An interactive display-based system for gilt-edged security broking

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Abstract

This paper describes experience in the development and use of a display-based interactive minicomputer system for gilt-edged security broking installed in the London Stock Exchange in January 1972. The system is located in the same office as the 12 dealers it serves and is continually up-dated with price information over a radio link from the exchange floor. For each security, current yields and deviations from the general trend are calculated and displayed on television monitors. Graphic terminals enable dealers to request individual stock-by-stock comparisons, fitted trend lines, and other facilities for investment analysis. The system is programmed in BASYS, a high-level language designed for ease of implementation of natural man-machine communication procedures.

1. Introduction

This paper describes experience in the development and use of a display-based interactive minicomputer system for gilt-edged security broking installed in the London Stock Exchange in January 1972. The configuration is illustrated in Figure 1 - it consists of: 20K x 16-bit core PDP11/20; 256K x 16-bit fixed-head disc; two 145K x 16-bit magnetic tape units; 6 channels of 32 line x 48 character television displays; 5 storage-tube graphic displays; and a 30 characters per second teleprinter. It is installed in the same office as the twelve dealers it serves and is continuously up-dated with information on price changes over a radio link from the exchange floor. For each security, current yields and deviations from the general trend are calculated and displayed on television monitors (Figure 2). The graphic terminals enable dealers to request individual stock-by-stock comparisons, fitted trend lines, and other facilities for investment analysis. The system is programmed in a high-level interactive language designed for ease of implementation of natural man-machine communication procedures.

This first section describes the system and its role in dealing whilst Section 2 of the paper outlines the design philosophy and lessons learned with special emphasis on the problems of the man-computer relationship. The final section discusses some aspects of the development of interactive software.

1.1 Dealing in Gilts

Appendix 1 gives a brief account of the main characteristics of British Government securities (Gilt-edged Stocks or Gilts) which currently total some £27,500,000,000 and form a vital means of funding any residual government budget deficit. Each gilt is quoted as to the price of £100 Nominal of Stock. This will guarantee a fixed payment (half the coupon) twice a year and £100 (and the final half-coupon payment) on the redemption date.

As an example:	Funding	6%	1993
	Name	Coupon	Redemption Date

Gilts are negotiable and rarely held by one owner to redemption - to the holder they represent a major form of asset into which other funds may be converted for a period to earn interest. Their main characteristics are security of investment, wide range of coupon and redemption date, and very high marketability (each price quoted in the "large" market stands for transactions of at least £500,000. It is possible to deal, on good prices in normal times, in £5 million to £25 million). The responsibility of the professional dealer is, therefore, financially heavy. He must have a full knowledge of the workings of the market and up-to-date price information, and be able

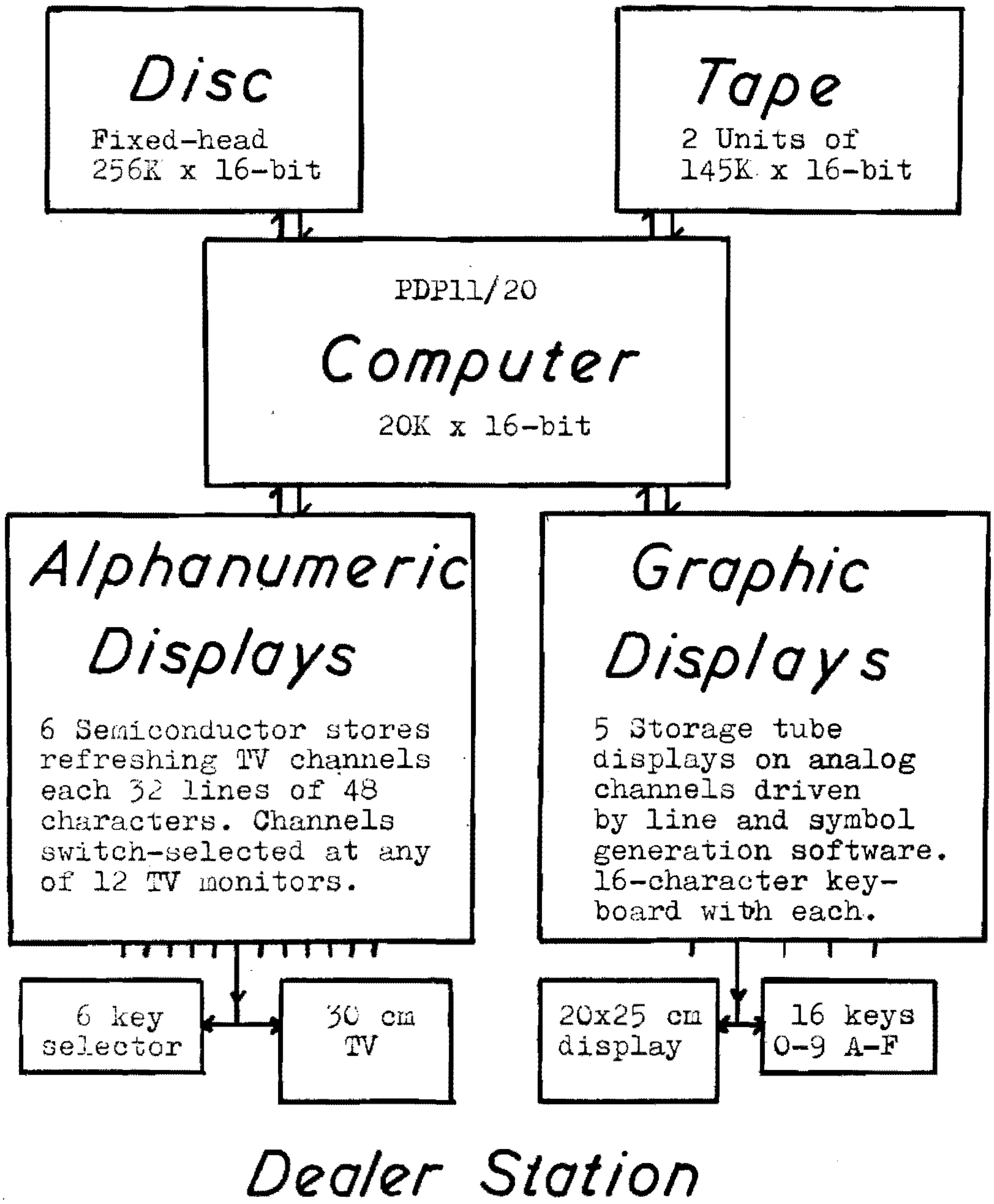

Figure 1 Computer System

to forecast the actions of other dealers and investors in the light of expected future events.

The physical dealing situation before a computer was installed was that twelve dealers and ancillary staff, each with a multi-line key-and-lamp telephone desk set, were in a small office grouped in clusters specialising in different types of stock. Price information was telephoned in from the exchange floor and written up on a roller-blind display in a maximally visible position. A list of prices and yields of all stocks, calculated from the previous nights closing position was circulated each day. Graphs of some bases for stock comparison, such as redemption-yield as a function of period to redemption were drawn by hand. Desk calculators were available for the recalculation of yields as prices changed during the day. A time-sharing computer bureau was used once a day to give stock by stock comparisons based on the last three months prices.

A partial justification of the utility of continuous access to a computer system is in the volume of price change information to be handled and the complex calculations (discounted cash flow) necessary to reduce this to a uniform basis for comparative assessment. The client relies on the dealer to have complete and accurate information about the current state of the market and the quality of this factual data can be improved by on-line computer processing. However, the system must be considered only as one more aid to dealing since many of the relevant factors are also qualitative and psychological, personal judgements based on interpretation of information in the light of experience and on the evaluation of what judgements others are likely to be making - a market may move not only on the basis of a rational financial process but also on the expectation of how that process will affect the actions of others dealing in it.

However, in all cases, it is advantageous to place such judgements in the context of financial facts - to be able to state that one stock gives a better yield than any other of comparable redemption period - to be able to state that the yield advantage of one stock over another is standing higher today than it has over the past three months - and so on. Information cannot replace judgement but it is generally assumed that enhanced information leads to enhanced judgement. This is the basic justification for the installation of a computer-based system - that the dealers have, and are known to have, more complete and up-to-date information presented in such a way that it highlights factors relevant to decisions on dealing.

1.2 Computer Facilities

The fixed information (Appendix A1.1) on the 50 or so gilts is held on the disc. The prices of each stock are the only independent dynamic variables and price changes in all stocks are

Figure 2 A Dealing Station

Figure 3 Television Monitor Yield Display

communicated over a radio link from the exchange floor to an operator at the teleprinter. He keys them in under an interactive data acquisition system which generates a variety of dialogues according to the type of stock and change made. A range of yields (A1.3) are calculated along with other functions such as maximum and minimum prices and yields of each stock over the day. On the disc are also retained "historic" daily records of the last 3 months maximum and minimum prices and yields for all stocks. Each month the past months historic records are archived on magnetic tape for long-term analysis.

The amount of raw information the computer holds is substantial and the amount of processed information it can generate, for example, by comparing one stock with another, is potentially very great. Taking full advantage of this material is a difficult problem in its own right. Human visual perception has an unparalleled capability to scan large quantities of information (presented meaningfully) and selectively extract that which is of interest. The generation of a book of tables and graphs of the computer-generated information would be excellent in making it accessible but it would have to be up-dated minute-by-minute. Computer-driven visual displays can achieve the same standard of presentation but do not facilitate visual scanning through large amounts of material.

In practice it was clear that the major items which should direct attention to themselves were price changes and it was decided to present these as a parallel, ever-present display on TV monitors (Figure 3) with markers indicating recent changes. Historic stock-by-stock comparisons are less dynamic and could best be presented in book form generated as an overnight printout. Graphical synopses of these comparisons and overall trend lines could be presented on the graphic displays (Figure 4) to draw attention to anomalies and interesting situations. Any single comparison could be requested in detail on a graphic display. This combination of continuous displays, printed material, and dynamically generated selected displays has proved very effective and it is clear from experience that no one technique or medium could satisfy all the differing requirements.

In summary the dealer has, literally at his fingertips, complete up-to-date figures of recent price changes, the current market prices, the associated yields, and deviations from the fitted curve of yields, for every stock. He is able to quote to clients in whatever detail is required the exact situation for every stock. In addition he can request at the graphics terminal a cross-comparison of two stocks he is discussing with a client and, within a few seconds, be able to quote comparative figures on the relative merits of the two stocks and their behaviour over the past three months. On a longer term basis the dealer may browse through a wealth of data about stocks for purposes of investment analysis and to confirm,

Figure 4 Graphic Display of Price Ratios

or dis-confirm, his appraisals of stocks based on other sources of information.

2. Interactive Computers in Commerce

The close integration of a computer system into an existent office environment clearly has its pitfalls and problems and it is interesting to analyse some aspects of this project for their more general implications, particularly in the choice of type of computing facility, mode of operation, and system development/programming.

2.1 Minicomputers and Conversational Utilities

Although gilt-edged security broking is in itself a specialist activity, it exemplifies many commercial dealing situations where success depends on continuous information management. A dealer in any commodity whose price is continually fluctuating, be it money, stocks, or physical supplies, requires real-time information about the deals of his colleagues and competitors and the state of the market - he requires on-stream processing of this continually changing information against an on-line file system of historic data acquired about the market. The facilities he requires typify those proposed for large-scale "computer utilities" (Parkhill 1966) providing "conversational access" (Orr 1968) to "national information systems" (Rubinoff 1965) through "teleprocessing" (Liu and Holmes 1970). However, whilst some large corporations have successfully established central computing utilities on this basis, the scale is not appropriate to smaller organisations and neither is it necessarily the most cost-effective approach. The problems and costs of fast reliable communication with a shared central utility are themselves substantial and may far outweigh the benefits of centralisation in itself. The costs of computers have been decreasing more rapidly than those of communications and the inessential transmission of information is an expense which requires major benefits to be justified.

The concepts and terminology applied to the dealer's requirements, on-stream, real-time, are more those of industrial process control than they are of conventional, punched-cards → line printer, batch-processing E.D.P., and in recent years interest has arisen in potential commercial applications of the minicomputer developed originally for scientific instrumentation and industrial process control. Technically the differences between minicomputers and E.D.P. machines are not substantial and the demarcation is in major part one of marketing and associated customer support. The main practical differences are that minicomputers are available in smaller packages, both in cost and in size, and have fewer prerequisites to their operation. Put another way it might be said that minicomputers historically lack the backup of operating systems and high-level languages possessed by E.D.P. machines. However, most software facilities, particularly when general-purpose, require extensive hardware configurations to support them. This both increases the cost of a minimal configuration and reduces the system designer's flexibility in optimising the overall cost-effectiveness by tailoring the system to the application.

At present the facilities associated with a computer utility can only be provided cost-effectively by a central installation when the amount of processing required is large compared with the amount of communication. When the opposite is true, as in the dealing situation, then the facilities are best provided on a distributed basis through a combination of the hardware modules from the catalogues of minicomputer manufacturers together with suitable interactive systems software. Even so the costs remain high enough to exclude all but a minority of applications. A minicomputer with some 32K characters of main memory, 5M characters of exchangeable disc memory, a typewriter and a visual display unit, costs some £8-10K. Configurations with multiple displays including graphics take this to some £20K. These are substantial capital expenditures to most small commercial groups and would be justified typically only in replacing the labour of one or more clerical staff. Since it is now folk-lore that computer installations add to staff requirements, some more substantial justification is necessary, generally in terms of improved quality of operation.

2.2 Symbiosis and Servility

Whence comes this improved quality of operation, however ? - there seems an implicit assumption always that there will be some improvement and the only basis for criticism is that the costs may outweigh the benefits. The possible deterioration from an existent level of operation is not considered although it is a real possibility, particularly when the existing system depends on skilled individuals already working at capacity under stress. Those who are potentially most able to benefit from computer aids are also those most likely to suffer if the "aids" themselves present a new information load requiring adaptation, extra skills, and perhaps more effort to obtain information than was previously required.

Many workers (e.g. Licklider 1960; Press 1971; Hormann 1971; Smith 1972) have discussed the relative roles of man and computer in integrated systems and hypothesized some optimum form of symbiotic relationship in which the computer's accurate memory and rapid numerical and logical processing are coupled with man's self-organising, goal-directed strategies and his semantic memory and perceptual abilities to generate, through partnership, a system more effective than either alone. The possibilities of such systems has been demonstrated in decision-making under uncertainty (Edwards 1968) and data analysis (Hall, Ball, Wolf and Eusebio 1968), but it has not proved to be easy to bridge the gap between laboratory experiments and cost-effective commercial systems.

We hypothesized that many of the past problems in the development of practical management information systems were ones of design conception, and that the usual problems of system definition had been greatly multiplied when close human interaction became fundamental to the system operation. It is very difficult to generate a complete, unambiguous description of even mechanistic devices, such as physical systems or accounting procedures, and when the ultimate non-mechanistic system, the human being, is involved systems analysis and definition becomes an essentially inexact process. However, starting from a viewpoint of man-computer symbiosis in which the computer is regarded as a partner, or, better still at present, as a servant, one has a range of human analogies to aid ones thought - from Dickens at least if not from modern life!

The servant coming from a different culture, perhaps with a different language, did not expect the master to change his life style or language - dread the thought. The servant adapted his dress, manners, sleeping habits, mealtimes, language, every aspect of his personality, to fit those of the master. The master's whims were the servant's commands - however, and again Dickens will testify, the good servant was a thinking being with a character of his own but one devoted to his master's ends. Not for him the unthinking leap of the horsemen over the cliff at the whim of the Chief. The master is disobeyed gently, but firmly, when he orders disaster. His orders are queried courteously when they have serious consequences that might not have been foreseen. And so on - droll the examples may be but they are serious and meaningful ones which illuminate many of the problems of commercial computer systems interacting with management decision making.

This analogy highlights the problems of system development centred on human requirements and gives a model of the end-objective. However, the problem of actual system specification and development remains - the servant was apprenticed to a craftsman rather than taught formally. Learning by doing with heightened perception of success/failure is probably vital to attaining the objective. Much can be done in advance since the master's activities can be discussed and analysed but it is doubtful that anyone can give a total specification - in addition the master may well wish to do more if he has a dependable servant. Here it seems logical to turn the problem upon itself by making the system design an interactive process and integrating the program development system itself into the interactive management information system. A time-sharing system can be sufficiently dynamic, flexible and protected for program development to be carried out at one terminal in the light of experience being gained simultaneously at another. It seems plausible that the advantages of close man-machine interaction will carry over from the run-time system to the developmental system, and that a highly interactive programming system will enable the design and development to be itself a dialogue between designer and users. In the next section some aspects of the technical problems of programming a suitable man-machine interaction are discussed.

3. Software Development

There was available with the machine a very comprehensive single-job disc operating system. It had two disadvantages for this system; no extension to multi-job working; more elaborate facilities than actually required, leading to higher overheads than necessary. It was, however, considered highly desirable that system software development should be minimised and as much manufacturer's software as possible should be used: (a) to ease maintenance problems by driving the peripherals with manufacturer's software; (b) to enable advantage to be taken of software drivers for new peripherals fitted to the system at future dates without excessive software re-engineering. Hence, a decision was taken to write drivers for the special peripherals under the standard D.O.S. and implement a scheduler using the line-frequency clock to run a simple time-sharing system apparently running as a single user to D.O.S.

A second major decision was whether to write the application programs in assembly language or in some high-level language. Three main factors were in favour of high-level language:

(i) The system specified was by no means complete and the application was novel - it was clear that considerable on-site development and modification of the system would be necessary and this would most conveniently take place whilst the system was in operation. Substantial re-assembly, linking and loading under these conditions would be difficult and, without hardware protection, would require the entire system to go down.

(ii) The time for the complete development was very short, some 3 to 6 months, and a high-level language, where a substantial number of the facilities required were already provided, was attractive.

(iii) It was desirable for the application software to be taken over eventually by Laurie Milbank - a suitable high-level language would make this feasible whilst assembly language might make it impossible.

A major part of the application software appeared to be terminal interaction and character-string handling and it was particularly required that this be done with the minimum imposition of conventions for the computer. None of the high-level languages available for the minicomputer configuration could satisfy this requirement, and it was finally decided to use BASYS (Facey 1972; Kennedy and Facey 1973; Facey and Gaines 1973) a systems programming language designed particularly for terminal interaction. BASYS has a syntax similar to Dartmouth BASIC but is extended to have SNOBOL-like pattern-matching string-handling facilities and very comprehensive file operations. Its implementation also lends itself readily to further language extensions and special facilities for driving the displays and graphics plotting could be added.

An interpretive implementation of BASYS with variable-length integer arithmetic (up to 7 x 16-bit signed operands = 33 decimal digits) was chosen as suitable both for the text handling and the financial calculations. This was implemented on the PDP11 to give a single-language time-sharing with job slots for each graphic terminal and for the typewriter. To maximize speed no automatic swapping was incorporated and all jobs are locked in core. However, the core allocations are completely flexible and dynamically adjusted automatically as application program overlays are called. Semaphores are used to overcome potential clashes in main memory requirements. Application program overlay calling is extremely simple in BASYS (all simple variables and whatever arrays and strings are specified are passed to the called program) and our previous experience had shown that there were advantages in writing such systems in a modular fashion as a succession of comparatively small BASYS overlays.

A good example of the way in which the string-handling facilities of BASYS can be used to adapt the computer system to the user is the "shorts language" developed for input and display of prices of the short stocks. These prices are communicated in a dealer's jargon which has various short forms for common situations and, on analysis, turns out to be consistent, unambiguous, and less prone to errors in verbal transmission than number strings. Briefly: only the buying and selling fractions are communicated (the number of whole pounds, the "big figure", is obvious with short stocks); sixteenths are referred to by the numerator only - 5 is 5/16; "under" means less 1/32, "close under" means less 1/64 - these were written, e.g. U3 (=5/32), CU3 (=11/64); similarly for "over" and "close over"; "either side" means a price range from -1/32 to +1/32 about a centre price - this was written, e.g. -7- (=13/32 to 15/32); "close to close" meant ±1/64, e.g. 1/2 CC (=31/64 to 33/64). The highly favourable dealer reaction to the change over from fractions to the commonly used jargon stressed once again the importance of using in full the computers encoding/decoding capabilities to match user expectations and requirements.

The better accepted and utilised the information-presentation system the more important is it that the data entry and other operator activities are carried out properly and accurately, and a great deal of effort went into programming an intelligent, servile, interactive system that minimised the operator's workload and gave maximum data-validation. The shorts "language" was also made available for data entry and many other techniques described elsewhere (Gaines and Facey 1974; Kennedy 1974) were used to make the system readily comprehensible with specific tutorial information accessible interactively at each stage of the dialogue.

4. Conclusions

The system described in this paper has been in full-time operation since January 1973 and has come to be accepted as part of the normal facilities for dealing. It demonstrates that a display-based, on-line minicomputer can be a very effective tool in a commercial environment and that the developmental effort required is reasonable in magnitude. Technically the project is a further illustration of the power of a high-level interpretive language on a minicomputer in providing a flexible, rapidly-adjusted system that can be closely matched to the terminology and requirements of its users.

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Appendix 1 British Government Securities

Individual gilts may be characterised by three types of information:

A1.1 Fixed characteristics - dates and coupon The name of a gilt has only historic significance. At present coupons vary between $2\frac{1}{2}$% and $10\frac{1}{2}$%. Redemption dates vary from 1973 to 2012/15. Some stocks, the government has the option to redeem on a certain date "or after". While the price is below 100 such a stock is grouped as "an irredeemable". It is convenient to classify four groups: period to redemption 0-5 years - a short; 5-10 years - medium; 10 upward - long; unspecified - irredeemable.

A1.2 Present state - price and touch The price is the only independent variable characterising a stock. It can fluctuate from minute to minute and up-to-date information on current prices is vital to dealing. It is generally obtained by continuous telephone communication with representatives on the stock exchange floor. The principal who "makes" the market, buying and selling stock on his own account, is the jobber. There are 6 or so gilt edged jobbers on the floor of the London Stock Exchange, and each will make two dealing prices in each stock - at the lower he will buy stock, at the higher he will sell it. In a particular sized bargain, the highest buying price (bid) in the market in conjunction with the lowest selling price (offer), (probably with two different jobbers), constitutes the closest dealing price possible, known as the touch.

A1.3 Calculated state characteristics - yields Whilst the price reflects the market value of a stock, it does not, by itself, indicate its worth to the investor. How should he choose between Treasury $8\frac{1}{2}$% 80/2 at 87 and Gas 3% 90/5 at 46 ? Both coupon and period to redemption are of major importance. Consider -

Example 1 A Treasury 10% 1998 at 100; B Funding $2\frac{1}{2}$% 1998 at 50. Looked as an investment to 1978 and assuming the Treasury stock stays at 100, on £100 nominal, A pays £10 per annum to 1978. B pays £5 per annum to 1978 on £200 nominal, but provides a maturity capital gain of £100 as well. On the assumptions made, an investor would buy B, and switch into A in 1978.

Thus, the worth of a stock must be related to the payments expected in the future, both of dividend and at maturity. The gross redemption yield (g.r.y.) is the rate of interest at which the price equals the future payments discounted back to the present. The g.r.y. is the best yardstick for valuing a stock and is equal to the return receivable on an investment in the stock to the redemption date. Since both dividend payments and capital gains are tax dependent, each investor will have his own set of net redemption yields. It is only necessary to calculate a few of these in order to get a view of the whole position.

A1.4 Dealing in Gilts It is difficult to give any short synopsis of the logic underlying dealing. The different tax bases of different types of investor are important, particularly as dividends may be sought by non taxed funds (e.g. pension funds) and strenuously avoided by others (surtax paying individuals etc.). Among others, there are the following dealing criteria.

(i) The avoiding or gathering of dividends.
(ii) The taking of 'over 1 year' tax free capital gains and the establishing of 'under 1 year' tax allowable capital losses.
(iii) Switching between similar stocks which appear out of line on historical grounds.
(iv) Policy switching between different sectors (e.g. shorts and longs) or between different types of stock (e.g. high and low coupons) - with the expectation that future changes either in interest rate levels or in the supply/demand ration for the two stocks will enable the switch to be reversed profitably. Cash can be considered a gilt with zero life and coupon equal to the available deposit rate.
(v) Short term - one or two days - trading. The funds referred to here, are not tied by legal, historical or traditional reasons to the gilt market, (differing in this respect from (iv) above).
(vi) Correction of secular trends - e.g. ensuring a 20 year fund stays invested, on average, at its correct term. Investment of redemption proceeds, dividends and new funds.

A1.5 Representation of comparative trends The dealing criteria listed demand two contrasting views - the broad sweeping presentation required for (iv) and (v), (query: which part of the market will perform best ?) and the individual stock versus stock comparison needed for (iii), (query: which stock is cheaper ?). The broad picture is most easily from a yield curve - the g.r.y. is plotted along the y-axis; the redemption date along the x-axis. An idea of the stock's relative cheapness can be found from its vertical distance (parallel to y-axis) from some "best fit" curve. This statistic can be criticised on the basis that some stocks are always apparently cheap - thus it is most useful to compare the current "vertical distance" with its historical record. Turning to the closer analysis; there are two standard comparisons. Each has its supporters and its drawbacks.

G.r.y. differences. If one of a pair of stocks becomes relatively cheap or dear to the other, the difference between their g.r.y's will change with respect to its historical trend. This is a widely used and valuable statistic - but it is misleading if used for large changes (greater than 1% in yield) in the whole yield structure.

Price Ratios. A change in the price ratio will indicate that one of a pair of stocks is worth looking at. This is valid for any change in price except that over a dividend payment for a medium, long or irredeemable gilt. Price Ratios are less often used due, I believe, to the complexities of division versus subtraction in pre-calculator days!