

Smoothing Fluctuations in the
Allocation of Building Society
Mortgages

by

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Abstract

A dynamic simulation model, using the methods of system dynamics, has been developed to study how an individual Building Society can control its cash flows in order to produce a smooth flow of mortgage funds. Of particular interest is the role that forecasting plays in the decision process.

It has been concluded that the use of a forecast of net deposits by investors with a five month time horizon can improve performance significantly over existing practice of using current values only. The improvement persists even when large errors are present in the forecast.

Introduction

This paper describes the use of a System Dynamics model to determine whether or not a change in the decision process of allocating mortgages in Building Societies could lead to a smoother pattern of allocations. Of particular interest was the implications of using various forecasts in the decision process rather than current values, which is the practice adopted in Societies with whom the author has had discussions.

Building societies are financial institutions whose sole purpose is to provide mortgage finance for house purchase - and further, almost exclusively for owner-occupiers. Their source of funds is again almost totally limited to the small saver; apart from overdraft facilities with banks, they attract virtually no cash from corporate bodies. They are non-profit-making and are true societies in that all borrowers and investors are 'members' to whom the management is ultimately responsible.

Because of a general reluctance on the part of the Building Society movement to vary their interest rates as rapidly as economic factors might demand, the differential between their rates and those of their rivals can fluctuate dramatically and lead consequently to a highly fluctuating pattern of inflow of funds. The uncertainties surrounding interest rates and their desire to satisfy the demand for mortgages means that these fluctuations are transmitted through the system to their allocation rate of new mortgages. Figure I highlights these aspects by graphing interest rate differentials and fund flow rates for the period 1965-72.

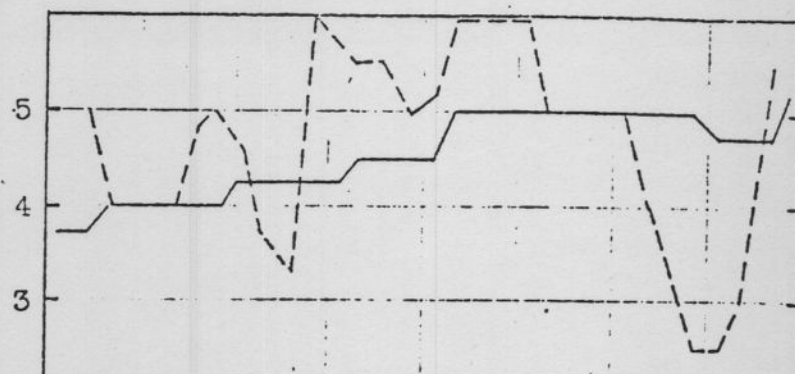
A great deal of financial information is available about individual societies, and the movement as a whole; each society produces an annual report for its members and a comprehensive report to the

Registrar of Friendly Societies who also publishes summary reports, the societies' trade association, the Building Societies Association, also publishes summary statements and tables in its Yearbook.

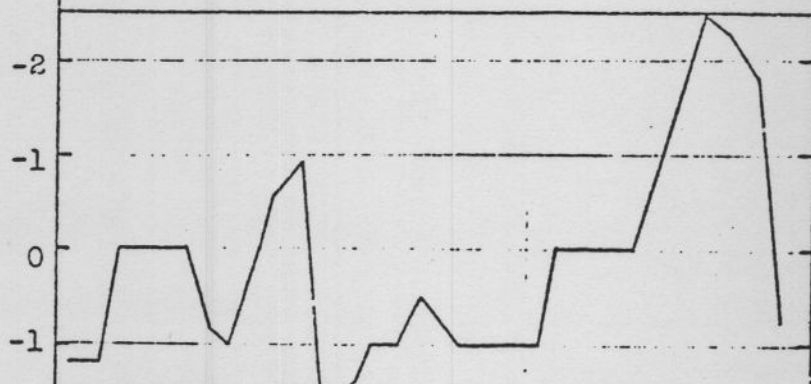
The building of the BLDSOC model was a two-stage process. The basic financial structure of all the societies is the same and can be determined from published statistics from such sources as those identified above. An initial influence diagram was therefore developed which represented the basic structure of a society. The second stage was to discuss the accuracy of this representation with building society managers and for them to describe in detail the decision-making processes within their individual societies which controlled the cash-flows. Three societies participated in this process and it was found that their control mechanisms were very similar. The final model represented a notional society in that an amalgam of these mechanisms was incorporated and the scale of figures used did not correspond to any particular society. The figures would represent a society in the top 20, and the model should be regarded as typical of a large or large/medium society.

A major problem exists with the building society system in that the objectives of the system, which must be defined in order to choose an appropriate performance measure, are much less clearcut than in the case of most business systems, e.g. maximisation of profit, minimisation of costs. An individual society may well judge its own performance in terms of growth rate in total assets (perhaps compared with other societies), and its ability to maintain certain accounting ratios that are specified in law. The movement as a whole is likely to be judged in political and socio-economic terms, by its ability to supply a steady and adequate flow of funds for house purchase, and the individual society will certainly also be judged but its members in terms of the ease with which it can offer mortgages

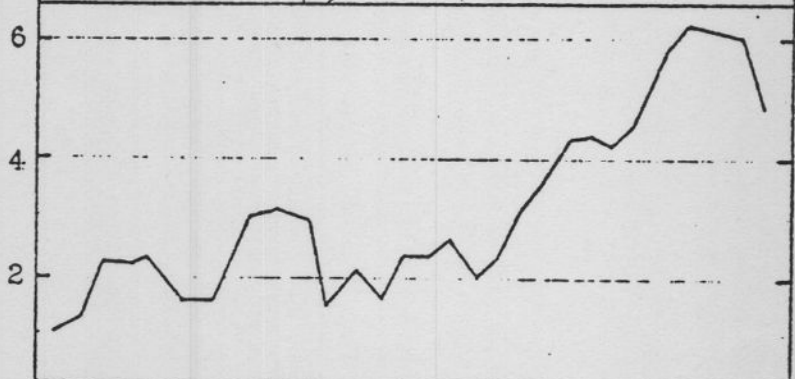
BUILDING
SOCIETY & BANK
DEPOSIT RATES
(%)



BUILDING
SOCIETY RATE
RELATIVE TO
BANK RATE
(%)



BUILDING
SOCIETY NET
DEPOSITS
(£'00m/month)



BUILDING
SOCIETY NEW
ADVANCES
(£'00m/month)

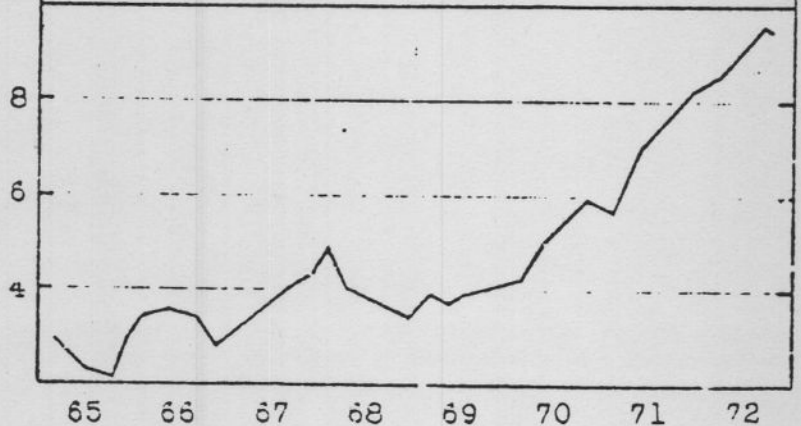


FIGURE 1 - Relationship between Interest Rate Differential and Net Deposits and New Mortgage Advances

(Source: Economist, 1972, p.73)

to them. Assessment has to be of a principally qualitative nature - the examination and comparison of the outputs of a number of variables representing the diverse objectives of the system. Quantitative measures are possible only through the use of "performance indices" based upon the fluctuation of key variables about smoothed mean values, or the length of time that certain variables are outside desired limits.

Description of the BLDSOC model

It is clear from the discussion of the building societies' operations above that the system is a very complex one. To consider fully the role the societies play in the national economy, a model would have to include the financial system (incorporating the banks, both commercial and small deposit aspects, the Post Office, the stock market and other forms of savings and investment opportunities), through the operation of the building society movement itself, and also on to the building industry and building materials sectors of the economy whose activities are obviously greatly influenced by mortgage lending patterns. Indeed, the large econometric models of national economies must include this aspect and the U.S. Federal Reserve - M.I.T. - Penn Econometric Model does include an extensive study of this field as reported by Gramlich and Jaffee (1971, 1972), de Leeuw and Gramlich (1968). (For other models of mortgage flows for house purchase in U.S.A. see Maisel (1965), Sparks (1968), Huang (1966) and for Canada see Smith, L.B. (1969)).

However, when it comes to study the control of cash flows within an individual society a rather different picture emerges. Because of the almost cartel-like operation of the societies within the Building Societies' Association (B.S.A.), to which all but a few of the smallest societies belong, much of the decision-making and flexibility in control is removed from the individual society. The societies decide for themselves such aspects as growth targets, siting of branches, advertising and priorities for allocating mortgages, but the fundamental

issues like the interest rates charged on mortgages and offered to investors are decided by the B.S.A. It is theoretically possible for societies not to adopt the B.S.A. recommended rates, but this is extremely rare except in the case of very small societies who may not have the economies of scale of the large societies and consequently have to work with a larger margin between the mortgage interest rate and the investment rate.

It is thus the case that interest rates are not in practice under the control of an individual society but are rather exogeneous inputs. The net deposit rate of investors with the society, that is the rate of new investment less withdrawals, is, as was discussed earlier, a function of the differential between the interest rates offered by the society and its rivals (and, of course, on other such factors as general economic climate, time of year). However, as the societies are generally offering exactly the same interest rate, there will be little cross-flow of funds from society to society. Consequently each individual society and the movement as a whole will experience highly similar patterns of flow of funds. (The only ways that cross-society flows are likely to be produced are from advertising and promotional campaigns, the use of networks of agents and brokers, and marginal differences in interest rates that can be offered on special savings arrangements like long-term deposits and Save-As-You-Earn, S.A.Y.E., schemes).

The implications of these circumstances for the modeller are that the sector of the system concerning the control of interest rates in relation to rival rates, and the effects of the relationship on the net deposits can be ignored in a model of an individual society as they lie beyond the boundary of the society's control. The net flow of deposits into the society thus becomes the exogeneous input to the system and it is to this input that the society must respond satisfactorily - i.e. it must smooth fluctuations in order to provide a smooth pattern of mortgage allocations, and it must control its levels of liquid assets and reserves. A further point about the rate-fixing of the B.S.A is that it tends to recommend rates with a constant margin or

difference between the mortgage rate and the investment rate. It is from this margin (and some other minor sources of income to be discussed later) that the societies have to pay their management expenses, corporation tax, and income tax on behalf of investors. This fixed margin and the setting of rates by the B.S.A. means that, providing interest rates are chosen that reflect this margin, they may be kept constant in the model over the whole length of the simulation.

The constraints under which the individual society operates mean, therefore, that its cash-flows can be represented by a comparatively simple model, even though the environment within which it operates is highly complex. The basic BLDSOC model, i.e. before the introduction of the forecasting functions and the performance indices equations, consists of twenty-nine variables, of which three are level or state variables. The structure is indicated by the influence diagram in Figure II, which includes variable names only, and a full list of variable names appears as Table I.

Discussion of the BLDSOC Results

The Basic run of the model wherein only current values for control variables were utilised is shown in Figure III. It can be seen that the plot for NETDEP (the rate of net deposits to the society) is identical in shape to the appropriate plot in Figure I - this is of course the exogeneous input to the system. Comparison of the plot for MORGTUP (the rate that newly allocated mortgages are taken up) with the appropriate plot on Figure I indicates that the model is replicating actual system behaviour reasonably well. It would not of course be expected that identical patterns would be produced but the basic components of peaks, growth rates and time lags are clearly very similar. This output should be used for comparison for subsequent

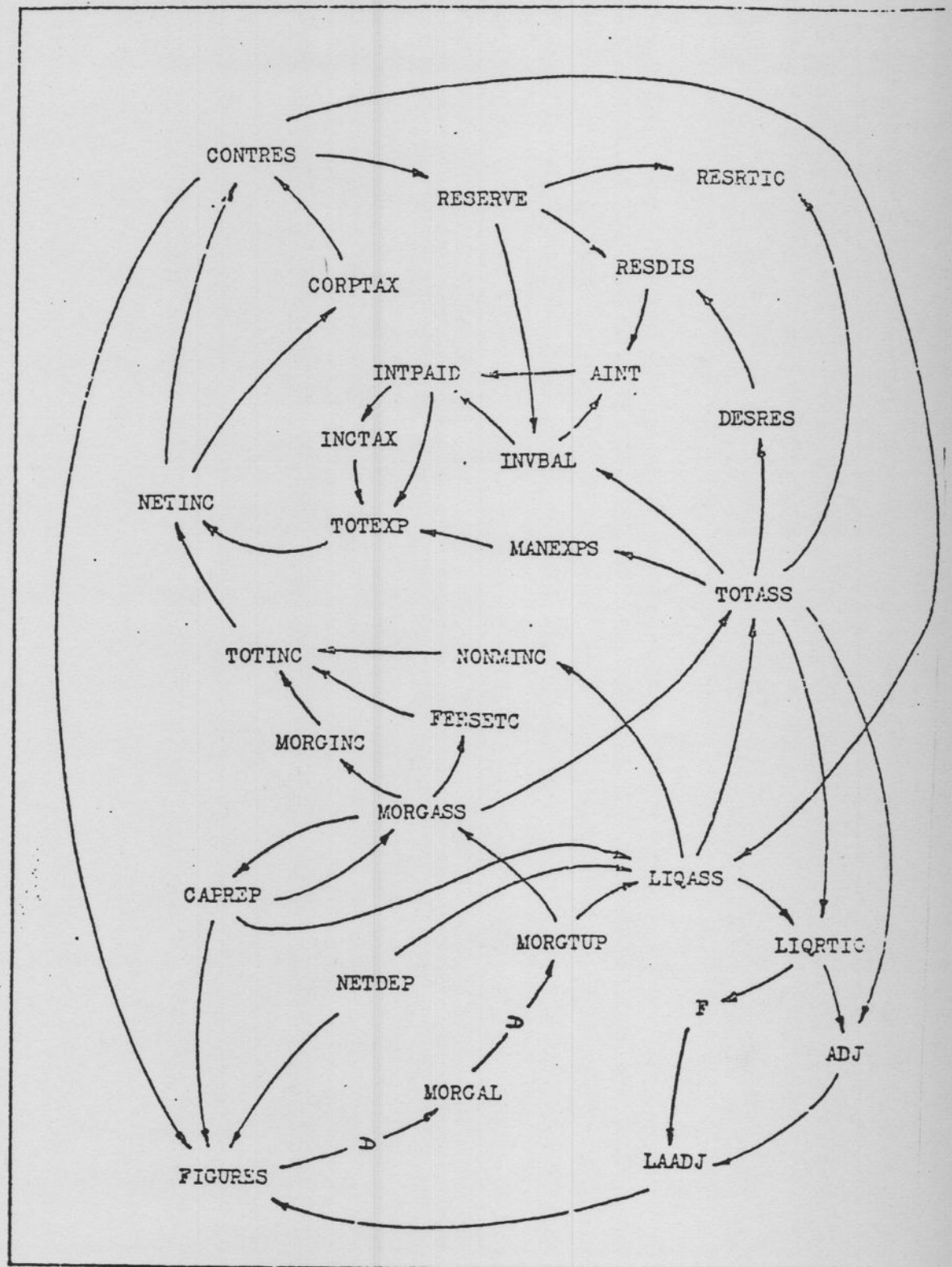


FIGURE II - Influence Diagram for Building Society Model, BLDSOC,
(Constants are not included)

runs, as should the values for the quantitative performance measures for the basic run:

Mean Absolute Deviation (MAD) in MORTGUP around a smooth mid-point	£2.74 x 10 ⁶						
Mean Squared Deviation (MSD)	£12.96 x 10 ¹²						
Proportion of run during which the liquidity ratio of the society deviated more than particular margins from the desired value of 15% (+1, 2, or 3%) lower the proportion the better the control)	<table> <tr> <td>+1%</td><td>74%</td></tr> <tr> <td>+2%</td><td>33%</td></tr> <tr> <td>+3%</td><td>15%</td></tr> </table>	+1%	74%	+2%	33%	+3%	15%
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+2%	33%						
+3%	15%						

A glance at Table II indicates that the incorporation of two particular forecasts, FORDEP - a forecast of net deposits, and FORLIQR - smoothed forecast of liquidity ratio with smoothing time of 6 months, produced significant improvements in performance with respect to both criteria. This is confirmed by examination of the graphical output - Figures IV and V respectively.

In terms of the smoothness of new mortgage take-ups, MORTGUP, there was little to choose between the two, although possibly the net deposits forecast run, while being less smooth in the short term, displayed a more even long-term pattern. Both runs have, however, eliminated the worst of the fluctuations in mortgage take-ups displayed by the BASIC model. With regard to the control of liquidity ratio the summary table suggests that the NETDEP forecast significantly outperformed the LIQRTIO forecast, and this is confirmed by the graphical output (care must be taken as the scales on the graphs are not the same). In the former case the liquidity ratio fluctuated slightly around the 16% mark - slightly higher than the desired level of 15%, but nevertheless extremely good control. With the liquidity ratio forecast, the fluctuations in liquidity ratio remained virtually

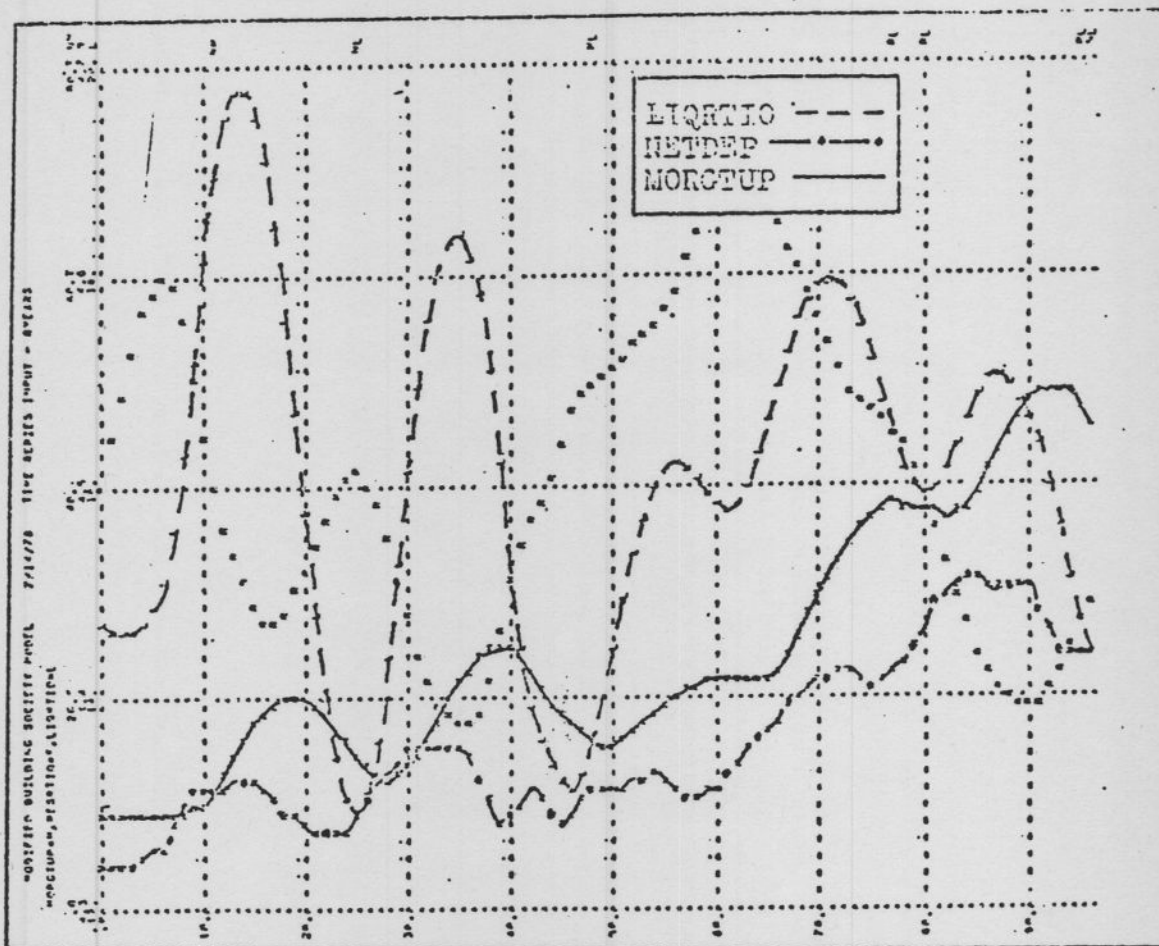


FIGURE III - Basic Run of BLDSOC Model, No Forecasts

unaltered, indeed the peaks were actually higher than in the BASIC run.

The other runs in this section all suggest that none of the other possible forecasts are likely to lead to improved performance. In the case of the forecast of capital repayment rate (FORCAP) the output is almost indistinguishable from the BASIC run. The fact that incorporating this forecast makes so little difference to performance is due to the nature of the variable. The capital repayment of mortgages is, in any case, a smooth variable representing the gradual and steady rate that the loan capital is paid off either through normal mortgage payments or when houses are sold off and the mortgage terminated early. Over the five month time horizon for forecasts in this system, it would be expected that the value of this variable would not change significantly enough to affect the fluctuations in the system. In terms of improving system performance as measured by the 'smoothness' criteria adapted here, using a forecast of CAPREP clearly has little potential.

Using either of the other two liquidity ratio forecasts also appears not to be recommended - the twelve month smoothed average, according to the graphical output, did produce a somewhat more desirable pattern of mortgage take-ups but control of liquidity ratio was very poor. The trend adjusted forecast (graphical output not included) led to disastrous performance, doubling the mean absolute deviation and causing the liquidity ratio to lie outside the $\pm 3\%$ limits for over half of the run.

As a result of these runs it did appear that the forecast of net deposits and the six-month smoothed forecast of liquidity ratio were the most likely to improve performance, with the former being the best of all. A final run was tried to see if the two in combination could produce even further improvement but as can be seen from Table II and was confirmed in the graphical output (not included), performance is no better than with FORDEP alone. The conclusion to be drawn from

Run Description	Deviations in MONGTUP		Proportion of run that LIQRTIO lay outside limits		
	MAD(10^6)	MSD(10^{12})	$\pm 1\%$	$\pm 2\%$	$\pm 3\%$
BASIC Current Practice - No forecasts	2.74	12.96	74%	33%	15%
FORDEP Forecast of Net Deposits	1.94	5.43	40%	0	0
FORCAP Forecast of Capital Repayment Rate	2.77	13.17	61%	32%	8%
FORLIQR F/C of LIQ.RATIO Exp. Sm. t = 6m.	2.41	9.24	51%	33%	22%
FORLIQR F/C of LIQ.RATIO Exp. Sm. t = 12 m.	2.79	11.80	84%	55%	39%
FORLIQR F/C of LIQ.RATIO Trend Adj. Smooth	5.60	44.53	24%	70%	52%
FORDEP + FORLIQR (Combination)	2.04	5.93	41%	0	0

TABLE II - Performance of BLDSOC Model with Prospective
Forecasts Incorporated

BLDSOC with Forecast of Net Deposits
 7/19/78 TIME SERIES INPUT - BYARS

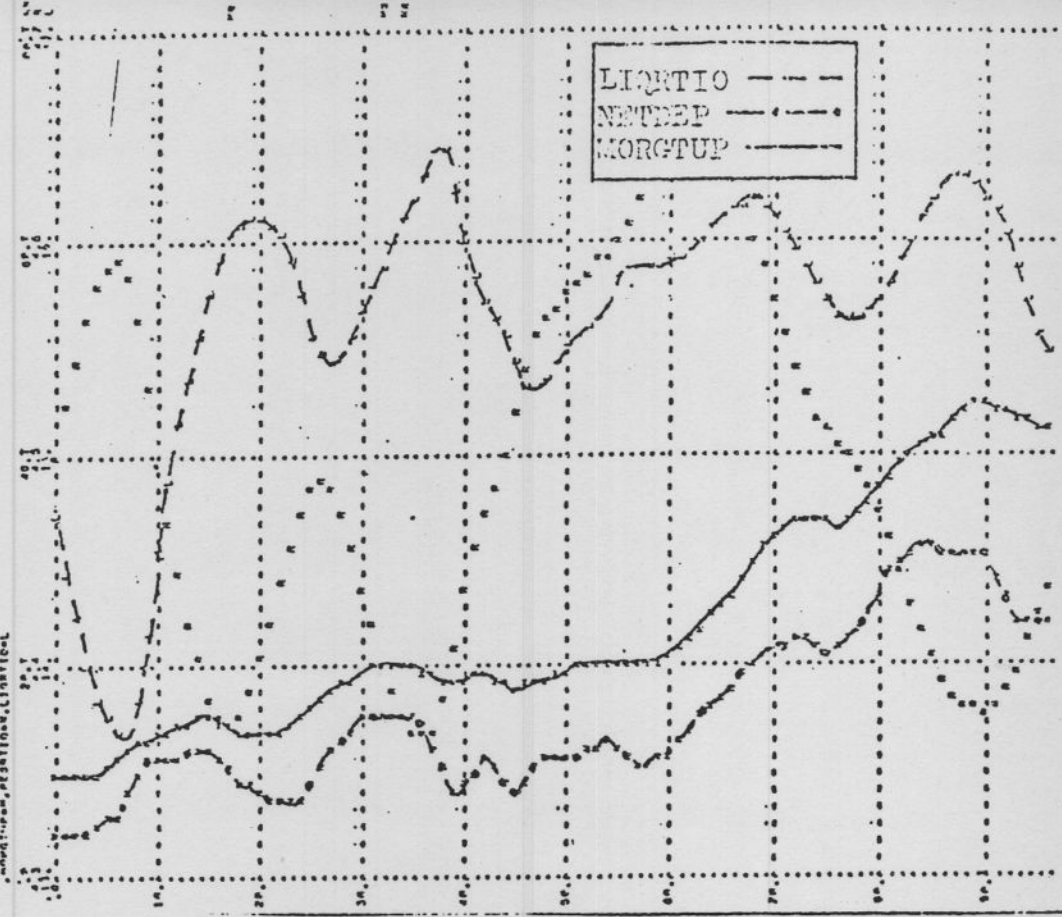
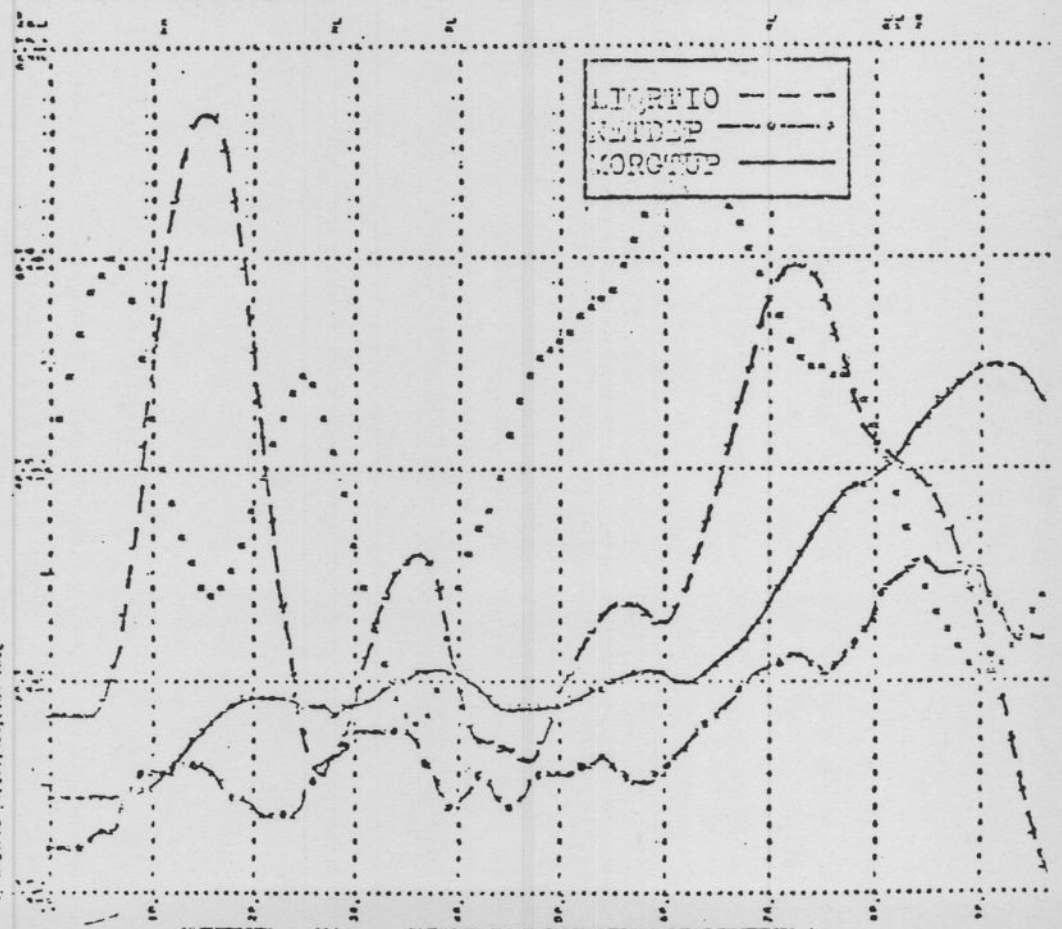


FIGURE IV - BLDSOC with Forecast of Net Deposits

BLDSOC with Forecast of Net Deposits
 7/19/78 TIME SERIES INPUT - BYARS



this first set was that the incorporation of a forecast of net deposit rate into the decision equation for mortgage allocations had great potential in improving performance over the existing practice of using current values. However in the model it was possible to obtain a perfect forecast for NETDEP by using the same input series with the appropriate lead time. In reality this variable may prove very difficult to forecast, being basically beyond the control of the individual society and even of the building society movement as a whole. The liquidity ratio forecast used in these experiments was derived within the model in just the way that it could be done in a society. Thus it represented a practical attainable forecast, rather than the 'perfect' value of the NETDEP forecast.

It was therefore necessary to examine the sensitivity of the system to the sort of errors that might be expected in the NETDEP forecast, before a final decision could be made between this and the Liquidity Ratio forecast as to which would be likely to be most beneficial - should the system prove to be sensitive to errors in FORDEP then FORLIQR, being easier to produce, should be adopted even though the possible improvement in absolute terms is not as great.

(A second point to come from these first experiment is that the introduction of forecasts does not guarantee improved performance. This was shown by the capital repayment and twelve-month smoothed liquidity ratio forecast. Further the introduction of an inappropriate forecast variable, or technique can have disastrous effects as with the trend-adjusted liquidity ratio forecast).

Potentially, then, the use of a net deposits could produce a significant improvement in performance - a reduction of 30% in mean absolute deviation and nearly 60% in squared deviation (which, of course, penalises extreme values more severely) was obtained, and

control of liquidity ratio was greatly improved with all deviations of greater than 2% from the desired level of 15% being eliminated. A second set of experiments was developed to discover if this improvement would be lost as a result of likely forecasting errors also being taken into consideration.

It is not appropriate at this point to discuss at any length the full results from this second set of experiments. Suffice it to say that it was found that the system performance maintained the improvement produced by introducing the forecast of net deposit rate into the control system area when quite large errors were introduced into the generation of that forecast. These degradations represented the typical errors that might be expected in any forecasting process - random noise, systematic bias and information delay. Figures VI and VII show the output for typical extreme results - Noise of $\pm 50\%$ and Bias of -25% and it can be seen that even with these large errors performance is still markedly better than the basic model run with no forecast at all!

Conclusions from the BLDSOC Experiments

The major points of interest from this set of experiments were dealt with as they arose during the discussion of the results earlier. However it is of value to summarise them as a whole here:

- (1) In terms of introducing forecasts into the decision making process in a building society, the best improvement in performance would be expected from the use of a forecast of net deposits. A second choice would be an exponentially smoothed average to forecast liquidity ratio for use in the adjustment factor for controlling the level of liquid assets.
- (2) There would appear to be no real advantage in using both these

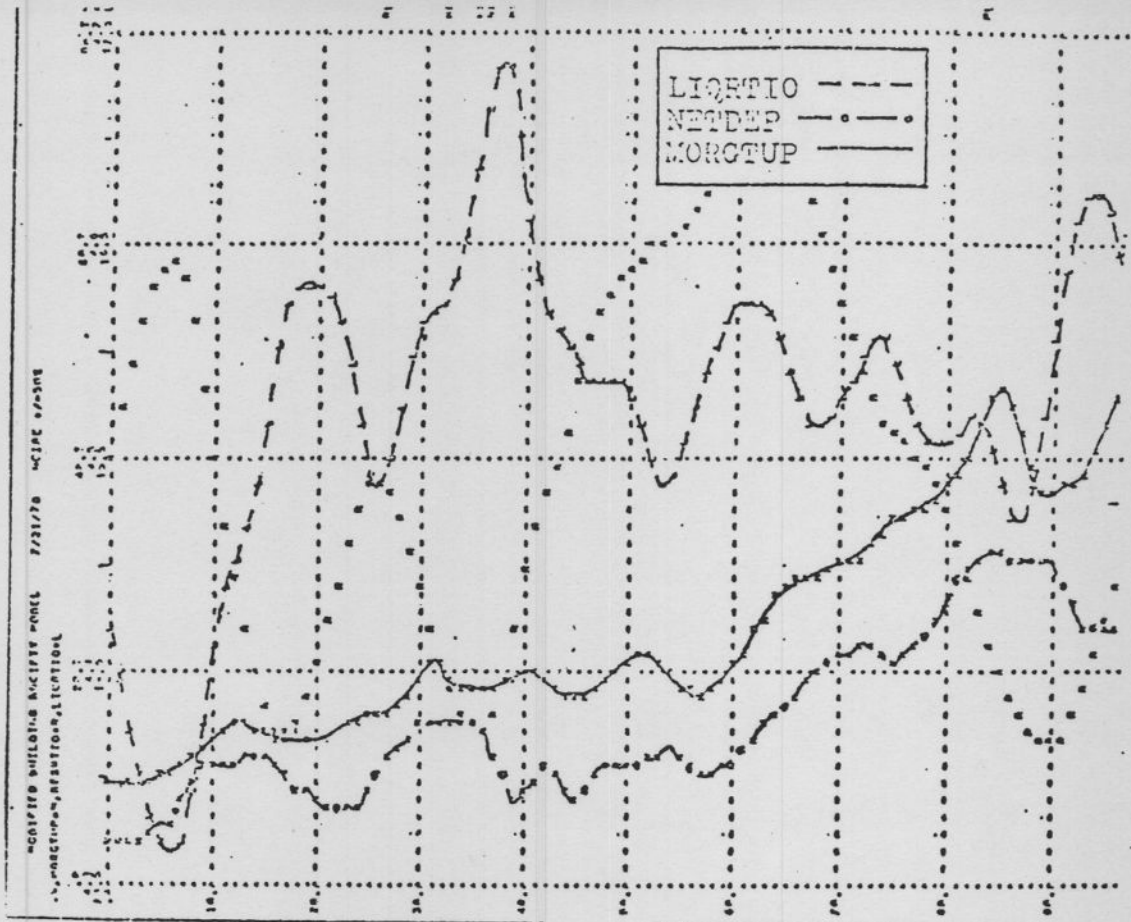


FIGURE VI - BLDSOC with Noise (+ 50%) in Forecast of Net Deposits

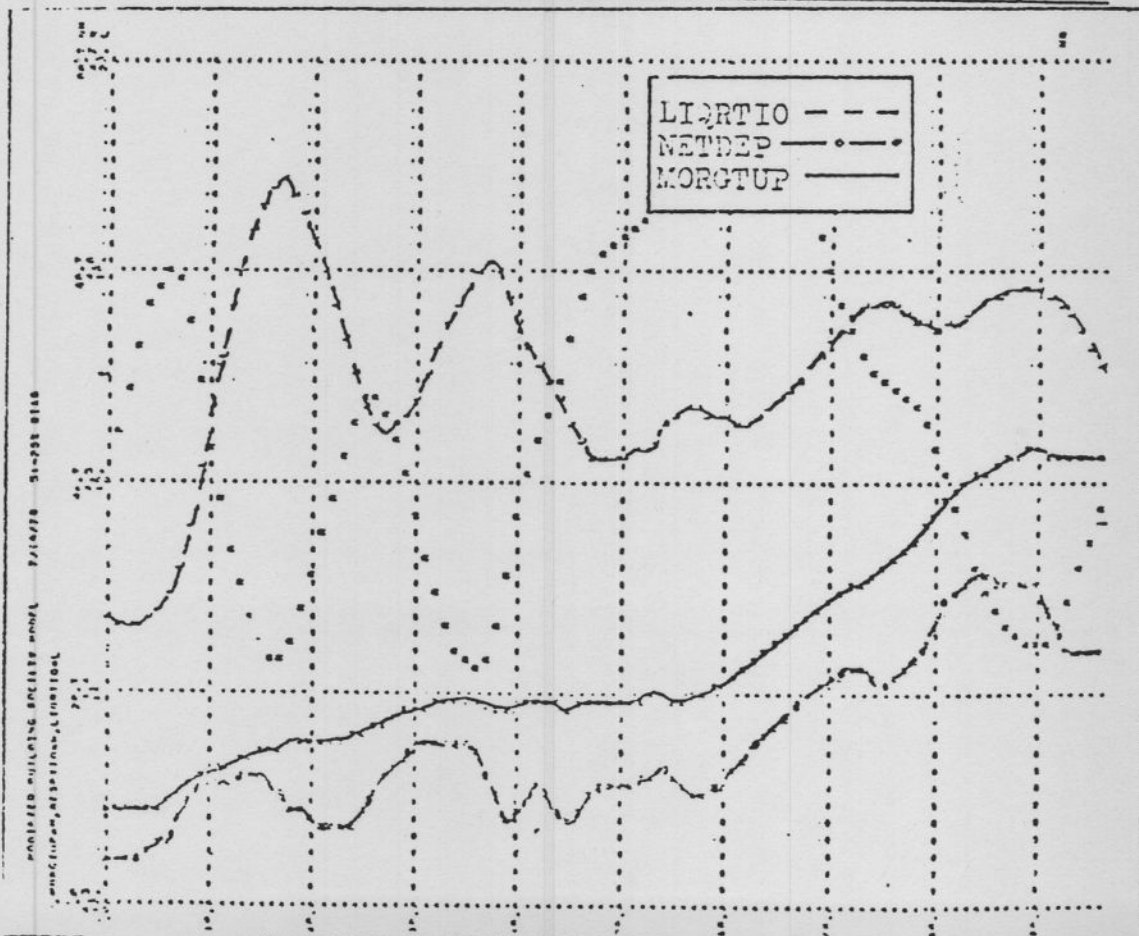


FIGURE VII - BLDSOC with Biased Forecast (-25%) of Net Deposits

forecasts together - no further improvement was gained in the experiments over the result for the net deposits forecast alone.

- (3) Of the other possible forecasts considered, none were of value in improving performance:
- CONTRES, rate of contribution to reserves, because it constituted only a fraction of one per cent of funds available for allocation.
 - CAPREP, rate of repayment of loan capital, because it was a steady smooth variable in any case, and showed little variation over the forecast horizon.
 - Other forecasts of liquidity ratio, i.e. with a longer smoothing time and trend adjusted, caused the system to perform less well than with no forecasts at all.
- (4) The forecast of net deposits was obtainable with perfect accuracy in the model because the input time-series could be used with an appropriate lead time; in reality this variable would be difficult to forecast. The liquidity ratio forecast was derived in the model as it might be in reality, and therefore could be considered to display reasonable and attainable accuracy. Final choice of forecast must therefore depend critically on the sensitivity of the system to degradations to the 'perfect' accuracy of the net deposits forecast.
- (5) The system proved to be very insensitive to typical errors in the net deposits forecast, and this variable would therefore be recommended for inclusion. With it incorporated considerable improvement in system performance, both in terms of smoothness of mortgage advances and control of financial ratio, could be expected - improvement is likely to remain significant even with extreme errors in the forecast.

This examination of a Building Society system and the role of forecasting in it, has given useful insights into possible benefits

of incorporating new forecasts into a control system, and into the process of evaluating potential forecasts. The current practice of the societies visited and upon whose policies the model was based, is not to use forecasts in the mortgage allocation decisions but to use only current values of variables. This is quite understandable for the 'hot favourite' to be forecast, the rate of inflow of net deposits can fluctuate widely from month to month besides exhibiting general cyclical behaviour. The societies are therefore sure that any forecast would contain substantial error, and they have erred on the side of caution and used 'exact' current values. The simulation experiments described here have shown, however, that the existing control system is highly insensitive to forecast errors, and so the substantial errors expected in the net deposits forecast may not in fact render it useless. (Random errors of the order of up to $\pm 50\%$ and systematic bias of $\pm 25\%$ could be present in the model and still allow significant improvement in performance over the no forecast situation).

This, perhaps surprising, behaviour might have been expected if the role of the forecast in the decision process, the nature of the forecast variables, and the objectives of the system had been examined in detail. The basic objective of the system was to provide a smooth flow of mortgage funds, while maintaining satisfactory control of certain internal financial ratios. The role of all the forecasts under consideration was to provide information on the funds available for allocation. One possible forecast variable could be eliminated immediately because it constituted a negligibly small proportion of funds; another might have been, the capital repayments rate, because it was a smooth variable and therefore unlikely to contribute to the fluctuations in allocation rate and in any case would not vary by much during the forecast horizon.

The other principal flow of funds was the net deposits which were known to fluctuate and, together with the amplifying effect of the

liquid assets adjustment factor, constituted the fluctuating force on the allocation rate. The use of a forecast of this variable would have the effect therefore of better allocating funds initially, thus causing smaller variations in liquid assets level - this effectively removing the amplifying effect due to liquid assets adjustment. (The use of a smoothed value for liquidity ratio rather than the true value might be expected to have a similar, if rather less effective, result). Further, because there are wide fluctuations in the net deposits pattern, a forecast for the appropriate time horizon ahead even one with large errors, is likely to be a better estimate of the true outcome than the current value - this accounts for the insensitivity to forecast errors in the model.

The experiments have also emphasised the point that the use of forecasts does not guarantee improved system performance - although a smoothed forecast of liquidity ratio with an averaging time of six months produced an improvement, one with a time of twelve month did not (response in the latter case was so slow that wide deviations in liquidity ratio were able to develop before control action was taken). Further an inappropriate technique, as with the trend adjusted liquidity ratio forecast, may prove to have disastrously adverse effects on performance.

As a more general point, the Building Society experiments did enable the role of forecasting to be examined in a complex system with unquantifiable objectives. It served to emphasise the value of graphical output with such systems, whereby the alternative futures represented by the behaviour of a number of variables over time can be examined and compared. It was possible to develop quantitative performance measures, and these proved useful in summarising the results. They could, however, give only a limited picture of the implications

of different policies and were frequently unable to convey the subtle differences in behaviour - examination of the graphical output proved itself much more effective and productive in the assessment of this system's performance.

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