Chinese Business Review, May 2017, Vol. 16, No. 5, 245-249
doi: 10.17265/1537-1506/2017.05.003

Assessing Probabilities for Events Pertaining to Buy/Sell and Similar Decisions

Warren Richard Hughes
The University of Waikato, Hamilton, New Zealand

Assessing probabilities for relevant and sometimes unique events in real-world decision situations can be problematic. This paper elucidates a 2-step process for assigning probabilities to relevant events enabling a rational decision process to supersede decision choices based only on a gut feeling. After assessing probabilities the decision maker can confirm or reverse a gut feeling choice using expected values for each available act and traditional decision theory methodology. A simple example involving a buy now or buy later situation with market uncertainty illustrates the process for typical yes or no decisions.

Keywords: probability assessment, expected value, decision theory

Introduction

Decisions involving the buying or selling of stock, foreign exchange, property and other financial assets will typically involve a timing decision, that is, Buy Now or Later after a possible price falls, or Sell Now or Later after a possible price rises. The time horizon may be days, months, or even longer. For this decision, judgments as to possible price changes are required for a "best" decision. This paper outlines a procedure for assigning probabilities to the relevant events that encompass the decision-maker's (DM) intuitive judgments as to the relative likelihoods of the pertinent events. The procedure is applicable to yes/no situations in general where three or more events comprise the decision situation.

The procedure involves two steps leading to two probabilities for each event. Then using an average or some other technique, a final probability is determined leading to an expected value (EV) for a particular act (buy, hold, yes, no etc.) that determines the optimal strategy at the time of assessment.

Events Pertinent to the Buy/Sell Decision

How the price of the asset will change in the near future is the crucial question for whether to buy (sell) or delay buying (selling) at the current time. For simplicity, five events are postulated requiring a probability for each event. These are outlined in Table 1.

The event space could be expanded but five discrete events suffice to demonstrate the methodology. The methodology employs pairwise comparisons of events as first proposed in Saaty's Analytic Hierarchy Process (AHP) or Analytic Network Process (ANP) as in Saaty (1980; 2005) and discussed in Hughes (2010). A modern concise introduction to and review of AHP procedures is contained in Brunelli (2015).

Warren Richard Hughes, Dr., The University of Waikato, Hamilton, New Zealand.
Correspondence concerning this article should be addressed to Warren Richard Hughes, 6 Taurarua Terrace, Parnell, Auckland, New Zealand.

Table 1

Possible Price Change Events for the Asset in Question

Price change event	Abbreviation
Significant fall in the price	SPF
Fall in the price	PF
Status quo-minimal price change of no consequence	SQ
Rise in the price	PR
Significant rise in the price	SPR

For a conventional AHP analysis, every event is compared with every other event leading to $n(n-1)/2$ comparisons for n events. For the procedure outlined here, only $2(n-1)$ comparisons are required although the methodology using the full AHP could be employed. In the case of probability assessment outlined here, the first requirement is for the events to be ordered from lowest probability to highest probability. Then follow $(n-1)$ pairwise judgments going from the event of lowest probability to that of the highest probability (comprises step 1). Subsequently a similar procedure (step 2) uses pairwise comparisons going from the highest probability event to the lowest probability event although utilising a slightly different comparison methodology. All events (apart from the least likely and most likely events) are judged relatively against two different events providing a different base benchmark for each of the two judgments. Typically, both judgments at steps 1 and 2 for the same event will not be perfectly consistent although this is possible. Accordingly, some averaging procedure (or other procedure) will be required to provide a final probability for each event. An expected value calculation then determines the current optimal act as in Buy Now or Buy Later, alternatively Sell Now or Sell Later.

Example Decision for Buy Now or Buy Later

A simple example for the Buy Now or Buy Later decision illustrates the main ideas. In this case, if the Buy Later act proves optimal, a similar analysis would hold at the latter time and would typically be made at that time subject to new information arriving in the interim that could influence probability assessment.

Table 2

Example Events and Outcomes for the Buy Now/Buy Later Decision

Event	Money outcome	Likelihood ordering
SPF	-6	5
PF	-3	3
SQ	0	1
PR	3	2
SPR	6	4

The likelihood ordering in Table 2 shows SQ as the most likely event and SPF as the least likely one. The money outcomes in Table 2 are illustrative only and can be considered the expected values for a price change described by the event in the left-hand column. That is, a price change in an event range will in actuality be on a continuum of values but the expected value for this range suffices for the subsequent EV evaluation. Although the price changes in Table 2 are symmetric about zero this need not be the case for a market trending noticeably up or down.

Note too that the money outcomes could be per unit of the asset in question or for a total package as in say a 1,000 shares in which the money outcomes could be thousands of dollars. For this example, the event ordering suggests a rising market, in which case a gut feeling decision for the DM may be Buy Now. The zero outcome for SQ suggests returns from holding cash currently approximately match any dividend, interest, rent etc. forthcoming from the asset in question if it were bought now. This means that the outcomes are framed from the point of view of the asset price at the time of a Buy Later decision being implemented. Accordingly a negative EV after probability determination would lead to a Buy Later decision. A positive EV implies that Buy Now is optimal since an (expected) extra cost is involved if buying later. Also note that the situation is analogous for a Sell Now/Sell Later decision. In this case, a positive EV would imply Sell Later is the better option. In general, the analysis here is illustrative for any yes/no situation where uncertainty of the outcome is present.

Probability Determination Using a 2-step Methodology

It remains to determine the probabilities using the likelihood ordering outlined in Table 2. First, we use "more likely" values in each pairwise comparison moving down the list of events from lowest likelihood to highest likelihood. In this paper, "more likely" means a precise numerical assessment as in 1.3 being 30% "more likely" than the alternative. This approach is fully described in Hughes (2010) with suggestions for situations where the DM's judgments emanate from a group rather than an individual.

Table 3

Step 1 in the Probability Determination Leading to the First Probabilities

Probability ranking	Price event	Pairwise "more likely" value	Compound "more likely" value	First probability*
Lowest	SPF	1.0	1.000	0.1064
	SPR	1.2	1.200	0.1277
	PF	1.8	1.800	0.1915
	PR	1.0	1.800	0.1915
Highest	SQ	2.0	3.600	0.3830
TOTALS			9.400	1.0000

Note. * All probabilities have been rounded to 4 decimals.

Since SPF was assigned the lowest likelihood of the five events, its pairwise value is defined to be 1.0. The event with the next lowest likelihood is SPR and the decision-maker's judgment here is that this event is 20% "more likely" than SPF with a pairwise value of 1.2. Subsequently, PF is judged 80% "more likely" than SPR with PR equally likely (hence 1.0) with PF. Finally, SQ is judged twice as likely as either PR or equivalently PF in this case. The compound "more likely" value is the progressive product as we move down the list using the corresponding pairwise values to get the current compound value. Normalising this column gives the first probabilities in the last column. Note that these values reflect exactly the respective "more likely" judgments in the middle column.

Table 3 results in a first pass at probability generation for the events under analysis. A second pass can be derived using a similar procedure but with a slightly different approach to determine relative likelihood as detailed in Table 4.

Table 4

Step 2 in the Probability Determination Leading to the Second Probabilities

Probability ranking	Price event	Percent of likelihood of next highest	Revised pairwise "more likely" value	Compound "more likely" value	Second probability*	First probability*	Average probability*
Highest	SQ	100	1.8182	2.8145	0.3482	0.3830	0.3656
	PR	55	1.0526	1.5480	0.1915	0.1915	0.1915
	PF	95	1.1765	1.4706	0.1819	0.1915	0.1867
	SPR	85	1.2500	1.2500	0.1546	0.1277	0.1412
Lowest	SPF	80	1.0000	1.0000	0.1237	0.1064	0.1150
TOTALS				8.0831	1.0000	1.0000	1.0000

Note. * Some numbers and all probabilities have been rounded to 4 decimals.

The procedure at step 2 starts with an ordering from highest to lowest probability. The percent of likelihood for the highest ranking event (SQ in this example) is defined as 100%. Then the second ranking event is assigned a fraction of 100% according to its relative likelihood compared with SQ. Given the initial ordering this proportion cannot exceed 100% and will typically be less than 100%. In Table 4, PR is assigned a likelihood of 55% of the likelihood of SQ. Of course, this means that SQ is 100/55 or 1.8182 "more likely" than PR according to this judgment which compares with the 2.0 previously assigned at step 1 in Table 3.

As at step 1, the compound "more likely" values (column 5) are derived and normalizing this column gives the second probabilities in Table 4 (column 6).

To examine the advantages of a 2-step procedure, the PR and PF pairwise judgments can be considered in more detail. At step 1, PF is the base event and the pairwise "more likely" value for the PR event is judged accordingly. This reveals an equally likely value of 1.0. At step 2, PR is the base event with a judgment that PF has an estimated 95% of PR's likelihood. This is in effect, a "less likely" appraisal. This implies a second pairwise "more likely" value for PR of 100/95 or 1.0526, about 5% higher than the step 1 judgment. While both judgments mutually assess PF and PR, the orientation of the judgments differs. This avoids reliance on a single judgment for probability assessment. Although we would expect a measure of consistency between the two pairwise judgments, perfect consistency is not a requirement. The subsequent average probability shown in Table 4 weights both sets of judgments equally.

Although perfect consistency of judgments is not a requirement, it may be that after step 2 reverting back to step 1 and re-evaluating those judgments in the light of results at step 2 could reduce significant inconsistencies to some acceptable level of overall consistency of judgments. It must be acknowledged, however, that the step by step procedures outlined here are an attempt to quantify intuition or rudimentary judgments of a DM so that perfect consistency between such judgments should not be expected.

Determination of the Optimal Act Between the Buy Now and Buy Later Options

It remains to determine which of the two acts to implement in light of the above judgments. The calculations are summarised in Table 5.

As noted above, using EVs for the event outcome values (e.g. -6 for SPF in Table 5) rather than a distribution over respective price continuums for each event is an approximation that simplifies the analysis. The objective here is not to accurately estimate the expected gain or loss from a given decision but to ascertain the correct or "better" decision between two options. The "better" decision is chosen given the information available to and judgment of the DM at a given moment in time. In the example presented here, the resulting optimal act would confirm any DM's gut feeling decision to Buy Now in a rising market. Note that the probability of a price rise at 0.3327 is about 10% higher than the probability of a price fall at 0.3017.

Table 5
The EV Calculation to Determine the Optimal Act

	Events				
	SPF	PF	SQ	PR	SPR
Outcome value	-6	-3	0	3	6
Probability	0.1150	0.1867	0.3656	0.1915	0.1412

Note. EV = 0.1716 leading to the decision Buy Now as there is a positive expected cost associated with Buy Later.

Conclusions

The methodology outlined here could be employed using the full AHP pairwise comparison procedure as in Hughes (2009). For a 5 event problem this would involve 10 pairwise comparisons compared with the 8 above for the 2-step procedure. As the number of events increases, the divergence in the number of comparisons required increases markedly with the potential for significant inconsistency in judgment using the full AHP procedure.

Many real-world situations involve decision making with yes/no options as in Buy Now/Buy Later. The analysis above is one example of those situations. In these situations, the DM may have a gut feeling as to whether yes or no is the better option. If he/she could dissect his/her intuition into a manageable set of constituent events, the procedure outlined here using traditional decision theory can confirm or reverse the gut feeling choice.

References

Brunelli, M. (2015). *Introduction to the analytic hierarchy process*. Heidelberg: Springer.

Hughes, W. R. (2009). A statistical framework for strategic decision making with AHP: Probability assessment and Bayesian revision. *OMEGA*, *37*, 463-470.

Hughes, W. R. (2010). Assessing probabilities of unique events: Calibrating qualitative judgments into a probability distribution. *Chinese Business Review*, *9*(9), 54-60.

Saaty, T. L. (1980). *The analytic hierarchy process*. New York: McGraw-Hill.

Saaty, T. L. (2005). *Theory and applications of the analytic network process*. Pittsburgh: RWS Publications.