

APPLICATION OF ADAPTIVE FILTERING FORECASTING TO THE GOLD BULLION PRICE

A method of forecasting Commodity Prices

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INTRODUCTION

"Recent research in a wide variety of behavioural contexts has indicated that hypotheses which assert that expectations tend to be related to past experience, often weighted average of past experience, are consistent with the data. Further, these hypotheses state that expectations tend to be systematically altered on the basis of new experience whenever unfolding events differ from what had been anticipated". This quotation, taken from a publication by Meiselman, is quoted by Michaelson 1).

ADAPTIVE FILTERING FORECASTING

Modern forecasting techniques such as adaptive filtering techniques, first applied by Wheelwright and Makridakis 2), has become a practical approach to follow when a medium sized computer is available. Adaptive filtering is a procedure that can be used to determine the value of a set of weights for use in time-series forecasting. The process of determining the weights is an iterative one with a cycle consisting of a set of N observations, computing a forecast for the next observation based on a set of N weights, then comparing that forecast with the observed value (using the mean square error) and finally revising the weights in such a way that the mean square error will be reduced 2). For the mathematical detail the reader is referred to the paper by Wheelwright et al. A copy of a computer program to apply the adaptive filtering technique was obtained from Steven Wheelwright but we re-wrote most of this original program in order to expedite iteration procedures.

We tested the adaptive filtering technique on the data of monthly values of residential construction (January 1959 — December 1969) that is used by the University of Wisconsin Computing Centre 3) as an example for the application of the Box-Jenkins method of forecasting. The adaptive

filtering technique gave a forecast of the last year's data within a mean percentage deviation (absolute) of 4.4%, whereas the similar deviation obtained with the Box-Jenkins method was 9.4%.

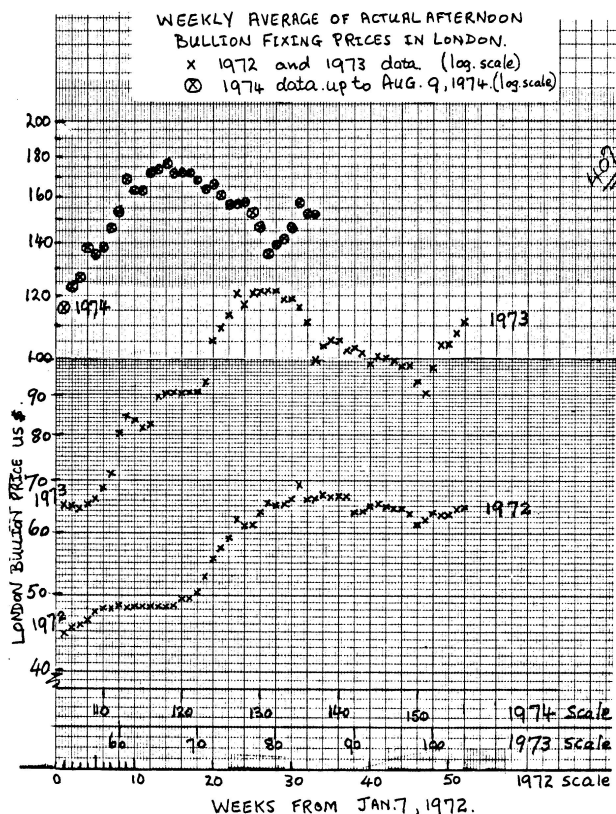
FORECASTING OF THE GOLD BULLION PRICE AT DIFFERENT TIMES IN 1974

Forecasting of the price for Gold Bullion per troy oz is a real problem with which many business analysts and investment managers are confronted with. We are grateful for the introduction to the problem by Grant Robinson after the publication of his paper 4) in February, 1974. Adaptive filtering was initially applied assuming Robinson's viewpoint that the long-term average of the Bullion price is expected to have an inherent positive exponential trend. This proved to be an unnecessary complication to be applied to our weighting parameters. It was thus ignored in any further work.

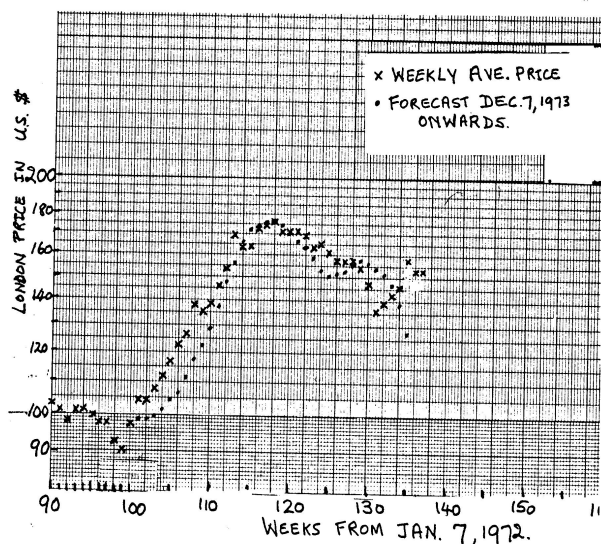
Our underlying assumptions are that contained in the quotation 1) due to Meiselman given above. It is our impression that in any market transaction some conscious or subconscious price norm is anticipated. Therefore, the often heard remarks that a particular share or commodity is "over-sold" or "overbought" and a reaction is then expected. This implies a forecast norm of the expected behaviour of the market price.

We thus attempted to analyse the gold bullion price data to empirically establish whether forecasting of the bullion price could be done and to what extent. A number of consecutive forecasts will be discussed below but they are supported with considerably more additional studies which we have done but are not reported here.

The weekly average of the daily afternoon fixing prices in London quoted in US Dollars per troy oz is given in figure 1, starting in January 1972. A log Y-scale is used. The X-axis represents the number of weeks from the beginning of 1972, i.e.

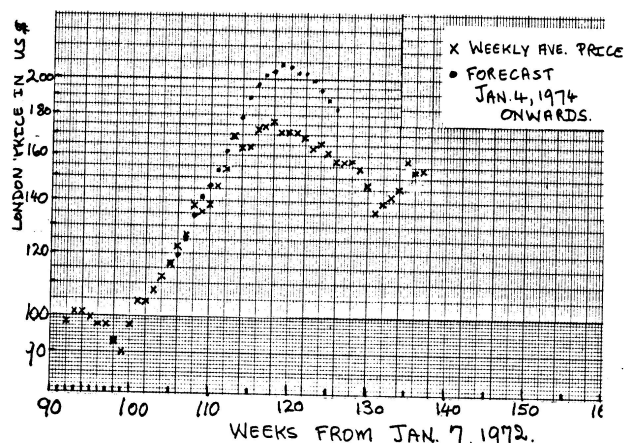


the week ending January 7, 1972. Figure 2 represents the actual data from the 90th week (again starting from January 7, 1972). Data up to week no. 100 was used to do a forecast and the results are recorded in fig. 2. The mean percentage



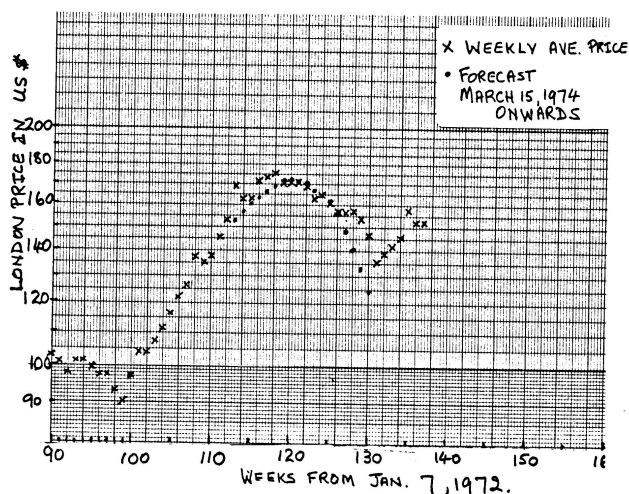
deviation (abs. value) obtained for the fit of the forecast values to the actual values over 32 weeks is 5,9%.

When a slight trend could be established, better fit in the short-term was obtained as represented in figure 3. A definite change in the trend can be identified in fig. 3 after week 113. This



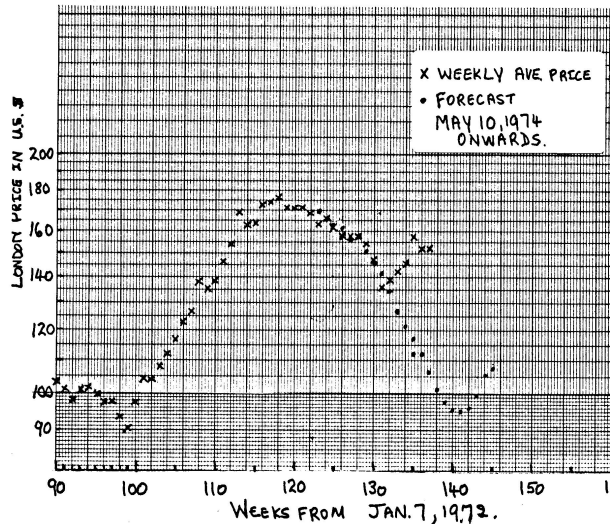
reminds one of second part of the quoted hypotheses of Meiselman 1). For 9 weeks, from week 105 up to week 113, the mean percentage absolute deviation between the forecast and the actual weekly values is 3,1%. At this point in time, i.e. end February 1974, many commentators expected that the Gold Bullion price would surpass \$200.

Another forecast (fig. 4) was done using data up to week 112. The turning point of the graph has been forecast reasonably accurately, about the same point in time as obtained in figure 3, but the fit to the actual values is quite satisfactory at the turning point. For the week ending March 1, 1974, (week 113) up to May 31, 1974 (week 126) the mean percentage absolute deviation between the forecast and the actual values is 3,3%.

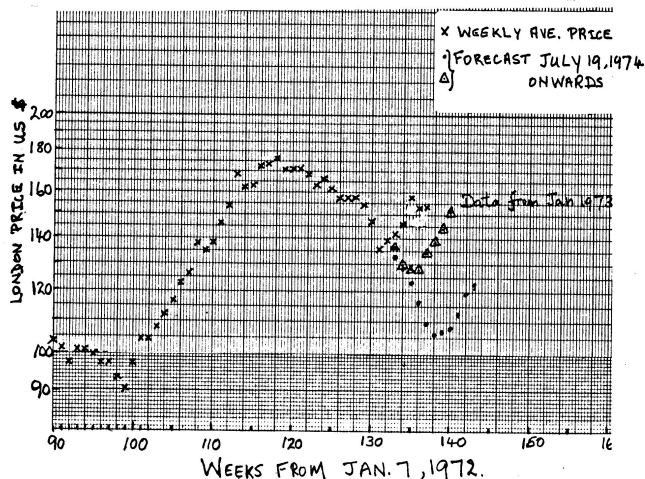


With data from January 1972 and including week 123 (week ending May 10, 1974) a further forecast was made (fig. 5). Again a good fit was obtained with the actual recorded weekly average of the daily prices over the nine weeks up to week 131 (week ending July 5, 1974) with a mean percentage absolute deviation of 2,9%. The data of 1972 was ignored and a similar forecast was made but it proved to be completely wrong (see the

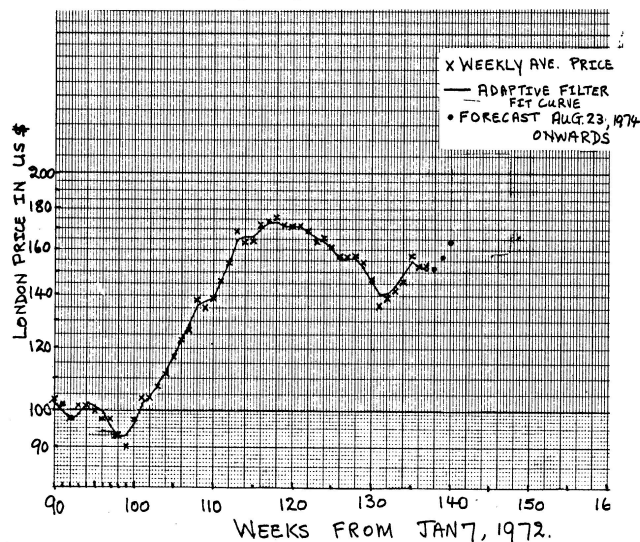
particular graph in fig. 5). Similar incorrect forecasts in March 1973 and April 1973 were obtained in cases where weekly data from January 1973 was used to get the required weights and weight training for the adaptive filtering technique. Enough weight training data through at least two cycles is required to do reliable forecasting. This experience confirms the experience of Wheelwright et al 2).



The forecast beyond week 131 (i.e. week ending July 5, 1974) is represented in fig. 6. Using data from January 1972, the iteration was terminated when the standard deviation of the estimate during the weight training period of 1.62% was obtained. In this weight training period the mean percentage deviation (absolute) of the estimated data from the actual data of 0.88% were obtained. A turning point is forecast in weeks 138 or 139 at about a weekly average of 105 US\$ as indicated in fig. 6. If we use only data from January 1973, the weight training period is not quite sufficient. Nevertheless, a standard deviation of estimate during the weight training period of 3.4% (absolute) has been obtained and a mean per-



centage absolute deviation of 1.9%. Such data then forecasts a turning point in either weeks 135 or 136 at about US\$127. We were, however, sceptical of the accuracy of this forecast because of the lack of enough weight training during the successive iteration procedures, although 111 iterations were carried out. This earlier turning point obtained without 1972 data, made us suspicious at the time. This suspicion turned out to be well founded and it subsequently proved that the price increase in week 132 (2nd week of July) was a definite change in the trend. It can be described as "a new experience" in terms of Meiselman's hypotheses. It is common knowledge that in July considerable interest in Gold was shown by buyers from the U.S.A.



With two further data points up to week 124 we still did not recognise the change as a new trend using data back to early 1972. After another two weeks have elapsed, the latter part of the data is recognised as a proper change in pattern with the turning point in weeks 137 or 138 at \$148. With the extra actual data for week 137, the fitted values for weeks 136 and 137 are \$153.41 and \$151.13 compared with the actual values of \$153.76 and \$153.70 respectively. (The standard deviation of the estimate is 1.9% and the mean percentage error (absolute value) of the forecast is 1.1%). The forecast has been obtained after 251 iterations. The results are reported in fig. 7. We are giving an example of the fitted values in this graph to demonstrate the closeness of the fit obtained.

In fig. 7 we are only giving a forecast for 3 weeks ahead as at the time of writing this article, there is an abnormal interest being shown in South African Gold Coins. This could also have an "unexpected" effect on the Gold Bullion price. Therefore, our forecast should be viewed in terms of the expected development taken from historic trends.

CONCLUSION

The future will prove the correctness of our assumptions based on the quoted hypotheses of Meiselman and therefore the correctness of the hypotheses themselves. There might be merit in applying this forecasting techniques to the prices of other commodities in the world market. Our success obtained so far on forecasting other economic parameters of interest in Banking supports this viewpoint.

ACKNOWLEDGEMENT

We are grateful to Grant Robinson of the School for Business Leadership of the University of South Africa for the data for the Gold Bullion price up to January, 1974, that he kindly made available to us.

1. JACOB B. MICHAELSON: "The Term Structure of Interest Rates", Intext Educational Publishers New York (1973), p.113 quoting: David Meiselman: "The Term Structure of Interest Rates", Prentice Hall, 1962, p.18.
2. STEVEN C. WHEELWRIGHT and SPYROS MAKRIDAKIS: *Revue Francaise d'Automatique, Informatique et Recherche Opérationnelle*, March 1973, V—1, pp.31—52.
3. University of Wisconsin Computing Centre: Computer Programs for the Analysis of Univariate Time Series using the method of Box and Jenkins, Supplementary Program Series No. 517.
4. Grant Robinson: "Get into Gold", *Management (South Africa)* 4, No. 6, pp.54—62 (1973).

ORGANISASIES — QUO VADIS?

"An inaugural Lecture seeks to identify themes and issues which will impinge upon the chosen subject during the tenure of the incoming Professor. An 'augurer' was a Roman religious official who foretold future events by omens, derived from the actions of birds, the appearance of victims entrails, celestial phenomena, etcetera. He was a soothsayer. (Latin: *avis* (bird) + *gar* from *garrere*, to talk or make known)." — Uit die intreerede van Gordon Wills aan die Cranfield Institute of Technology.

INLEIDING

Die mens is in 'n voortdurende wisselwerking met sy omgewing, en ter wille van sy voortbestaan en ontwikkeling moet hy dit kan beheers. Om beter oplossings vir probleme in die omgewing te vind as dié waartoe hulle as individue in staat is, begin mense dus gesamentlik organisasies vorm.

Vir die bereiking van talle doelwitte vorm hulle 'n verskeidenheid uiteenlopende organisasies. Voorbeelde hiervan is kerklike organisasies, welsyns- en ander gemeenskapsdienste soos die staatsdiens, gesondheidsdienste, jeugorganisasies, opvoedkundige inrigtings, die polisie, stads-organisasies en ook bedryfsorganisasies waar winsgewendheid gewoonlik belangrik is. Sonder veel teenspraak kan daar beweer word dat elke persoon inderdaad elke dag van sy lewe of deel vorm van 'n organisasie of intiem deur die bestaan en werking

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van organisasies geraak word. Dit is ook 'n verskynsel wat lank bestaan. Reeds in Bybelse tye is daar blyke dat Moses met die funksionering van organisasies te doen gehad het. In hierdie bespreking val die klem op bedryfsorganisasies, dog die beginsels geld ongetwyfeld ook vir organisasies in die algemeen ongeag hul besondere aard of algehele doelwit.

Aangesien enige organisasie (en veral 'n groot een) uit 'n groot aantal dele bestaan, is die werking van so 'n organisasie normaalweg ingewikkeld. Boonop moet daar gewoonlik aan 'n aantal uiteenlopende doelwitte voldoen en 'n verskeidenheid van beperkings in ag geneem word. Byvoorbeeld, die mikpunt van doeltreffende dienslewering word gewoonlik deur kosteoorwegings beperk. Verskillende groepe belanghebbendes het verskillende

1) Intreerede gelewer op 20 Junie 1974 in die Senaatsaal van die Universiteit van Suid-Afrika, Pretoria, by die aanvaarding van 'n Professoraat in Bedryfsleiding aan die Skool vir Bedryfsleiding van die Universiteit van Suid-Afrika.