exchange"**, January 1990.
90/08 TM/EP	Tawfik JELASSI and B. SINCLAIR-DESGAGNÉ	**"Modelling with MCDSS: What about Ethics?"**, January 1990.
90/09 EP/FIN	Alberto GIOVANNINI and Jae WON PARK	**"Capital Controls and International Trade Finance"**, January 1990.
90/10 TM	Joyce BRYER and Tawfik JELASSI	**"The Impact of Language Theories on DSS Dialog"**, January 1990.
90/11 TM	Enver YUCESAN	**"An Overview of Frequency Domain Methodology for Simulation Sensitivity Analysis"**, January 1990.
90/12 EP	Michael BURDA	**"Structural Change, Unemployment Benefits and High Unemployment: A U.S.-European Comparison"**, January 1990.
90/13 TM	Soumitra DUTTA and Shashi SHEKHAR	**"Approximate Reasoning about Temporal Constraints in Real Time Planning and Search"**, January 1990.
90/14 TM	Albert ANGEHRN and Hans-Jakob LÜTHI	**"Visual Interactive Modelling and Intelligent DSS: Putting Theory Into Practice"**, January 1990.
90/15 TM	Arnoud DE MEYER, Dirk DESCHOOLMEESTER, Rudy MOENAERT and Jan BARBE	**"The Internal Technological Renewal of a Business Unit with a Mature Technology"**, January 1990.
90/16 FIN	Richard LEVICH and Ingo WALTER	**"Tax-Driven Regulatory Drag: European Financial Centers in the 1990's"**, January 1990.
90/17 FIN	Nathalie DIERKENS	**"Information Asymmetry and Equity Issues"**, Revised January 1990.
90/18 MKT	Wilfried VANHONACKER	**"Managerial Decision Rules and the Estimation of Dynamic Sales Response Models"**, Revised January 1990.
90/19 TM	Beth JONES and Tawfik JELASSI	**"The Effect of Computer Intervention and Task Structure on Bargaining Outcome"**, February 1990.
90/20 TM	Tawfik JELASSI, Gregory KERSTEN and Stanley ZIONTS	**"An Introduction to Group Decision and Negotiation Support"**, February 1990.
90/21 FIN	Roy SMITH and Ingo WALTER	**"Reconfiguration of the Global Securities Industry in the 1990's"**, February 1990.
90/22 FIN	Ingo WALTER	**"European Financial Integration and Its Implications for the United States"**, February 1990.
90/23 EP/SM	Damien NEVEN	**"EEC Integration towards 1992: Some Distributional Aspects"**, Revised December 1989
90/24 FIN/EP	Lars Tyge NIELSEN	**"Positive Prices in CAPM"**, January 1990.
90/25 FIN/EP	Lars Tyge NIELSEN	**"Existence of Equilibrium in CAPM"**, January 1990.
90/26 OB/BP	Charles KADUSHIN and Michael BRIMM	**"Why networking Fails: Double Binds and the Limitations of Shadow Networks"**, February 1990.
90/27 TM	Abbas FOROUGHI and Tawfik JELASSI	**"NSS Solutions to Major Negotiation Stumbling Blocks"**, February 1990.
90/28 TM	Arnoud DE MEYER	**"The Manufacturing Contribution to Innovation"**, February 1990.

90/29 FIN/AC	Nathalie DIERKENS	"A Discussion of Correct Measures of Information Asymmetry", January 1990.
90/30 FIN/EP	Lars Tyge NIELSEN	"The Expected Utility of Portfolios of Assets", March 1990.
90/31 MKT/EP	David GAUTSCHI and Roger BETANCOURT	"What Determines U.S. Retail Margins?", February 1990.
90/32 SM	Srinivasan BALAK-RISHNAN and Mitchell KOZA	"Information Asymmetry, Adverse Selection and Joint-Ventures: Theory and Evidence", Revised, January 1990.
90/33 OB	Caren SIEHL, David BOWEN and Christine PEARSON	"The Role of Rites of Integration in Service Delivery", March 1990.
90/34 FIN/EP	Jean DERMINE	"The Gains from European Banking Integration, a Call for a Pro-Active Competition Policy", April 1990.
90/35 EP	Jae Won PARK	"Changing Uncertainty and the Time-Varying Risk Premia in the Term Structure of Nominal Interest Rates", December 1988, Revised March 1990.
90/36 TM	Arnoud DE MEYER	"An Empirical Investigation of Manufacturing Strategies in European Industry", April 1990.
90/37 TM/OB/SM	William CATS-BARIL	"Executive Information Systems: Developing an Approach to Open the Possibles", April 1990.
90/38 MKT	Wilfried VANHONACKER	"Managerial Decision Behaviour and the Estimation of Dynamic Sales Response Models", (Revised February 1990).
90/39 TM	Louis LE BLANC and Tawfik JELASSI	"An Evaluation and Selection Methodology for Expert System Shells", May 1990.
90/40 OB	Manfred KETS DE VRIES	"Leaders on the Couch: The case of Roberto Calvi", April 1990.
90/41 FIN/EP	Gabriel HAWAWINI, Itzhak SWARY and Ik HWAN JANG	"Capital Market Reaction to the Announcement of Interstate Banking Legislation", March 1990.
90/42 MKT	Joel STECKEL and Wilfried VANHONACKER	"Cross-Validating Regression Models in Marketing Research", (Revised April 1990).
90/43 FIN	Robert KORAJCZYK and Claude VIALLET	"Equity Risk Premia and the Pricing of Foreign Exchange Risk", May 1990.
90/44 OB	Gilles AMADO, Claude FAUCHEUX and André LAURENT	"Organisational Change and Cultural Realities: Franco-American Contrasts", April 1990.
90/45 TM	Soumitra DUTTA and Piero BONISSONE	"Integrating Case Based and Rule Based Reasoning: The Possibilistic Connection", May 1990.
90/46 TM	Spyros MAKRIDAKIS and Michèle HIBON	"Exponential Smoothing: The Effect of Initial Values and Loss Functions on Post-Sample Forecasting Accuracy".
90/47 MKT	Lydia PRICE and Wilfried VANHONACKER	"Improper Sampling in Natural Experiments: Limitations on the Use of Meta-Analysis Results in Bayesian Updating", Revised May 1990.
90/48 EP	Jae WON PARK	"The Information in the Term Structure of Interest Rates: Out-of-Sample Forecasting Performance", June 1990.
90/49 TM	Soumitra DUTTA	"Approximate Reasoning by Analogy to Answer Null Queries", June 1990.
90/50 EP	Daniel COHEN and Charles WYPLOSZ	"Price and Trade Effects of Exchange Rates Fluctuations and the Design of Policy Coordination", April 1990.

90/51 EP	Michael BURDA and Charles WYPLOSZ	"Gross Labour Market Flows in Europe: Some Stylized Facts", June 1990.
90/52 FIN	Lars Tyge NIELSEN	"The Utility of Infinite Menus", June 1990.
90/53 EP	Michael Burda	"The Consequences of German Economic and Monetary Union", June 1990.
90/54 EP	Damien NEVEN and Colin MEYER	"European Financial Regulation: A Framework for Policy Analysis", (Revised May 1990).
90/55 EP	Michael BURDA and Stefan GERLACH	"Intertemporal Prices and the US Trade Balance", (Revised July 1990).
90/56 EP	Damien NEVEN and Lars-Hendrik RÖLLER	"The Structure and Determinants of East-West Trade: A Preliminary Analysis of the Manufacturing Sector", July 1990
90/57 FIN/EP/ TM	Lars Tyge NIELSEN	Common Knowledge of a Multivariate Aggregate Statistic", July 1990
90/58 FIN/EP/TM	Lars Tyge NIELSEN	"Common Knowledge of Price and Expected Cost in an Oligopolistic Market", August 1990
90/59 FIN	Jean DERMINE and Lars-Hendrik RÖLLER	"Economies of Scale and Scope in the French Mutual Funds (SICAV) Industry", August 1990
90/60 TM	Peri IZ and Tawfik JELASSI	"An Interactive Group Decision Aid for Multiobjective Problems: An Empirical Assessment", September 1990
90/61 TM	Pankaj CHANDRA and Mihkel TOMBAK	"Models for the Evlauation of Manufacturing Flexibility", August 1990
90/62 EP	Damien NEVEN and Menno VAN DIJK	"Public Policy Towards TV Broadcasting in the Netherlands", August 1990
90/63 SM	Sumantra GHOSHAL and Eleanor WESTNEY	"Organising Competitor Analysis Systems", August 1990
90/64 SM	Sumantra GHOSHAL	"Internal Differentiation and Corporate Performance: Case of the Multinational Corporation", August 1990
90/65 EP	Charles WYPLOSZ	"A Note on the Real Exchange Rate Effect of German Unification", August 1990
90/66 TM/SE/FIN	Soumitra DUTTA and Piero BONISSONE	"Computer Support for Strategic and Tactical Planning in Mergers and Acquisitions", September 1990
90/67 TM/SE/FIN	Soumitra DUTTA and Piero BONISSONE	"Integrating Prior Cases and Expert Knowledge In a Mergers and Acquisitions Reasoning System", September 1990
90/68 TM/SE	Soumitra DUTTA	"A Framework and Methodology for Enhancing the Business Impact of Artificial Intelligence Applications", September 1990
90/69 TM	Soumitra DUTTA	"A Model for Temporal Reasoning in Medical Expert Systems", September 1990
90/70 TM	Albert ANGEHRN	"'Triple C': A Visual Interactive MCDSS", September 1990
90/71 MKT	Philip PARKER and Hubert GATIGNON	"Competitive Effects in Diffusion Models: An Empirical Analysis", September 1990
90/72 TM	Enver YÜCESAN	"Analysis of Markov Chains Using Simulation Graph Models", October 1990
90/73 TM	Arnoud DE MEYER and Kasra FERDOWS	"Removing the Barriers in Manufacturing", October 1990
90/74 SM	Sumantra GHOSHAL and Nitin NOHRIA	"Requisite Complexity: Organising Headquarters-Subsidiary Relations in MNCs", October 1990

90/75 MKT	Roger BETANCOURT and David GAUTSCHI	"The Outputs of Retail Activities: Concepts, Measurement and Evidence", October 1990
90/76 MKT	Wilfried VANHONACKER	"Managerial Decision Behaviour and the Estimation of Dynamic Sales Response Models", Revised October 1990
90/77 MKT	Wilfried VANHONACKER	"Testing the Koyck Scheme of Sales Response to Advertising: An Aggregation-Independent Autocorrelation Test", October 1990
90/78 EP	Michael BURDA and Stefan GERLACH	"Exchange Rate Dynamics and Currency Unification: The Ostmark - DM Rate", October 1990
90/79 TM	Anil GABA	"Inferences with an Unknown Noise Level in a Bernoulli Process", October 1990
90/80 TM	Anil GABA and Robert WINKLER	"Using Survey Data in Inferences about Purchase Behaviour", October 1990
90/81 TM	Tawfik JELASSI	"Du Présent au Futur: Bilan et Orientations des Systèmes Interactifs d'Aide à la Décision," October 1990
90/82 EP	Charles WYPLOSZ	"Monetary Union and Fiscal Policy Discipline," November 1990
90/83 FIN/TM	Nathalie DIERKENS and Bernard SINCLAIR-DESGAGNE	"Information Asymmetry and Corporate Communication: Results of a Pilot Study", November 1990
90/84 MKT	Philip M. PARKER	"The Effect of Advertising on Price and Quality: The Optometric Industry Revisited," December 1990
90/85 MKT	Avijit GHOSH and Vikas TIBREWALA	"Optimal Timing and Location in Competitive Markets," November 1990
90/86 EP/TM	Olivier CADOT and Bernard SINCLAIR-DESGAGNE	"Prudence and Success in Politics," November 1990
90/87 FIN/EP	Lars Tyge NIELSEN	"Existence of Equilibrium in CAPM: Further Results", December 1990
90/88 OB/MKT	Susan C. SCHNEIDER and Reinhard ANGELMAR	"Cognition in Organisational Analysis: Who's Minding the Store?" Revised, December 1990
90/89 OB	Manfred F.R. KETS DE VRIES	"The CEO Who Couldn't Talk Straight and Other Tales from the Board Room," December 1990
90/90 MKT	Philip PARKER	"Price Elasticity Dynamics over the Adoption Lifecycle: An Empirical Study," December 1990

<u>1991</u>

91/01 TM/SM	Luk VAN WASSENHOVE, Leonard FORTUIN and Paul VAN BEEK	"Operational Research Can Do More for Managers Than They Think!," January 1991
91/02 TM/SM	Luk VAN WASSENHOVE, Leonard FORTUIN and Paul VAN BEEK	"Operational Research and Environment," January 1991
91/03 FIN	Pekka HIETALA and Timo LÖYTTYNIEMI	"An Implicit Dividend Increase in Rights Issues: Theory and Evidence," January 1991
91/04 FIN	Lars Tyge NIELSEN	"Two-Fund Separation, Factor Structure and Robustness," January 1991
91/05 OB	Susan SCHNEIDER	"Managing Boundaries in Organisations," January 1991
91/06 OB	Manfred KETS DE VRIES, Danny MILLER and Alain NOEL	"Understanding the Leader-Strategy Interface: Application of the Strategic Relationship Interview Method," January 1990 (89/11, revised April 1990)

91/07 EP	Olivier CADOT	"Lending to Insolvent Countries: A Paradoxical Story," January 1991
91/08 EP	Charles WYPLOSZ	"Post-Reform East and West: Capital Accumulation and the Labour Mobility Constraint," January 1991
91/09 TM	Spyros MAKRIDAKIS	"What can we Learn from Failure?", February 1991
91/10 TM	Luc Van WASSENHOVE and C. N. POTTS	"Integrating Scheduling with Batching and Lot-Sizing: A Review of Algorithms and Complexity", February 1991
91/11 TM	Luc VAN WASSENHOVE et al.	"Multi-Item Lotsizing in Capacitated Multi-Stage Serial Systems", February 1991
91/12 TM	Albert ANGEHRN	"Interpretative Computer Intelligence: A Link between Users, Models and Methods in DSS", February 1991
91/13 EP	Michael BURDA	"Labor and Product Markets in Czechoslovakia and the Ex-GDR: A Twin Study", February 1991
91/14 MKT	Roger BETANCOURT and David GAUTSCHI	"The Output of Retail Activities: French Evidence", February 1991
91/15 OB	Manfred F.R. KETS DE VRIES	"Exploding the Myth about Rational Organisations and Executives", March 1991
91/16 TM	Arnoud DE MEYER and Kasra FERDOWS et.al.	"Factories of the Future: Executive Summary of the 1990 International Manufacturing Futures Survey", March 1991
91/17 TM	Dirk CATTRYSSE, Roelof KUIK, Marc SALOMON and Luk VAN WASSENHOVE	"Heuristics for the Discrete Lotsizing and Scheduling Problem with Setup Times", March 1991
91/18 TM	C.N. POTTS and Luk VAN WASSENHOVE	"Approximation Algorithms for Scheduling a Single Machine to Minimize Total Late Work", March 1991
91/19 MKT	Vikas TIBREWALA and Bruce BUCHANAN	"An Aggregate Test of Purchase Regularity", March 1991
91/20 MKT	Darius SABAVALA and Vikas TIBREWALA	"Monitoring Short-Run Changes in Purchasing Behaviour", March 1991
91/21 SM	Sumantra GHOSHAL, Harry KORINE and Gabriel SZULANSKI	"Interunit Communication within MNCs: The Influence of Formal Structure Versus Integrative Processes", April 1991
91/22 EP	David GOOD, Lars-Hendrik RÖLLER and Robin SICKLES	"EC Integration and the Structure of the Franco-American Airline Industries: Implications for Efficiency and Welfare", April 1991