THE BUSINESS VALUE EFFECTS OF COGNITIVE BIASES IN TRADING WORKSTATION WINDOW DESIGN

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Abstract

Recent research on information technology (IT) value has focused on examining new theoretical bases from which to construct robust valuation methods and models. This paper considers two literatures which previously have not been explored in this context: research on behavioral decision making and information presentation effects. We begin by identifying a typology of potential cognitive biases and heuristics which may enhance or suppress IT value when workstations are used to provide decision support. To illustrate, we examine how these effects may become operative in screen-based securities and foreign exchange trading activities, where designers can choose among information presentation formats which support trader decision making. We adapt a recent model by Kroeck, Kirs and Fiedler (1989) to identify where and how information effects, heuristics and biases come into play in the trading environment. Our investigation concludes that managerial recognition of the potential value tradeoffs associated with alternative trading workstation window designs is an important concern for fine-tuning trading decision support systems. In this way, the "business value linkage" between trading workstation investments and the returns they provide can be more fully understood.

1. Introduction

Recent advances in methods to measure the value of information technology (IT) investments have focused on identifying ways to represent the context in which value is created (Weill, 1988; and Weill and Olson, 1989), and theoretical bases to support business value measures. Kauffman and Weill (1989) have argued that it will take new methods and approaches from outside standard referent literatures for information systems research to make additional progress towards solving some of the more difficult measurement problems. Some of the areas they suggested were marketing science, game theory in microeconomics, decision theory and cognitive psychology. In addition, Bakos (1987) and Crowston and Treacy (1986) have called for an investigation of transaction cost theory (Williamson, 1975) and a variety of approaches from organizational theory. Each of the areas provides a theoretical basis which is worthwhile exploring to determine its applicability for formulating robust measures for the value of IT.

Having a theoretical basis to guide measure selection is important for several reasons. First, using measures which have some basis in theory enables a manager to construct what Swanson (1989) has called a "justificatory argument." This is the reasoning behind the measure or system of measures which conveys how IT deployment influences the value of the firm. Unless managers have a clear picture of the ways in which IT affects a firm's performance, it is highly unlikely that the right things will be measured. Second, measures based in theory lend themselves to testing whether the proposed impacts of IT are actually occurring. This is a key concern when many of the impacts an IT creates are "soft", and thus not easily quantified. Knowing whether an impact is occurring at all is a more basic concern than knowing how much value is being created. Third, theory-based business value measures also make it possible for other researchers to validate results across contexts.

1.1. Behavioral Decision Research and Business Value Measurement at the Information System Level

In this paper we focus on the measurement of value created at the individual or information system level (Bakos, 1987) from the perspective of an as yet unexplored theory base for the creation and testing of 'business value linkages' for IT: behavioral decision research. This unit of analysis is the least likely to suffer from "dilution" that makes identifying the marginal contribution of IT difficult (Kauffman and Weill, 1989). But still there are some difficult measurement problems. Some IT valuation problems we have considered include a microcomputer on a corporate treasurer's desk, changes in the inquiry processing capability of a funds transfer system, and trading workstations in Wall Street money market operations. System outputs at this level rarely can be quantified in dollars and cents terms. Though tangible outputs may be easily identified, it may not be clear how they map into operating cost reduction or revenue enhancement. On the other hand, in each of the examples it is easy to cite decisions that rely on tangible system outputs.

Consider the following quote from a money market trader who relies on a workstation-based information system to provide important information about the markets in which he trades.

"Arbitrarily we can say that there are five types of markets, meaning from a very slow market to a very fast, or directional one. Market Type One is a very slow, or nondirectional, market, and Type Five is a very fast directional kind of market. ... The idea is that if I'm in a Type Five Market right now, I don't want all the Type One days of the past seven years to influence my signal for tomorrow. I would prefer that they be excluded from the decision making process. I would want included in the decision making process only the other Type Five days. ... In essence, each day is given a number based on the type of day it is considered to be, and then a research process is run over each parameter so that each evening, I can get the signals for the next day." (Aren, 1989, p. 71.)

Behavioral decision research (**BDR**) and experiments on information presentation, whose important results we will examine in some detail shortly, represent interesting literatures to explore for their relevance to measuring IT value at the individual or system level for several reasons. First, using BDR can help to focus the justificatory argument on the ways in which the system is likely to influence decisions which have economic content. In a funds transfer inquiry subsystem, for example, inquiry specialists rely entirely on information presented by the system to make judgments about how to correct apparent errors. Correcting a faulty transaction has direct economic consequences, since a bank must recompense the customer made from the value of unavailable funds during the period the error ensues. Using the information provided by the system often involves inferences by the inquiry specialist, based on the presentation of information in fixed screen-based formats. The formats may be ideal for handling some inquiries but poor for others.

Second, since measures for usage or user satisfaction may have very little in common with value created in each of the cases we discussed above, BDR can be used to suggest the direction and strength of potential effects of different information display designs, assuming that some usage occurs. This assumption is not a strong one; it suggests that the information would have an impact some of the time on some decisions. (For additional perspective on this argument, see Banker, Kauffman and Morey (1989).) A third aspect of its potential usefulness is the set of experimental approaches associated with models to describe human decision making in the presence of different information displays. Although we are still exploring these ideas, we feel that what has been learned in the experimental literatures on BDR and information presentation effects can be used to suggest how business value measures for IT might be constructed.

Several recent papers have argued for measuring value where it occurs, more or less as a direct output (Bakos, 1987; Barua, Kriebel and Mukhophadhayay, 1989; and Kauffman, Ghosh and Bansal, 1989). This requires the analyst to very carefully specify the manner in which IT affects intermediate production within the firm. At the system level, the local context of measurement is all important. The basic questions include:

- What are the relevant local production or decision processes which are influenced by the IT, and how are they characterized?

- How are the direct physical outputs of the IT used?

- What are the relevant measures to track that measure value?
- Is some threshold level of system usage a prerequisite for the creation of value?
- What are the contextual factors moderating IT value, and how are they to be represented?

1.2. Relevance to Methods for IT Value Measurement

Dealing with the concerns stated above is central to making progress on specific IT measurement problems. Substantial efforts have been made in the last several years to attempt to address some of the issues. The trend we see developing is toward more careful treatment of less direct, hard to quantify impacts. Berger (1988) and Banker and Kauffman (1988b) suggested typologies for the kinds of outputs which IT creates. Swanson (1988) argued that measurement is only part of the picture: what must support a measurement scheme is a solid foundation of reasoning. This enables managers to understand, interpret and take meaningful actions based on measures for IT value. Kaplan (1985) stated that the most valuable impacts of a technology (he considered computer integrated manufacturing) are often hidden from current management accounting measurement methods. Kriebel (1989) and Kauffman and Kriebel (1988a) made a similar case for generalized investment in IT in the firm, suggesting that methods from microeconomics will prove helpful in gauging the strategic value of IT.

More recent work we have been conducting in this area has focused on econometric testing of *business value linkages* for IT (Kauffman, 1988; Kauffman and Kriebel, 1988b). Identifying business value linkages for IT puts an emphasis on the process of production which leads to the creation of value. Banker and Kauffman (1989), for example, developed a market share model which estimated how the value of automated teller machine deployment changed when bank branches operated under different competitive conditions. Other research has suggested that IT value research has failed to properly treat the context of production influenced by IT. Weill and Olson (1989) recognized that organizational factors can enhance or suppress a firm's ability to convert IT investment into outputs such as cost reductions and sales increases. Kauffman, Ghosh and Bansal (1989) took a similar perspective, suggesting that demographic factors in a firm's competitive environment also need to be explicitly incorporated into models which validate the business value linkage for IT. Banker, Kauffman and Morey (1989) supplemented these views by observing that IT, as a secondary factor of production, is likely to have probabilistic impacts on productive efficiency. They provided a methodology to incorporate this kind of information explicitly into a testable model which focuses on input resource costs. Thus, the relevance of the BDR and information presentation literature to research work on IT value is the potential they hold for opening up new ways to validate a business value linkage for IT in environments where information display design influences management decision.

1.3. Outline of Paper

Section 2 examines results found in the empirical literature on behavioral decision research and information presentation effects in order to clearly frame the aspects we think are relevant to IT valuation. Section 3 illustrates our approach using trading workstation information display design in the money or securities market operations of a financial firm. We

present a description of real-time trader workstation technology, the environment in which they are deployed, and the kinds of information they present. We go on to suggest a potential business value linkage, based on a model by Kroeck, Kirs and Fiedler (1989). In Section 4 we present a typology of impacts and ways in which information displays may affect the risk/reward trade-offs perceived by traders. We also discuss how this may affect the positions they create and their trading performance, and discuss how it could be tested experimentally. Section 5 concludes with a brief discussion of some issues that still need to explored more carefully in further research before this approach will yield interesting empirical results for the business value of trading workstations.

2. Behavioral Decision Research, Information Presentation Effects and IT Value

2.1. Behavioral Decision Research

The heuristics and biases proposed by Daniel Kahneman and Amos Tversky (Slovic, Fischhoff and Lichtenstein, 1977; Kahneman and Tversky, 1984) which characterize much of behavioral decision research help explain many situations in which individuals appear to make irrational choices. Prospect theory (Kahneman and Tversky, 1979) provides a rigorous base for much of this work when it proposes a two-stage decision process. In the first phase acts, outcomes, and contingencies of the decision are "edited", or mapped into subjective views of the decision maker with attendant subjective values and probabilities. Prospect theory goes on to describe the relationships which make up this mapping process. The second phase of the decision process is the evaluation of these framed alternatives.

The act of editing can introduce a number of biases. For example, individuals have been shown to be risk seeking when they perceive themselves to be operating from a base of losses and risk averse when operating from a base of gains. This is also referred to as *framing bias.* The *hindsight bias* has also been investigated (Fischhoff, 1975). This occurs when individuals systematically overestimate their *ex ante* predictions when asked to recall them after an accurate forecast. Following an incorrect forecast subjects often underestimate their earlier predictions. This bias alters the weighting scheme a decision maker uses when evaluating information about prior outcomes.

Behavioral decision research attempts to understand decision processes by inducing inconsistencies in the decision outcome through the manipulation of the information provided to the decision maker. Specific outcomes are then used to imply particular cognitive processes. Preference reversals are the most common inconsistency studied (Johnson, Payne and Bettman, 1988). They occur when preferences are elicited using two different presentations of the same information, and the individual exhibits different preferences in each case. Alternatively, the individual's preference may be solicited in two different response modes, such as in terms of rankings versus willingness to pay. Again, a preference reversal is indicated if the subject makes different choices in each mode.

Although the influence of decision biases on individual performance has been considered experimentally, none has considered the economic impacts of decision biases at the business unit level. Moreover, few attempts have been made to systematically gauge the overall impact of

decision biases in terms of the economic impact on the organization.

2.2. Presentation Effects Literature

Much of the research on the effect of presentation manipulations has compared tabular with graphic presentations (e.g., Dickson, Senn, and Chervany, 1977; Remus, 1984). This body of literature generally is characterized by a great deal of inconsistencies in results. Jarvenpaa, Dickson, and DeSanctis (1985) have suggested that many of the inconsistencies are due to lack of precision in the definition of variables and the absence of a systematic investigation of the task dependencies in the use of graphs. Several researchers, such as Bell (1984), have reported on experiments which indicated that the preferred form of information display is task dependant. This conclusion follows from earlier experimental results (e.g., Dickson, Senn and Chervany, 1977) indicating that tables support more accurate decisions, while graphs support more rapid decisions.

Vessey (1988) also presented evidence that suggests that the contextual characteristic which defines the performance of graphs versus tables is the match between the extent of the "SPATIAL-NESS" or "SYMBOLIC-NESS" of the information presented and that of the task at hand. This conclusion focuses attention on information processing. It implies that there are better and worse ways of processing specific decisions, and information presentation can be tailored to suit particular decision processes. Huber (1980) conducted a series of experiments which supports this conclusion. His study indicated that individuals who were presented with verbal information used decision strategies which did not require mental arithmetic. The subjects in Huber's experiment allowed their decision processing strategy to be determined by the presentation of the information rather than by the problem at hand.

Johnson, Payne and Bettman (1988) investigated shifts in cognitive processes as the complexity of the information presented changed. By presenting data in simple fractions, more complex fractions and decimals they induced different frequencies of preference reversals by the participants. Using process tracing techniques they observed that decision makers moved from alternative-based, expectation type evaluation strategies to more attribute-based, or heuristic strategies, as complexity increased. Alternative-based strategies are generally more accurate, but require more cognitive effort for equivalent tasks.

Other studies have broadened the idea of presentation effects in various ways. The influence of the amount of information available in risk perception tasks was investigated by Levin, Johnson, Russo and Deldin (1985). They examined the influence of the number of attributes of the stimulus on incidence of framing in three different tasks, focusing on inferences decision makers make in the absence of complete information. Johnson and Tversky (1984) investigated the influence of the representation of risk on the relative ranking of risk. They found that the ranking of various risks differed according to the ways in which the participants in the study evaluated the risks (i.e., by comparison of similarity and prediction or by dimensional evaluation). This study also showed that decision strategy influences the outcome of the decision process even when contingencies are materially the same. The effect of grouping information on decision making was investigated by Behling, Gifford and Tolliver (1980). They argued that decision makers manipulate categories rather than calculate precise values. By implication, it is possible to influence the outcome of decisions by grouping

alternatives together.

The various sources of bias and altered decision processing outlined in this section have been investigated primarily in laboratory settings, although some researchers have tried to develop a degree of realism in their experiments. For example Puto (1985) utilized professionals in scenarios similar to those encountered in their daily work. However, no study appears to have considered the systems actually used in the workplace and the biases which may be encountered in that context.

We turn next to a discussion of trader workstations and the financial decision making context which occurs in money and securities market trading operations. The type of decisions encountered and the conditions under which they are made clearly influences the impact information systems can have on the process and the biasing effect the use of heuristics and presentation styles may have. We will discuss how some of the biases we have described may become operative intrading and other financial decision making settings and also consider specific biases which may influence the quality of decisions supported by trading workstations.

3. A Business Value Linkage for Trader Workstation Performance Evaluation

The need for information is of paramount importance for firms which are serious players in the securities and money market trading business. Robert M. Mark and Steven N. Roth, experienced senior managers with responsibilities for technology applications in securities and money market trading operations of large New York City-based financial firms, have recently noted that:

> *"... [to] anyone who has thought about or invested in stocks, bonds, futures,options, or commodities, it is clear that accurate, timely information is the prime imperative in making investment decisions. To those who trade in the pits on a trading floor (such as the New York Stock Exchange) or in a dealing room (where most large financial institutions do their trading), the timeliness of market information is critical. To a trader, such as an arbitrageur, who scans a reasonably large cross section of a financial market, automated assistance has become an absolute necessity." (Mark and Roth, 1989)*

3.1. Technology

Mark and Roth have identified several kinds of data which are essential in capital markets operations: updated raw prices of instruments and currencies, interest rates in regional and international markets, yields of specific instruments, and market news. These data are transformed into useful information for traders when they are assembled into scannable formats, plugged into analytic models which estimate fair-market price trajectories and create yield curves, and presented on an as-demanded basis via a workstation designed to support trading operations.

Today's "real-time" trader workstations support trading in both international and domestic markets. High-powered engineering workstations and 286 and 386-based personal

computers provide the user interfaces, and engineering workstations and vector processors operating behind the scenes are used to provide rapid data manipulation capabilities and the raw horsepower for the analytics which help traders make more profitable trades. In addition to the real-time information provided, traders have on-line access to a variety of historical data related to instruments, currencies and firms which are also useful in arriving at predictions about the expected profitability of a specific transaction.

Much of this information is normally presented in standardized "page formats". Firms such as Telerate, Knight/Ridder, PC Quote and CQI Comstock consolidate data they obtain in digital form from exchange tickers and the news media, and then convert them into the standard formats. An example of a Telerate 80-column page format is shown below in Figure 1. (The interested reader should see Mark and Roth (1989), for additional details).

Figure 1. Telerate Standard Page Format (from Mark and Roth, 1989)

```
11/18   14:43 EST              [U.S. TREASURY AND MONEY MARKETS                PAGE 5
FEDERAL FUNDS  14.42  | T-BILL          14.42  YIELD |EURO$DEP 14.35  |      GOV      RP 13.23
BID   6 1/2  OPN  6 1/2  | *3M   5.78-76   -.10   5.943 | 7 3/8   - 1/2  |  O/N   6.30-20
ASK   6 1/2  HGH  6 1/2  | *6M   6.27-25   -.02   6.561 | 7 7/16  - 9/16 |  1WK   6.65-45
LST   6 1/2  LOW  6 1/4  | 1YR   6.54-52   -.04   6.956 | 7 13/16 -13/16 |  2WK   6.65-45
FUNDS SOURCE: G. CUYBUTLER  |  *CHANGE FROM AUCTION |                        |  1MO   6.70-60

TREAS  CPNS  NY  EST   14.42  YIELD  | CD-BID      14.40      | BAS-BID      14.40
07.875  10/89  100.08-12  +01  7.660 |             | EARLY      | LATE      | EARLY      | LATE
08.000  11/90   99.31-03  UNC  7.964 | DEC  | 6.82 -03 | 6.82 -03 | 6.75 -05 | 6.75 -05
08.125  09/91  102.29-01  UNC  8.192 | JAN  | 7.20 -10 | 7.20 -10 | 7.10 -02 | 7.10 -02
08.375  11/92   99.31-03  UNC  8.352 | FEB  | 7.20 -05 | 7.20 -05 | 7.10 -02 | 7.10 -02
08.500  10/94  104.08-12  +04  8.643 | MAR  | 7.25 -10 | 7.25 -10 | 7.10 -05 | 7.10 -05
08.875  11/97  100.06-10  +01  8.827 | APR  | 7.30 -10 | 7.30 -10 | 7.10 -05 | 7.10 -05
09.375  02/06  102.16-20  -03  9.075 | MAY  | 7.30 -15 | 7.30 -15 | 7.10 -02 | 7.10 -02
09.250  02/16  102.08-12   -04  9.014 | DEALER COMML PAPER OFFER 12.05      |BANK RATES
08.750  05/17   97.15-19   -03  8.984 | 30  6.74   90  7.12   180  7.12     |PRIME    8.75
08.875  08/17   99.10-14   -01  8.922 | 60  7.09   120 7.12   240  7.12     |BROKER   8.00
```

Other firms re-package this data into products for the trading floor which provide traders with access to multiple kinds of consolidated data formats. Some trading houses have taken the lead in designing their own value-added real-time trading systems, in order to customize the formats of data presented to traders and even to allow traders to construct their own unique screens. Microsoft Windows-based trading support applications, for example, are becoming increasingly popular. They enable traders to access various levels of detail via pull down menus, while other portions of the window are only momentarily covered, but not lost.

3.2. Valuation Context

A brief examination of such widely read money-market trading industry publications as *Computers in Banking* and *Wall Street Computer Review* is useful to gain additional perspective on depth of interest and the scope of technology investments made in trading operations. Obviously, information plays a central role, but important and basic questions remain regarding its value in both raw, unprocessed form and as it is displayed in value-added formats by

workstations. These questions include:

- Since the costs involved in delivering trading workstations can be readily determined, how can we estimate what the benefits of such a system are in order to arrive at a measure for their value?

- What is the value of flexibility in presenting information on a trading workstation window?

- Given that alternatives exist, how would one know whether a given presentation of information is likely to be more or less valuable in supporting a particular kind of trading?

- How does a specific mode of information presentation affect a trader's decisions (if at all) and do the effects lead to more profitable trading?

Traditional IT value analysis might lead to selecting the department as the unit of analysis; broadly speaking, workstation impacts must be confined to the trading area. And, since money market trading operations are profit centers, it is likely that a range of candidate measures would be available. There is a problem, however: choosing the trading area, in aggregate, as the unit of analysis creates the potential for dilution of impact. Instead of directly impacting the area as a whole, it is probably more accurate to argue that the information a trader workstation can provide (given the design trade-offs implicit in choosing the final bundle of screen-based information) influences a trader's perception of risk and reward. This probably only happens some of time, because the information presented by the workstation is not the only factor driving a trader's decision. If this information can be represented in the IT valuation methodology, then we would expect the measures of performance we collect, on average, to be less biased.

We now turn to a more detailed consideration of how trader workstations fit into a model of decision making in trading environments.

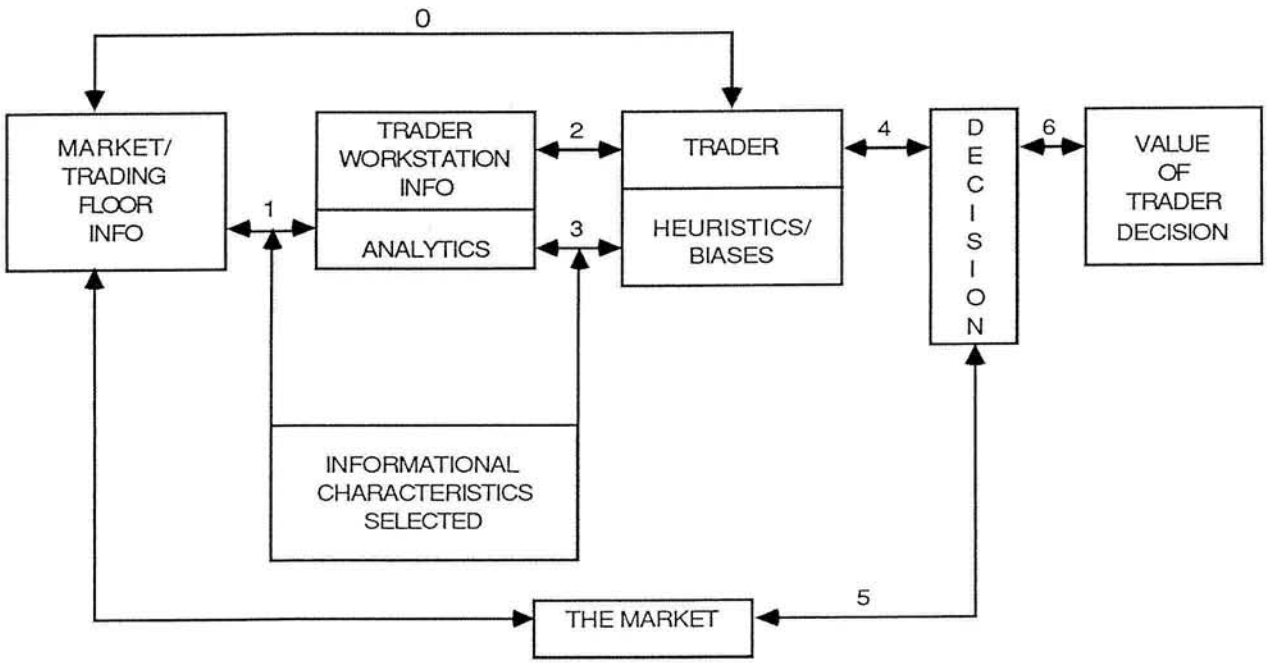
3.3. Modeling the Influence of Information Presentation on Trader Decisions

One of the primary difficulties associated with evaluating trader workstation window design alternatives is that much of what occurs as "decision making" (and the influences which drive it) is not directly observable to an analyst. What an analyst would recognize, however, is that some decisions require culling the information available in the entire market and trading floor environment. On the other hand, arbitrage opportunities can be identified algorthmically, or by traders scanning information reported in a trader workstation window or by telephone. These trading decisions require the trader to do little more than identify that a situation exists, and do not require much processing of other information related to the past or an uncertain future.

Other decisions require synthesizing varied amounts of information. Some information is reported on a screen; some becomes available only as groups of traders test the market with transactions. In these cases, there is only a chance that the introduction of information

technology in the decision process will effect some change in the decision. In Figure 2 below, we present a model adapted from Kroeck, Kirs and Fiedler (1989), which describes how information is used in a trader's decision processes. News from the market comes in two forms: as unprocessed data and as processed information.

Figure 2. Sketch of Information Use and Effects in a Trading Environment



Explanation of Numbered Links

LINK #0 - Retrieval of Unprocessed Information from Trading Floor and Market
LINK #1 - Data Filtering and Setup, with Selected Analytics
LINK #2 - Workstation Information Incorporated into Trader's Decision Process
LINK #3 - Appearance of Trader Biases and Heuristics Based on Info Presented
LINK #4 - Trading Decision Outcome
LINK #5 - Market Context of Trading Decisions
LINK #6 - Evaluation of Trader's Decision in Terms of Market Opportunities

Note: This figure is adapted from a more general model for the cognitive analysis of information presented in Kroeck, Kirs and Fiedler (1989).

This model is useful to understand the trading decision process and the role of trader workstations for several reasons. First, it explicitly captures the idea that workstations do not provide the only source of information. Traders gather information from the market, from newspapers and other print sources, and from other traders as well (LINK #0). Traders also make use of information which has been filtered, analyzed and set up by trading floor automation

(LINK #1), and then presented in workstation windows (LINK #2). Depending on the nature of the trading decision, traders may choose to ignore LINK #1 and LINK #2, and focus instead on getting "a feel for the market".

At some point, the trader's focus will shift from the gathering to synthesizing information towards identifying a trading opportunity or making a final decision. When this occurs a limited set of "informational characteristics" will be selected by the trader. This information should be task-relevant, but what is actually available for processing by the trader is limited by the firm's trading automation (LINK #1) and the screen-based presentation of information.

Since each trader has individual heuristics which embody the expertise that leads to successful trading, not all traders agree on what information is relevant in deciding on a specific trade opportunity. Moreover, the potential for biases to affect trading decisions also arises here, since (in most cases) individual traders have little control over how even basic information is presented. In fact, discussions we have had with trading automation executives at major New York City commercial and investment banks suggest that trading workstation windows are designed with the "average trader" engaged in a specific kind of trading (e.g., mortgage-backed securities, foreign exchange, and derivative instruments) in mind.

Once a trader reaches a tentative decision (LINK #4), it will be compared with current events and new information available from the market and the workstation to ensure that it is still an appropriate move in the ever-changing market context (LINK #5). After the trade is made, the profitability of the trade can be determined using standard evaluation methods available in the industry (LINK #6).

The model we suggest is also useful as a "business value linkage" for trader workstations. It helps to identify the key elements which combine to produce valuable decisions for the firm: the market, the information system which provides updates on the market, analytics to gauge how a trader should react in the current market, the trader himself and a measurement system which audits the quality of the trades he makes. While the business value linkage does not directly suggest a means to gauge the value of the workstation in the trading process, it helps to make the case that measurement can occur at the level of the trader. We next consider how workstation value may vary in terms of information presentation choices and the biases that may go along with them.

4. Dimensions of Bias Applied to Trading in Financial Markets

The trading environments we have described manifest a set of characteristics which make particular heuristics more likely to be used in decision processing. The availability of information, timing of decisions and sophistication of the decision makers all influence the way information is used. Although we believe that promising opportunities exist to conduct research into information presentation effects in simulated trading experiments, due to space limitations we concentrate on biases and heuristics suggested in BDR only. Although we expect that presentation effects can also bias financial decision making, the field of BDR, through its theoretical development, provides us with a more generalizable theoretical framework with

which to initially attack the domain of trading decisions.

In Table 1 below, we present an overview of seven heuristics and suggest ways in which they may become operative in financial decision making. These seven heuristics are not intended to be an exhaustive list; they were culled from a number of sources, including Kroeck, Kirs, and Fiedler (1989). Behavioral decision research has provided an abundance of evidence that the use of these heuristics in decision making leads to biases in the decision process, and we anticipate that each of these biases will have an impact on financial decision making.

A decision maker is often called upon to make a comparison of a current situation with previous events in order to judge the relative likelihood of various outcomes. The *availability heuristic* suggests that the decision maker judges the frequency of previous events based on the relative ease of recall of these events. Those more easily recalled are judged to be more probable. The difficulty of recall is closely related to the saliance of the event, that is, the extent to which it sticks out compared to other events. Biases in decision making occur when the salience of prior events is not related to their frequency.

Salience may be influenced by the impact previous events had on a trader's portfolio. In this situation a particularly positive event may be recalled relatively easily and assigned a probability of recurrence beyond its actual probability. For examle, a trader may have been particularly successful (and lucky) taking a position in an initial public offering by a firm in an up and coming industry. When another new issue becomes available in that industry, the trader may recallhis own prior success and not the many failures that have also occurred. The position resulting from this evaluation will be more risky than the position attained through trading on the basis of a more objective reckoning of previous information.

Anchoring and adjustment describes a heuristic used to make estimates when some pcint away from the point to be estimated is known. Decision makers tend to make evaluations in this situation by starting at the known point, the anchor, and adjusting to reflect the current situation. This method has been shown to lead to inaccurate estimates (Tversky and Kahneman, 1974). When the adjustment is made upward the estimate is often low, and when the adjustment from the anchor is down, the estimate is high.

A risk manager, whose responsibility it is to set levels of exposure for various porfolios, may begin by taking last year's risk levels and adjusting for expectations of market volatility. This tactic may be appropriate if market conditions for the instruments making up the portfolio reflect the average market conditions. However, if the market differs, the risk manager will end up either overexposed or underexposed.

A foreign exchange trader may also use the anchoring heuristic when evaluating appropriate trigger points in upward and downward price trends. If the price of a foreign currency is trending upwards in relation to the U.S. dollar the trader may anchor off a price lower than the price at which the most profitable trade could be made in the present market conditions. If the price of the currency is on a downward trend, the trade will probably be made at a higher price than otherwise.

Table 1. Seven Biases and Their Potential Impact on Workstation Value

Bias	Description	Measurement Context/ Operative Bias	Economic Impact of Bias on Workstation Value
Availability	Ease of recall of event or info affects judgment of frequency	FX Trading: Overestimate probability that recent movements recur	Chance of nonrational choice based on overestimation of probabilities
		Portfolio Management: develop too risky a portfolio position	Return variance could lead to unexpected loss levels
Anchoring & Adjustment	Prediction by anchoring on a value and adjusting growth depending on present case	Fin. Planning: Planned growth based on current year's growth, not on potential	Over/underestimate if current year was high or low
		Purchase Decision Making: Price offered or accepted based on last auction, not on current market	Quoted price unacceptable or below market value
Represen-tativeness	Likelihood of event judged on similarity of event to class of events, not specific event	Financial Planning: Takeover likelihood judged on industry norm, not specific firm	Strategic threats unanticipated, opportunities missed
		Stock Trading: buys decided on industry basis, not firm basis	Average firms in industry over-rated, better firms underrated
Selective Perception	Information search and rentention influenced by prior expectations, tend to reinforce priors	Stock Trading: Expectation of movement leads to reactive trades in response to random random moves of the market	Loss of arbitrage opportunities, excessive trading expenses due to excess trades
		FX Trading: Start of movement not recognized if contrary to prior expectation	Loss of arbitrage opportunity, loss in market position
Concrete Information	Quantifiable, statistically vivid data dominates abstract info	Fin. Evaluation: Perception of management quality emphasized over market data	Management given credit for outcomes due to market forces
		Stock Trading: Purchases made on basis of analysts' briefings, not on evaluation of firm fundamentals	Poor choices due to inaccurate information
Frequency	Frequency used as as cue to judge strength of predicted relationship	Fin. Evaluation: Absolute number of successes considered rather than ratio of success to attempts	Project risk underestimated, leading to high variance in return
		Stock Trading: Trading volume used as indicator of general trend even if price is stable, volume used as indicator of attractiveness of stock	Loss of trading margin, development of undesirable position
Regression	Outliers used to indicate a growing trend	FX Trading: Market calms after volatile period, trader attributes calmer market to threat of govternment intervention	Faulty attribution leads to incorrect expectation; decision not based on regression to the mean may be more risky

The *representativeness heuristic* is similar to what is widely known as stereotyping. When a decision must be made concerning some event about which not much is known, a decision maker will often assume that the event has the same characteristics as some other similar class of events about which more is known. This stereotyping leads to the misattribution of characteristics when the specific event deviates from others of a similar class.

A stock broker may be especially optimistic about firms in a particular industry. In order to gain some advantage the trader may purchase a quantity of stock in a relatively obscure firm from that particular industry without investigating the specific firm adequately. If the firm happens to be an above average performer for the industry, the broker may do well. But if the firm is below average, the broker will have made a mistake. In either case, the broker's decision has been biased by the representative heuristic.

The representativeness heuristic can also influence the way in which traders perceive trends in the market. For this reason, an increasingly popular tool many traders are eager to try out is termed a "breakout system".

> *"A breakout system signals irregular market activity that may indicate money making trend or a negative direction in the market. Ideally, the broker learns of the trend in time to respond appropriately by jumping in or quickly exiting the market the system is monitoring." (Aren, 1989, p. 8)*

The basic idea is that an information system provides a means to help the trader decide whether the current situation is adequately represented by all the other data monitored in a decision process.

The *selective perception* of a trader is another mechanism which can lead to biases in decision making. An individual's prior expectations about the characteristics of an item influence what information is sought out and retained. If a particular stock is thought to be especially undervalued based on the fundamentals of a firm's operations, or for any other reason, information to the contrary will tend to be filtered out. The basis for the prior expectation is not important; its existence is sufficient for the bias to occur.

If a firm is thought to be in a weak financial condition, a small downward movement in price may be interpreted as the start of a downward trend, and reacted to accordingly. If the same movement occurred in the price of a strong firm, it would more likely be ignored. About the time national economic performance figures are due out a foreign exchange trader may already have a set of expectations about what they will be. At this point, if a currency makes a small movement, the trader may react according to his expectations, rather than waiting for the figures to be released.

Personal experiences and distinct events are treated as if they are more *concrete information* than statistics compiled on an industry or the market, in general. Anecdotal knowledge tends to be easily recalled. The effect is similar to that of the availability heuristic; more reliable, though abstract, statistics are passed over in favor of vividly recallable personal evidence. For example, an analyst who has attended a private briefing by a firm may base her evaluation disproportionately on the information received through that channel as

opposed to the analysis of publicly available data. Similarly the heroic efforts of a management team to turn around a firm may be overemphasized in comparison to the effect of market forces on the firm's success.

Frequency is often inappropriately used as a cue to judge the strength of a relationship. The total number of occurrences is not necessarily an indicator of a strong relationship. For example, an investment firm may be evaluated on the basis of deals completed without regard to the total number of deals initiated. The firm may be three times as large as another investment firm but complete only twice as many deals, so the firm may not be more efficient. The ratio of successes to attempts is a more relevant measure of competence.

Another way in which frequency may be misused as a signal occurs in trading. A high volume of trading in a particular issue may be interpreted as an indication of attractiveness. The volume, however, may simply be the result of a portfolio adjustment by a large institutional trader which might not be indicative of the stock's future earnings potential. Trading on the basis of the high volume, in this case, would lead to an unintended market position in terms of expected profit potential.

The final of our seven heuristics and biases is *regression.* This bias results from a common misperception of simple statistical variance. Outcomes deviate about some mean in the normal course of events. However, data points far from the mean are often attributed to some external force. This leads to a misattribution of causality and inappropriate actions on the part of the decision maker. For example, if a market calms after being particularly volatile, a trader may attribute the calming to some threat of government intervention. Trading on the basis of this misperception will lead to position inappropriate for actual market conditions.

4.2. Capturing Potential Biases: Moderators in the Business Value Linkage

Traders are willing to utilize information presented by trading workstations because their experience with it over time suggests that the information possesses predictive ability. In general, information on a set of variables related to the performance of a currency or money market instrument will be useful if the likelihood functions describing the variables shift in the presence of impending increases or decreases in the price of the currency or the money market instrument. If the likelihood functions are very similar, the set of variables chosen will provide little predictive ability to identify the direction of price movements (Tully, 1987).

Previous literature in accounting research is very useful to focus in on this problem further. Beaver (1968), for example, examined the extent to which financial statement ratios enable an analyst to more accurately predict the occurrence of bankruptcy among firms. The basic insight provided by the study was that the time lag between the financial ratios used to support the prediction and the bankruptcy event itself had to be small for the ratios to provide useful information. Tully (1987) argued that this provides an ideal opportunity to conduct experimental research since the dates of the financial ratios can be manipulated by the experimenter.

In fact, we believe that such "experiments" are actually conducted in practice, as money market firms deploy trader workstations with ready-made window design choices. A trader's

role is to pursue a strategy of profit maximization (in view of the risks taken) and thus the automation which supports the trader should be designed to increase the likelihood of profitable trades. Whether this actually occurs is open to question, and most firms are short on empirical facts to shed light on this conjecture. The heuristics used by traders are their private information, and the biases they exhibit go largely unobserved. Identifying aspects of the value of a trader workstation requires an analyst to more fully understand what kinds of decisions it is used for, and which aspects of the information presented are utilized.

In order to capture the impact of the heuristics as moderators in the business value linkage for trader workstations, we support designing and conducting laboratory experiments that simulate just a portion of the trading process. The relevant portions to capture (holding all the other iinks fixed in an experimental design) are LINK #2 (trader identifies relevant data) and LINK #3 (trader applies heuristics and may allow bias from information presentation to affect decision). Given the difficulties experienced by researchers who have conducted experimental work on biases in other contexts, we expect the design of workable experiments which shed light on the questions of interest to be challenging. In an experimental setting, to determine whether varied information presentations tend to lead to some of the biases discussed above in financial decision making contexts would require careful manipulation of the format so that the information content is unaltered.

Our interest in conducting experiments on window design alternatives is focused on determining what kinds of decisions are influenced, and the extent to which less profitable trades occur in a relatively controlled environment. From this, we could extrapolate to what is actually occurring on the trading floor (probabilistically, at least). The result would be estimates of the costs associated with using a given window design alternative to support a certain kind of trading. The costs would be "deadweight losses" based on the profitability associated with the experimentally ideal trades. We can only infer that a similar process would be occurring on the trading floor, but this is no different than what happens with trader workstations in practice, day to day.

5. Conclusion

In this paper, we have argued for an examination of a new theory base -- behavioral decision research -- in order to guide the evaluation of trader workstations in money market operations. Our review of the literature on behavioral decision theory, information presentation effects and cognitive biases suggests some promising new avenues from which to view the problem of developing partial business value estimates for this technology. We also presented a model, based on the recent work of Kroeck, Kirs and Fiedler (1989), which is useful in representing the key elements of the trading decision making process. In addition, we observed that this revised model can serve as a business value linkage for trader workstations, because it clearly articulates a series of links between the technology, the intermediate decision making production process it affects, and the key business value output in trading, profitable trades.

The ideas this paper presents are clearly exploratory. We recognize that considerable difficulties will have to be overcome to make the estimation of business value workable using

this approach. Nevertheless, we think the approach has promise enough to warrant further investigation, but questions remain.

- How can laboratory experiments be conducted to simulate trading to isolate the impacts of trader biases and heuristics?

- How might similar experimental methods might be used in a field study of a real trading operation?

Virtually all of the research in the areas of presentation effects and behavioral decision research has been done in the laboratory. The stylized scenarios utilized are typically designed to yield clear results, often to the disadvantage of realism. Internal validity is emphasized over external validity, an understandable, even preferable, approach early in the development of a field of study. The observation of subtle influences requires close control of the experimental variables until such time that the experimenters know where to look.

One stream of research has already begun to add realism to the experimental scenario, Vessey (1988) examined the context dependency of the impact of presentation effects. Though it is not yet part of a practitioner's toolkit, this work contributes an added dimension of understanding to the work that has gone before. In general, there are two directions that may be pursued to enhance the external validity of experimental work in the laboratory. First, the tasks and experimental materials can be made more realistic. The screen displays can be based on those in actual use, with the inevitable complexity and extraneous information involved, and the trading task can be replicated as completely as possible. It may even be possible to utilize actual data as it would have been available to the trader on the floor. In a lab it is impossible to recreate a trading environment in its entirety, but at least the task can be made more true-to-life. The data yielded by this sort of experiment will necessarily be more complex than that obtained through a highly stylized experiment, but it can also yield a great deal more insight if the experiment has been well designed.

A second approach to enhancing external validity is to utilize practitioners in stylized experiments. This would allow the experimenter to investigate how the individual interacts with their data. When undergraduates or MBA students are used to investigate the behavior of traders, at best you would see the behavior of inexperienced traders. If training or experience plays a large role in the development of particular decision making strategies, information would be lost in an experiment without the involvement of actual trading pros. There has been work that has shown that biases persist in experienced decision makers (e.g., McNeil, Pauker, Sox and Tversky, 1982), but we feel that once the complexity of the experiment begins to approach that encountered in the work environment, the expertise of the practitioner becomes necessary to obtain realistic results.

Ideally, lab experiments at this stage in the development of the field would utilize practitioners of various levels of expertise in simulations involving realistic decision scenarios. The hub-bub of a trading floor cannot easily be recreated in a laboratory, but the realism of the stimuli can still be recreated.

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