How can the market be efficient if investors are not rational?

It is always difficult to try to make an exact science where human behaviour is involved. The question **JOHN LIVANAS** tries to answer is: how can a market be efficient when investors make irrational decisions?

John Livanas F Fin, BSc (Eng), MBA
General Manager, FuturePlus Financial Services

Following Keynes (who always held the belief that psychological factors played a role in economic behaviour), the 40s and 50s were characterised by a re-emergence of a theory of rational markets based on the rational behaviour of individuals. This theory, led by economists like Samuelson,[1] characterised investors as having an optimal marginal utility, being capable of making a choice of investments that corresponded to their particular efficient frontier – *Homo economicus*. In the 50s, Simon questioned the notion of 'economic man' and set out to create a new model to describe the decision-making processes.

Simon argued that well-meaning investors who propose to undertake a 'rational choice' do so under a number of constraints that create 'boundaries'[2] within which rational decisions can be taken – drawing into question the assumptions of rational choice in the Utility Curve. These constraints may be external to the investor, or may arise from the biases inherent in the investor's reference point and knowledge. The constraints include: the constraint of investment alternatives accessible to the investor; the limited range of outcomes expected from each option; and the relative preferences of the investor for each of the investment options.

The core hypothesis is as follows: "Because of the physiological limitations of the organism … actual human rationality-striving can be at best a … crude and simplified approximation to … global rationality implied … by game-theoretical models"[3] (Simon 1955). His point is that an investor attempting to optimise the 'pay-off' from an investment decision will make the best decision available to him within his capacity to assess the alternatives, and to execute a decision.

Simon proposed three ways that a decision maker may optimise their pay-off:

Using game-theory's max-min rule,[4] each investor considers the worst possible outcome '$V_{min}(s)$' for each investment, and constructs a portfolio that will produce the largest value when made up of a combination of these (minimum) values. (Of course you would wonder how anyone could choose equities, given that the worst possible outcome for equities is total loss.)

Secondly, an investor could construct a combination of investment options where the probability '$P_a(s)$' of each outcome, times the value of each outcome 'V(s)', is maximised:

$$\hat{V}(\hat{a}) = \text{Max\_}V(s)P_a(s)$$

(Had he added, "… based on the risk profile of each portfolio…", we would no doubt recognise these as steps in a modern portfolio construction.)

Lastly, Simon imagines the investor choosing one entire set from a set of options that will maximise value. This is akin to picking the set containing 'equities' only, or 'bonds' only, from available investment options.

Simon considers that the complexity of calculation is beyond the average investor: "… there is a complete lack of evidence that, in actual human choice situations of any complexity, these computations can be, or are in fact, performed" (Simon 1955). Reviewing Simon's paper, written in the '50s, his concern with the computational aspect of decision as being one of the key bounds to the rational process is interesting. With the current availability and use of sophisticated modelling in financial markets, and with substantially better disclosure and analysis, it can be argued that better approximations of payoffs (through quantitative portfolio analysis) can be made by professional investors. This doesn't discount Simon's views, particularly about non-professional investors.[5]

Characterising the increasing reliance on the social sciences to provide answers to decision making, Kahneman and Tversky developed prospect theory as a progression to the classic 'Utility Theory' of economics.

Kahneman and Tversky began a long collaboration exploring the psychology of intuitive beliefs and choices. Arguably their most famous work was *Prospect Theory* – recognised in part with Kahneman's award of the Nobel Prize for economics in 2002.

What is Prospect Theory? To begin with, a 'Prospect' is no more than a game of choice under risk, or a lottery. For Kahneman and Tversky, it is a framework with which to revisit the basic assumptions of Utility Theory, and to propose a model for decision making. Their paper on Prospect Theory starts, like that of Simon's, on a review and critique of Utility Theory. Kahneman and Tversky referred to a series of laboratory experiments (many conducted by Allais)[6] that seemed to demonstrate conclusively that people were making decisions under risk that were seemingly at odds with what would be predicted under 'rational' decision making. Based on these observations Kahneman and Tversky developed their Prospect Theory[7] stressing all the while that they expected field observations to further validate the model.

WHAT IS PROSPECT THEORY?

Prospect Theory essentially proposes a framework to explain how decisions are made. Where Utility Theory expects the investor to make purely rational decisions, rapidly, using all the information available, Prospect Theory proposes a two-phase process:

- Firstly, investors **edit** the information they receive, using their reference points, beliefs, etc. to modify this information as if they were using 'rules of thumb' or the like to convert the information into readily understood symbols or ideas.
- Following this, investors **evaluate** this information according to the relative value of the outcome to *themselves*. The value of a cold ice-cream on a hot day may have greater relative value than a hot soup on a hot day, to one who prefers ice-cream.

FIGURE 1 EDITING

Coding	**Combination**	**Segregation**	**Cancellation**
Change an absolute outcome to one of Gains and Losses. (Current wealth doesn't matter)	Combine prospects that seemingly have identical outcomes as one prospect with combined outcomes.	Separate the 'riskless' from the 'risky' component and decide on each independently.	Discard common components to the prospect – such as common entry criteria, i.e. cost to play
Simplification		**Dominance**	
An investor may round 49% and $101 to 50% and $100.		An investor may ignore extremely improbable outcomes.	

Based on these laboratory experiments, Kahneman and Tversky proposed that the 'editing' phase would follow a set of rules in modifying the information. Figure 1 highlights the key components or rules of thumb in editing:

Following the editing phase during which the decision maker has 'reframed and reconstructed' the information, the decision maker reviews the 'objective' probabilities of each outcome 'p_j', and the 'absolute' value 'x_j' of each outcome.

Considering the probabilities, the decision maker refers to their own beliefs and rules of thumb to assign what they think the probability of outcome 'really' is. Mathematically the decision maker reweighs these probabilities by assigning a decision weight 'π' to 'p_j', to make $\pi(p_j)$.

Considering the values, the decision maker assigns a value '$v(x_j)$' to each 'x_j' based on the value of the outcome to the decision maker.

Conceptually, this 'mapping' is shown in Figure 2.

FIGURE 2: EVALUATING

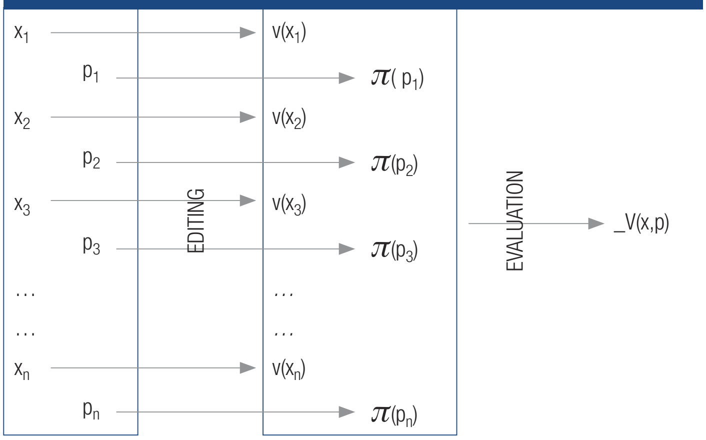

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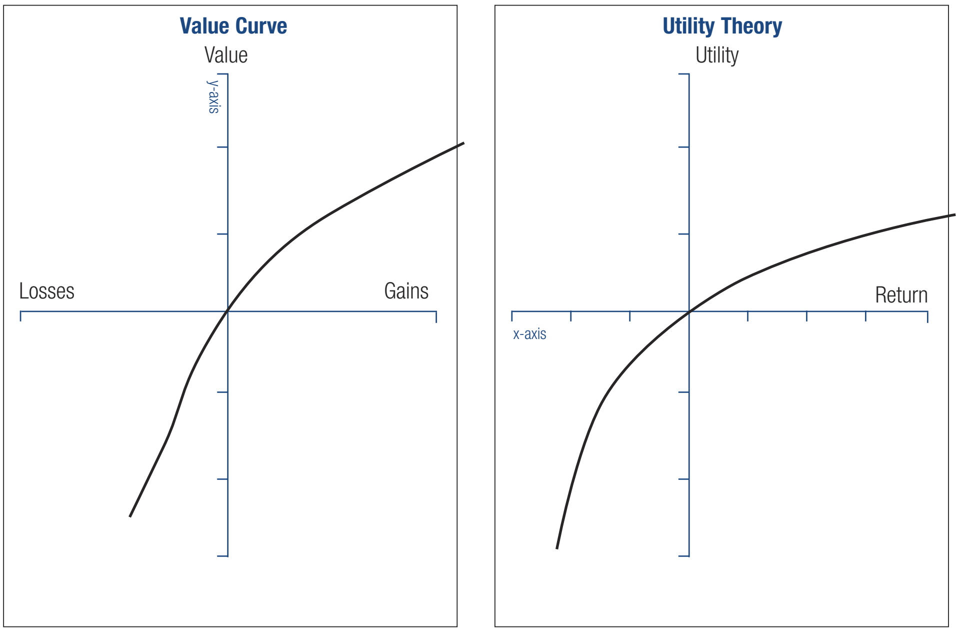
FIGURE 3: THE VALUE FUNCTION AND UTILITY CURVE COMPARED



y-axis:

Utility Theory: Utility based on expected outcomes
Value Function: Modification of expected outcomes as a result of editing and evaluation

x-axis:

Utility Theory: the relative change in wealth over the future period
Value Function: Gains or losses against a specific *reference point*

Curves

Value Function: Concave for gains, Convex for losses – more pronounced curvature at reference point
Utility Theory: Concave Function.

The overall value of a particular set of 'prospects', to the investor, is the sum of the mapped values $v(x)_i$, each multiplied by the 'transformed' probabilities $\pi(p_i)$. The sum of these forms the Value Function – which now can be seen as a modification of the Utility Curve.

UTILITY THEORY vs. PROSPECT THEORY

Kahneman and Tversky imply that the Value Function is asymmetric in contrast to the Utility Curve's symmetry about risk. Kahneman and Tversky argue that decision makers take progressively less risk per unit gain, and yet take more risk to avoid a unit loss: "… losses loom larger than gains". Furthermore, the Value Function proposes that decision makers choose according to changes in wealth, rather than their own perceptions of the impact of the prospect on their wealth.[8]

Figure 3 highlights some of the differences between Kahneman and Tversky's proposed modification of the decision maker's utility function as compared to that of Classic Utility Theory.

Kahneman and Tversky's 'Prospect Theory' is a powerful framework for describing choice, and builds somewhat on Simon's work. Decision making operates according to a reference point, with substantial editing and evaluation of information within the context and content of the decision.

So, if human decision making is more complex, subject to arbitrary references and weighting of probabilities, does this imply that the markets are not efficient? Fama doesn't think so. We will consider his fundamental premise below.

Fama's approach is fundamentally different from Kahneman and Tversky, Simon and other behavioural scientists. Rather than being interested in investigating the rational, (or otherwise) decision making of individuals, Fama is interested in whether the market as a whole is efficient in the allocation of capital. His point is that: "… disagreement among investors does not in itself imply market inefficiency unless there are investors who can consistently make better evaluation of available information … [than is] … implicit in market prices" (Fama 1955).

This approach has allowed him to argue strongly that any evidence of (irrational) investor behaviour on an individual level has not been shown to impact the efficiency of the market as a whole.[9] Time and again, his argument maintains that no other model for market behaviour has yet shown conclusively that it is better at predicting market behaviour, than Efficient Market Hypothesis (EMH).

Fama's definition of an 'efficient market' is:

1. The market uses *all* the information available; and
2. The market *understands* all the implications of this information.

Fama defines the three forms of EMH:

- Weak form – the market considers all historical information
- Semi-strong form – the market also considers other publicly available information (announcement of annual earnings, stock splits etc.)
- Strong form – a condition where even monopolistic (e.g. insider) information is reflected in the market.

WEAK FORM

Fama's test of the weak form is that, in the absence of any other information (eg. annual returns, announcements, stock splits, etc.), the expectation must be that the price of the security will increase from period to period while following a random walk. While this sounds entirely counterintuitive, it can be seen that investors will require recompense for the cost of holding the security. So, in the absence of any new information, the market will set a price today that provides an investor with the required return.

This is known as a 'fair game'.

Mathematically, this can be stated as follows:

$$E(p_{j,t+1} \mid \_t) \geq p_{j,t}$$

The *expected* price for security 'p' at time 't + 1', given all the information '_t' available at time 't', is greater than the price of the preceding period.

Fama argues that the processes that generate pricing can best be described as a random walk. "A random walk arises … when the environment is such … that investor tastes and the … new information combine to produce equilibria in which the return distributions repeat themselves through time." (Fama 1970). Fama's position is that, irrespective of the actions of individual investors, the market (perhaps with the functioning of arbitrageurs) operates to price securities efficiently.

For the weak form, Fama used the following tests to determine whether the market considers all historical information in setting the price:

Firstly, by looking at the sequence of prices over a period of time (excluding specific events), Fama considered whether this sequence demonstrated any serial correlation which would show specific relationships of prices over time. Fama's review of first order serial correlations of successive changes in $\log_e$ prices[10] of individual securities led him to argue convincingly that the sequence of prices follows a random walk that conforms to a 'submartingale' (prices increase with an otherwise random walk).

Secondly, Fama constructed a test to determine whether the market follows a 'fair game' by assessing whether an arbitrageur, following a 'filter' rule (perhaps based on buy and sell signals triggered by changes in the value of current prices relative to previous prices), could generate an excessive return. Again the data supports the weak form.

Finally, Fama looked at the relative pricing of securities, by looking at movements in the parameters of the capital asset pricing model (CAPM). Again the evidence seemed to imply that the market was setting the relative prices of securities according to the implied market model.

It is worthwhile considering the debate between Hayes (2001) and Drew (2000) in considering the evidence in the Australian market regarding EMH. Hayes contends that, on the basis of outperformance of benchmark, this lends weight to active managers being able to outperform the market on a risk adjusted basis, and argues for an inefficient market. Using Fama's argument for weak form efficiency, the performance of active managers doesn't pass the weak form test, unless the basis of their active management is either: 'technical analysis' (using information in the historical prices of equities); the use of standardised filters; or the use of long-term shifts in the CAPM to provide trading direction. It is more consistent to view these active managers as arbitrageurs. This implies that Hayes' arguments would not undermine the weak form of EMH.

A key result referred to in Fama's paper, and one that may yield clues as to the interaction of individual investors and the 'market', was that factor analysis indicated that 50% of a common stock's return could be accounted for by a 'market factor' which affects the returns on all stock, and a further 10% by 'industry factors'. The implication is that, at best, investor influence in stock prices is 40% or less.

So what does all this mean? The weak form of the EMH essentially describes a distribution of prices where all historical information is correctly reflected in current prices. (Technical trading has no capacity for making excess returns.) Security prices then move randomly, recompensing the investor with an overall positive return, until a specific market or industry-related factor influences pricing.

SEMI-STRONG FORM

Semi-strong form tests of EMH are concerned with whether events (or other publicly released information) are quickly and efficiently reflected in market prices of securities.

Fama's cornerstone research was looking at whether a stock split affected the prices of the stock. The semi-strong form implies that stock splits in themselves should not affect the value of the underlying firm or asset. Consequently, if the market's valuation of the underlying asset or firm changed before or after the stock split, the market could be seen as not semi-strong-efficient. In testing this, Fama found some anomalies, one of which was that the price of securities increased preceding the stock split. However, a ready explanation was found in the argument that firms would engage in stock splits during times when they were doing well and their stock was increasing.

… on the basis of outperformance of benchmark, this lends weight to active managers being able to outperform the market on a risk adjusted basis, and argues for an inefficient market.

Other work on the effect of public announcements seems, on balance, to support the semi-strong form of the EMH.

So what are the implications of the semi-strong hypothesis? For a start, it provides evidence that the market is able to adjust prices. Where the weak form deals with the operation of the market in 'steady state', the semi-strong form deals with adjustments to events.

STRONG FORM

Finally, the strong form is defined as the condition where all information, public or private, monopolistic or otherwise, is reflected in the market price.

One proposed test of the strong form was to assess whether a large mutual fund will beat the theoretical market line for a given risk and return set, on the basis that a mutual fund manager has privileged information.

Interestingly enough, even when adjusted for costs, the data assert that mutual funds actually operate below the idealised risk-return framework. Seemingly mutual funds seem to be less capable that the rest of the market in efficiently constructing investments to reflect the risk-return characteristics postulated by the market model. The implication of the empirical evidence seems to be that, in the efficient functioning of a market, arbitrageurs are required. These arbitrageurs are unlikely to be able to operate at the scale of mutual funds leading to the discrepancies shown.

Fama questioned whether this hypothesis formed a strong form test and commented on being uncomfortable with the evidence.

Drew and Noland (2000), in 'EMH is Alive and Well', present Australian data that implies Australian active managers of equity funds for superannuation organisations have underperformed the market on a risk-adjusted basis. When read with Fama's test for the strong form, assuming that these managers represent a substantial proportion of the market, this data may provide some evidence against the strong form of EMH, while still allowing for the weak or semi-strong form.

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SUMMARY

So how does one reconcile these seemingly opposing views? After all, how can the market be efficient when investors seem to make decisions that perhaps are rational – but only within bounds?

Fama's model accounts for investor disagreement. His point is that even in the weak form, the variations in investor decision making will tend to cancel out, allowing prices to follow a type of random walk. An investor can make any type of "irrational" decision they like – there will likely always be another with an opposite view. If Fama is right, we have to rely at least on the semi-strong form of his EMH to be sure that prices adjust and reflect accurately the continuous information at hand. This then poses the question as to who will be making these judgements; how will we be sure that they are rational in an absolute, market model tested sense; and how we can be sure that they will influence the market appropriately to adjust prices.

Kahneman would add that these "market moving" decision makers would need to make decisions that are more rational than a normal investor. In the absence of an alternative model, we rely on Fama's model for the broad description of the market and Kahneman for a descriptor of investors individually.

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Notes

1. Samuelson published *Foundations of Economic Analysis* in 1947, consolidating a trend to using mathematics.
2. In 1957, following on from this paper, Simon describes the term "bounded rationality" as describing that the way that a 'choosing organism' behaves rationally within the bounds of its goals and resources.
3. Simon seemed to be having a shot at the newly defined von Neumann's game theory. Von Neumann is reputed to have said to his partner Morgenstern that, with game theory the modelling of economics was complete. It wasn't the first time he was wrong. (Perhaps a review of game theory is next).
4. At the core of von Neumann's and Morgenstern's theories is the concept that a rational decision can be thought of as a game whereby the player wishes to minimise the maximum potential loss.
5. Interestingly, the corollary of Simon's argument is that where market prices are influenced fundamentally by professional investors, and where these investors operate with expanded 'bounds of rationality', markets would in turn operate under more rational choice.
6. Allais, M. (1953), "Le Comportement de l'Homme Rationnel devant le Risque, Critique des Postulants er Axiomes de l'Ecole Américaine," *Econometrica*, 21 (1953), 503-546.
7. In their later work, referred to in Kahneman's paper "Maps of Bounded Rationality: A Perspective on Intuitive Judgement and Choice", Kahneman expand this to propose a two system approach, with an intuitive 'reflex' response acting instantaneously on decisions, while the 'rational' requiring time to operate.
8. In 1738 Bernoulli postulated that people's utility from additional wealth u(w) increases at a decreasing rate as their wealth increases. This is the concept of diminishing marginal utility.
9. Fama used this argument effectively in his rebuff of behavioural finance in an article that was published in 1997 in *The Journal of Financial Economics*, entitled "Market Efficiency, Long-Term Returns and Behavioural Finance".
10. One of the key constraints on security prices is that they cannot fall below zero. Consequently the pattern of distribution can best be described by a logarithmic function, and it is in the test of the serial correlation of the natural log of prices that Fama argued that there was no information contained in the probability distribution of these prices to allow arbitrageurs to 'beat the market'. J

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