PROSPECTING RESEARCH: KNOWING WHEN TO STOP

Draft of paper published in *Marketing Letters, 12*(4), 299-313, 2001.

Michael Wood and Richard Christy

University of Portsmouth Business School

Michael.wood@port.ac.uk

4 April 2001

PROSPECTING RESEARCH: KNOWING WHEN TO STOP

Abstract

An important aim of many surveys is to undertake prospecting research: the search for new possibilities and an understanding of the diversity in a population. This paper develops a method - the extrapolation of resampled possibilities (ERP) - for predicting how much new information will be revealed by extending a sample. This is useful for deciding whether it is likely to be worthwhile sampling more cases, bearing in mind the costs and the benefits. The method avoids making any assumptions about the nature of the underlying population, apart from the information implicit in the existing sample.

Keywords: Prospecting research; Research; Sampling; Survey; Learning.

PROSPECTING RESEARCH: KNOWING WHEN TO STOP

In market research it is often useful to produce a list of possibilities exhibited by members of a population. For example, companies engaged in a segmentation study are looking for subgroups of demand (in a larger market) that can be chosen for specialised attention. A list of the possibilities - types of special need - helps to ensure that the choices made by the firm result from an appropriately broad consideration of the market. Similarly, new product development needs to cast its net as widely as possible at first. The possibilities being sought may be new applications for an existing product, or new ways in which an existing product could be augmented by value added services.

The same interest in lists of possibilities may occur in many other areas of empirical research: for example, risk analysts may want to compile a list of possible risks, employers may want a list of potential sources of satisfaction and dissatisfaction for their employees, educational researchers may want a list of possible difficulties in learning a new topic, lecturers may want a list of different views on a course from the students taking it, management researchers may be interested in a list of things that can go wrong when firms try to implement a new management creed, academics may want a list of points made (possible ideas) in the literature on a topic, biologists may want a list of new species in a particular habitat, and so on.

Such lists may be of interest in their own right for understanding the diversity in a population. They may also be a starting point for a detailed study aimed at understanding some of the possibilities in more depth, or for a statistical analysis of the prevalence of some of the possibilities. In all cases, it is clearly important that the lists should be as complete as possible: they should cover as much as is feasible of the diversity in the population.

The term "prospecting research" has been suggested for this type of research, and the term "illustrative inference" - in contrast to statistical inference - for the inferences about what is possible in a given context that can be drawn from single illustrations of possibilities (Wood and Christy, 1999; Christy and Wood, 1999). The argument of both of these papers is that prospecting research and illustrative inference are important and largely unrecognised by the formal language of research methods. If conventional statistical research is the equivalent of taking an aerial photograph of a landscape to see the main features, and qualitative, "depth" research is the equivalent of exploring a small area in detail, then prospecting research is the equivalent of a systematic search of the whole landscape to compile a list of things of possible interest. This is often precisely what researchers are after.

The analysis of the power of a sample in terms of the number of possibilities, or diversity, that it can satisfactorily cover, presented in Christy and Wood (1999) reveals that very small samples may be surprisingly limited in this respect. In practice this means there is a danger of certain potentially interesting possibilities being ignored by research based on such small samples, and of detailed investigation being focused on unimportant possibilities. On the other hand, qualitative research techniques tend to be labour intensive and to require skilled and expensive researchers. This means that they typically have a high cost per respondent, so small samples have clear advantages in terms of cost, as well as timing and practicality. It is clearly important to balance the advantages of large and small samples carefully so as to arrive at a rational decision regarding the sample size used.

The approach to this problem using probabilities (Christy and Wood, 1999) provides a means of designing a sample to search for possibilities, based upon some assumptions about the population. For example, if we assume that there are 50 possibilities of interest each of which occurs in 10% of the population, then a random sample of 70 is sufficient to be 95% certain of covering each of these possibilities (from Table 1 in Christy and Wood, 1999). This does, however, require us to make assumptions both about the number and the prevalence of the possibilities. In practice these assumptions are likely to be made on a "what if?" basis, as discussed in Christy and Wood (1999).

The present paper takes a different perspective: that of a researcher who has already investigated some individuals in the population and wishes to estimate the likely value of investigating more. The method discussed here takes account of the performance of the sample taken so far, and uses this to calculate the likely value of contacting further individuals. Its value is that it can be applied in the middle of a research programme to make rational decisions about resource allocation.

The method involves *resampling* (in the sense of taking successive random samples from an existing sample) data on the number of possibilities found in the sample, and then extrapolating the results: hence the name, Extrapolation of Resampled Possibilities, or ERP. The tactic of resampling is increasingly used in statistics as a method of estimating probabilities and other parameters without the necessity of making simplifying and often unrealistic assumptions to ensure a fit to a tractable mathematical model (Diaconis and Efron, 1983; Noreen, 1989; Davison and Hinkley, 1997).

As far as we are aware, there are no other formal methods for deciding whether it is worth extending a sample from this point of view. There are sequential decision procedures for deciding when enough data has been collected to answer *statistical* questions such as whether to reject a null hypothesis. However, the question of interest here - how many more different possibilities are likely to be revealed if the sample is extended - is fundamentally different from statistical questions (Wood and Christy, 1999), so these methods are irrelevant. Using the ordinary methods of statistics to answer questions about prospecting research makes no more sense than deciding at random.

1. The extrapolation of resampled possibilities

We will illustrate the method by a simple example: the results of an email survey of staff at a University Business School comprising one question:

> *New battery technology will soon allow the production of a small, cheap, electric-powered city car, with a range of 200 miles on one charge. What features or capabilities would you most like to see on a car like this?*

We received 60 responses to our questionnaire. These yielded a total of 181 suggestions (including duplicates) which we coded into 39 categories. These were the *possibilities* which we were interested in listing and exploring. Possibility 1, for example, is "ease of recharging", and Possibility 2 is "reliability". Our analysis obviously depends crucially on this coding - which we discuss in more detail below.

Table 1 contains some of these results to illustrate the format. For example Possibility 1 was mentioned by 7 of the respondents whose data is shown (and by a further 17 whose data is not shown in Table 1), whereas Possibility 39 ("lower road tax") was mentioned only by Respondent AX. This table - and our subsequent discussion - uses the term "case" for an individual respondent. The word "case" is used because of its generality: a case may be an individual person, or an interview with an individual, or an organisation, or a case study of an organisation, or a situation from which risks may be identified, and so on. The cases in Table 1 are identified by a letter code to avoid confusion with the random orders which the resampling method involves. Our problem is to predict how many new possibilities would be revealed by questioning further respondents to yield more cases.

TABLE 1 HERE

The obvious approach to this question is perhaps to set up a probability model (Wood and Christy, 1999). The difficulty with such a model is that it is necessary to make prior assumptions about how many possibilities there are to be found, about how prevalent they are and how they are distributed in the population. Obviously, in practice, we are not likely to have this information: all we can do is estimate the prevalence of the possibilities which we have found - possibility 1, for example, was mentioned by 24/60 or 40% of respondents. We cannot do the same for possibilities which we have not yet found. On the other hand, the data does give rise to some intuitions about how many more possibilities we are likely to find if we questioned another 60 people - we would be unlikely, for example, to find another 100 possibilities using the same questioning strategy which has yielded 39 possibilities from 60 respondents.

One possible starting point would be to calculate how many new possibilities were revealed by the first respondent, how many by the second and so on. This sequence of numbers could then, in principle, be extrapolated to the 61st and further respondents. In Table 1, Case (respondent) A revealed one possibility (No. 1), Case B revealed three possibilities (Nos. 2, 3, 4), Case C revealed two possibilities (Nos. 5, 6), and Case D revealed two possibilities (Nos. 1, 7). However, Possibility 1 was revealed by Case A, so Case D only reveals one *new* possibility (No. 7). In this way it is easy to calculate the number of new possibilities revealed by each case in the sequence.

However, the order of the cases in Table 1 is essentially arbitrary. If we want to know the number of new possibilities revealed by the first case to be analysed, by the second, and so on, we should consider the mean over all possible orders of the 60 cases. As there are more than $8x10^{81}$ such orders this is impractical, but a reasonable approximation can be obtained by taking a random sample of a few thousand of these orders, and using this for the analysis. These reorderings of the original sample are referred to as resamples for obvious reasons.

We have written a simple program (available on the web from http://www.pbs.port.ac.uk/~woodm/rp.htm) to do this. This program is designed to allow the user to step through the method in detail if the number resamples is five or less. We will first describe how the program works for a demonstration run with five resamples, and then give the results for 10,000 resamples.

The first resample started:

Case V, Case C, Case AU, Case AO ...

and the number of new possibilities revealed by these cases are (as the reader may verify from Table 1):

1, 2, 1, 3

respectively. The second resample is:

Case C, Case BG, Case AS, Case O ...

and the number of new possibilities revealed are:

2, 1, 4, 3

Table 2 shows the results from the first four cases, and the 60th, from the five resamples. The final column gives the mean number of new possibilities over the five resamples.

TABLE 2 HERE

FIGURE 1 HERE

Figure 1 shows the corresponding results from 10,000 resamples. The mean number of new possibilities revealed by each case in the sequence declines steadily for the simple reason that later cases are less likely to find new possibilities which have not been revealed by earlier cases.

The resample results in Figure 1 can obviously only go to the 60th case in the sequence. Beyond that it is necessary to extrapolate the line. The method we used in the diagrams in this paper is explained in the Appendix.

The extrapolation of the results in Figure 1 enables us to predict the expected (in the statistical sense) number of additional possibilities which would be found by extending the sample: the prediction for the 61st respondent is 0.29, possibilities, for the 100th respondent is 0.19 possibilities, and for the ten respondents, 61, 62 ... 70 the prediction is 2.7.

The method of extrapolation in the Appendix inevitably incorporates arbitrary assumptions. Any other method would incorporate a different set of arbitrary assumptions. We cannot envisage any method which would have any claim to being correct in all situations. However, it does seem clear that all reasonable methods are likely to give similar results for the next few additional respondents. For example, the very crude method of extrapolation of assuming that the number of additional possibilities remains unchanged from its value for the 60th respondent gives a prediction for the 61st of 0.291 (the earlier estimate was 0.287), for the 100th of 0.29 again, and for the 61st to the 70th of 2.9. These predictions are all very similar to the earlier ones except the prediction for the 100th respondent. The extrapolation method in the Appendix is likely to be robust for extrapolating a few additional respondents, but not for a large number.

In practice, we would recommend making predictions about the value of the next few respondents, and then using the ERP again to decide whether it is worth going further. This means that the inevitable inaccuracies in making predictions about large extensions to the sample are not likely to matter in practice.

Different data sets will yield different prediction patterns. Figure 2 shows the results of applying the resampling process to two contrasting, simulated samples each of 60 cases. The first, "equal probability" sample, is generated from the assumption that there are 10 possibilities to be found, and the probability of each possibility being found in each case is 10%. The second, "varying probability" sample, is also generated from the assumption that there are 10 possibilities, but in this case the first has a chance of 1/2 of being found in each case, the second has a probability of $1/2^2$, and so on to the tenth which has a probability of $1/2^{10}$ of being revealed by each case. As might be expected the first simulated sample revealed all 10 possibilities, whereas the second revealed only 7 of the 10 - the last, for example, having a probability of less than 0.1% was not found in the sample of 60. The two graphs are of a different shape as might be expected; it is clearly likely to be more useful to extend the second sample than the first. The purpose of the ERP is to help researchers recognise this.

FIGURE 2 HERE

2. The accuracy of the ERP

As well as providing a mean number of new possibilities the ERP can also provide an estimate of how variable the number of new possibilities is likely to be. Table 2 shows, for example, that the number of new possibilities revealed by the first case in the sequence varied from 1 to 4, whereas the 60th case varied from 0 to 1. The resampling program provides the frequencies of each number of new possibilities for each case in the sequence, and then works out from this the appropriate percentiles to form confidence intervals. For example, the frequencies corresponding to the 60th case in the full (10,000 resample) analysis of the data from the car survey were as follows:

0 possibilities occurred 7840 times in 10 000 resamples

1 possibility occurred 1520 times in 10 000 resamples

2 possibilities occurred 488 times in 10 000 resamples

3 possibilities occurred 152 times in 10 000 resamples

The 95% confidence interval derived from this extends from the 2.5 percentile to the 97.5 percentile: ie from 0 to 2 possibilities.

In practice, confidence intervals for individual cases are of limited value; it is more useful to work in groups of, say, 10 cases. Figure 3 shows resampling results from grouping the cases in 10's, and the corresponding extrapolation line. The resampling results are worked out as before except that the number of new possibilities are combined in groups of 10 cases. This enables the program to estimate confidence intervals for groups of 10 cases. These are then extrapolated in just the same way as the mean (see Appendix). The results shown in Figure 3 give a mean predicted number of possibilities for the group of cases 61-70 of 2.7, with a 95% interval extending from 0 to 6 (rounding off the predictions from the extrapolation line for the confidence interval to the nearest whole number as these percentiles must be whole numbers to be meaningful). The corresponding figures for cases 91-100 are a mean of 2.0, and a 95% confidence interval extending from 0 to 5.

FIGURE 3 HERE

These results need to be treated with some caution. There is no reason to suppose that the estimates of the means will be consistently biased either up or down, but this is not true of the confidence intervals. All the resamples are drawn from data which reveals 39 possibilities. An equivalent group of real samples would include some samples revealing more possibilities and some revealing less. This is likely to make the estimates more varied than those obtained from resampling. This means that we would expect the resampling method to underestimate the width of the confidence intervals - although not necessarily by a large margin.

This is borne out by some trials in which we took subsamples of 30 from the sample of 60 (at random, of course), and then used the ERP to predict the number of possibilities which would be revealed by the next 10 cases to be sampled. These predictions can then be compared with the actual data (ie the next 10 cases from the sample of 60). Figure 4 shows one such trial. (The limits of the confidence intervals in this figure are rounded off to the nearest integer to facilitate comparison with the actual results.)

FIGURE 4 HERE

The results of 10 similar trials are shown in Table 3. The mean of the predictions is very similar to the mean of the actuals (3.4 and 3.5 respectively) The 50% confidence intervals include the actual value on 40% of the trials, but the 95% intervals only score a 70% success rate.

TABLE 3 HERE

3. Underlying assumptions

There are three assumptions underlying the ERP. The first is that all members of the sample, and of the potential extended sample, are, from an *a priori* perspective, equally promising for providing information. This is the rationale behind the resampling method of shuffling the order, and also of extrapolating the pattern found in the existing sample to other cases which have not yet been sampled.

This assumption might not hold in practice. If the sampling method is a purposive one, with the most interesting cases being sampled first, then the early cases in the sequences may be more informative than the later ones for this reason alone. Similarly, if the members of the sample are self-selected there may be a tendency for sample members to have more to say than those not yet chosen. In either case, it does not make sense to shuffle the order of the cases. On the other hand, if the selection, and ordering, of the sample is random, or based on criteria independent of the likely information derived from each case, then the ERP is justified from this point of view. Even if this condition is not met exactly, it may well be judged close enough for the ERP to be useful.

The second assumption on which the ERP depends is that the information revealed by a case can be coded into discrete possibilities, which are either revealed, or not revealed, but never partially revealed.

This means using a coding scheme at the right level of detail for the purposes of the research. For example, "ease of recharging" and "time taken to recharge" would be given the same code if the researchers were merely interested in the possibility that recharging may be perceived as a problem: from this point of view nothing new - which is of interest - would be learned by distinguishing between these two possibilities. On the other hand, if the researchers are also interested in the different ways in which recharging may be problematic, then it would be appropriate to give them different codes. The coding scheme depends on the interests of the researchers: researchers interested in the recharging problem would obviously need a different coding scheme from researchers interested in the accessories potential customers are interesting in having. A particular coding scheme is likely to ignore some details deemed of little importance to the research: for example our coding scheme ignored the suggestion of "fold-up peddles" (sic) because this is not relevant to the car we have in mind. On the other hand, this suggestion might be very relevant to a researcher with a broader idea of the possibilities.

The fact that the coding scheme has to reflect the research aims means that the scheme produced for a given analysis is likely to depend on the perspective of the people who designed the research. There is an inevitable subjectivity in the design of *any* coding scheme (just as there is in the formulation of research objectives). This means that it is important for all members of the research team to be involved in the process of defining the codes, so that they will all share the same idea of what constitutes a single interesting possibility.

Having defined the coding scheme, we can then ask about the reliability with which it is applied. The important issue here is whether different judges will identify the same possibilities in each case. We gave the emails on which Table 1 is based, reordered at random, to another judge, not involved in the formulation of the coding scheme. This judge was asked to use the coding scheme - each possibility being defined by a phrase such as "ease of recharging" - to produce another version of the "data" in Table 1. There was agreement between this judge and the original coder for 63% of the cases: 38 of the 60 rows of data were identical to the corresponding rows in Table 1. This is quite a stringent test as agreement requires agreement on the presence or absence of all 39 possibilities. (An alternative measure - the proportion of individual entries which agree in the two matrices, which was 96%, is misleading because of the large proportion of entries which are 0.)

An agreement rate of 63% may seem low, but we are not, of course, interested in particular possibilities identified, but in estimating how many new possibilities we are likely to uncover by extending the sample. A key result for this extrapolation is the average number of new possibilities revealed by the 60th case in the resample. This was *0.291* in the original data set (see Figure 1); running the new data set through the resampling program gives a new value of *0.297*, which suggests that the unreliability in the coding scheme has very little impact (2%) on the final result. There is no guarantee that this would always be true, but it would always be possible to check in this way.

The third assumption underlying the ERP is that the value of the information provided by each possibility is similar to that provided by the other possibilities, so that a simple count of new possibilities revealed is a reasonable metric. To some extent, this can be achieved by defining a suitable coding scheme, but if some possibilities are substantially more informative than others, a simple count may not give a meaningful measure of the amount of new information revealed.

The ERP could easily be adapted to deal with this. The procedure would be to define a (rough) unit of value (in terms of money, time, etc: obviously depending on the objectives of the research), and then treat each possibility as comprising a number of such units. For example, "ease of recharging" might be regarded as, say 1 unit, and the next possibility as 2 units. In practice, it may be very difficult to estimate the value of information about each possibility before it has been thoroughly investigated, and agreement between different judges would probably be more difficult to achieve, so valuing possibilities in this way may not be feasible in many contexts. However, when it is possible, it would mean that the final result - the value of extending the sample - would be expressed in more useful units.

The extent to which these three assumptions are met in any given study, and so the extent to which the ERP will give useful results, are inevitably a matter of judgment. Just as with standard statistical tests, whose conditions are seldom met exactly, the ERP may provide a useful guide even when the assumptions are only approximately true.

Prospecting research can also be viewed in terms of learning. From this point of view, the ERP models the amount of new information gleaned as a sample is extended. This is a similar concept to the familiar "learning curve" concept in training (Bass and Vaughan, 1966). While there certainly are some parallels, we would highlight one important distinction between the two ideas. In some types of learning curve, the acquisition of some learning in the early stages has the effect of facilitating the acquisition of further learning, which will accelerate the learning. In the search for possibilities, we assume that there is no such interrelationship between discovered possibilities: an awareness of the nature of the first, say, five possibilities does not make it easier to discover the next five. In the later stages of the process, however, the two ideas may be more similar. In prospecting research, the rate of discovery of new possibilities will eventually decline as more and more of them become known to the researcher. This is essentially similar to the declining rate of learning that would be experienced by a student on, say, a foreign language course at a particular level: beyond a certain point, the course ceases to offer anything new to that student.

4. Conclusions: the practical value of the ERP

The method proposed here is essentially a formalisation of intuitions about when a search for more data should be abandoned. Any sensible fieldworker reduces their efforts to gather new information as the rate at which new information is found falls. Eventually this rate is reduced to the level at which it does not seem worthwhile continuing the search.

Our method is simply a way of quantifying this intuitive process. To take a very crude example to illustrate how the results can be used, suppose that the data summarised in Table 1 represented some more expensive research in which each case cost $200 to research. Suppose further, that the estimated average value of each new possibility revealed were $2,000. This value would incorporate client satisfaction and other relevant factors. It would clearly be difficult to estimate, but any rational approach to the problem of deciding when to stop has to incorporate some valuation of the information gained from the research, even if only on an informal basis. Then, using the results derived above, the estimated expected value of the information revealed by the 61st case would be $580 (0.29 x $2,000), and by taking another 10 cases, it would be $5,400 (2.7 x $2,000). The costs are $200 for the one extra case, and $2,000 for the ten extra cases, so on the basis of expected net payoff, the further sampling is justified. The sample is obviously worth extending until the value of the new possibilities revealed by extending the sample has dropped to the cost of extending the sample: this happens when the sample size reaches 197 (although obviously the precision of this result should not be taken seriously).

On the other hand, the confidence interval analysis indicates that extending the sample would be risky: the 95% interval for the value of the information revealed by the next 10 cases extends from 0 to $120,000.

This is the sort of calculation which would normally be undertaken intuitively. The costs are likely to be predictable, but the benefits much less so.

Deciding how far a survey should be extended is a fairly common problem. For example, one of the authors, when working for a major management consulting firm, had the task of carrying out executive interviews with senior managers of European organisations for the exploratory phase of a large project. As might be expected, the first few interviews were very useful in building up understanding. As a result of this, however, new insights and perspectives began to appear less frequently as the interview programme progressed, raising the question of when data collection for this phase of the work should be regarded as provisionally complete. From the point of view of both client and consultant, the question was not trivial – each further interview was likely to involve substantial air travel and other costs, together with the consultant's fee for the time spent. The incremental cost per interview would be very likely to exceed $2,000, a sum that would become unjustifiable if little or no new understanding was gained. The obvious question is that of deciding when the likely value of the next interview means that it is worth stopping. This question was answered informally at the time; this paper has proposed a formal approach.

This is just one example. Besides its applications in marketing, the ERP is potentially relevant to almost *any* field of empirical research: eg risk management, general management, education, biology and academic literature searches, but these are obviously a haphazard selection from an almost infinite list.

The ERP is useful for deciding whether it is worthwhile to extend a sample. It cannot, however, be used before any data has been collected. The method based on probabilities described in Christy and Wood (1999) can be used to derive some initial plans regarding sample size. For example, in the introductory section above we explained how, starting from assumptions which would be difficult to justify rigorously, this method produced a recommendation for a sample of 70. The ERP can then be used to decide whether it is worth extending this sample, and, indeed, whether it is worth stopping short of the sample of 70.

The assumption on which the figure of 70 was based is that there are 50 possibilities each of which occur in 10% of the population. (Table 1 in Christy and Wood, 1999, shows that this sample is actually sufficient for 81 possibilities - this being the smallest number greater than 50 shown in the appropriate column of the table.) This is a prior probability distribution in the sense that it is formulated without reference to any data, which prompts the question of whether we can use our sample of data to update it by means of Bayes theorem, as an alternative to using the ERP. However, this is not feasible because the possibilities in which we are interested are those we have not yet found, so we have no data on their prevalence, and Bayes theorem could only give trivial results. The ERP is the only realistic approach.

Appendix: Method used for extrapolating resample results

Wood and Christy (1999) suggest two possible algebraic formulae for making extrapolations. One of the these fitted the resample results in that paper, and also those in the present paper more closely, so we used this equation:

$$V_n = V_1 /\{1+(n-1)b\} \tag{1}$$

where n is the case sequence number, V_n is the corresponding result from the resample distribution (mean or percentile), and V_1 and b are parameters which are chosen to make the curve fit the data as closely as possible. The conventional method of doing this is the "least squares" criterion; this, however gives results which are not quite intuitively reasonable (see Figure 1 in Wood and Christy, 1999). The difficulty is that the later points in the sequence need to carry more weight in estimating the parameters. This can be achieved by giving the last point a weight of 1, the one before a weight of c, the one before that a weight of c^2, and so on. We decided to choose a value of c which meant that the last 5 points had half of the total weight. (In fact, our experiments suggested that the exact value of c had little effect on the results.) This implies that $c = 0.87$ because

$$1 + c + c^2 + c^3 + c^4 \text{ is approximately equal to } c^5 + \ldots + c^{59}$$

We then entered some provisional values for the two parameters, V_1 and b, on a spreadsheet, calculated the discrepancy between the points based on the resampling and the extrapolations (using Equation 2) for each value of n, squared each of these discrepancies, multiplied each by the appropriate weight, and summed the column to find the total weighted square discrepancy. The Optimiser Tool on the spreadsheet Quattro Pro (Solver on Excel would doubtless have given similar results) was then used to find the values of the two parameters which resulted in the minimum value of this total weighted squared discrepancy. The extrapolation equation used in the figures was Equation 2 with these values of V_1 and b.

Exactly the same method is used for extrapolating resample results from groups of 10, except that c is taken to be $0.87^{10} = 0.25$ since each group spans 10 individual cases.

References

Bass, B. M., & Vaughan, J. A. (1966). Training in industry: the management of learning. London: Tavistock Publications Ltd.

Christy, R., & Wood, M. (1999). Researching possibilities in marketing. Qualitative Market Research, 2, 3, 189-196.

Davison, A. C., & Hinkley, D. V. (1997). Bootstrap methods and their application. Cambridge: CUP.

Diaconis, P., & Efron, B. (1983, May). Computer intensive methods in statistics. Scientific American, 248, 96-108.

Noreen, E. W. (1989). Computer intensive methods for testing hypotheses. Chichester: Wiley.

Wood, M., & Christy, R. (1999). Sampling for possibilities. Quality & Quantity, 33, 185-202.

Table 1: Some of the data from the car survey

CASE	POSSIBILITY			
	1	10	20	30
A	100000000	0000000000	0000000000	0000000000
B	011100000	0000000000	0000000000	0000000000
C	000011000	0000000000	0000000000	0000000000
D	100000100	0000000000	0000000000	0000000000
E	000000011	0000000000	0000000000	0000000000
F	001000000	0000000000	0000000000	0000000000
G	100000010	0000000000	0000000000	0000000000
O	101100100	0100000100	0000000000	0000000000
V	100000000	0000000000	0000000000	0000000000
AO	111000000	0000100000	0000000000	0000000000
AS	001110000	0110000000	0000000000	0000000000
AU	100000100	0000000000	0000000000	0000000000
AX	000010000	0000000000	0000000000	0000000011
BG	000000010	0000000000	0000000000	0000000000
BH	000000000	0000000000	0000100000	0000000000

The cases are individual respondents. 1 indicates that the respondent mentioned the possibility, and 0 indicates that the possibility was not mentioned by the respondent. This table only shows selected cases – including those mentioned in the text.

Table 2: New possibilities revealed in five resamples

	Resample					
	1	*2*	*3*	*4*	*5*	*Mean*
First Case	1	2	4	2	3	2.4
Second Case	2	1	1	2	1	1.4
Third Case	1	4	2	3	3	2.6
Fourth Case	3	3	0	2	1	1.8
.....	...	...	...	...	...	.....
60th Case	0	1	0	1	1	0.6

Table 3: Predicted and actual numbers of new possibilities found in Cases 31-40 (predictions based on sub-samples of 30)

Trial	*Predicted mean*	*95% conf interval*	*50% conf interval*	*Actual number*	*Actual in 95% int?*	*Actual in 50% int?*
1	2.6	0 - 6	2 - 4	4	yes	yes
2	2.5	0 - 6	1 - 4	3	yes	yes
3	3.7	1 - 8	2 - 5	3	yes	yes
4	4.6	1 - 10	3 - 6	2	yes	no
5	2.9	1 - 5	2 - 4	3	yes	yes
6	5.0	1 - 11	3 - 7	1	yes	no
7	2.6	1 - 6	2 - 4	7	no	no
8	3.1	1 - 7	2 - 4	6	yes	no
9	4.8	1 - 9	3 - 6	0	no	no
10	2.4	1 - 5	1 - 3	6	no	no
Means	3.4			3.5	70%	40%

Figure 1: Mean number of new possibilities

Figure 2: Mean number of new possibilities - two sets of simulated data

Figure 3: Number of new possibilities in groups of 10 cases

Figure 4: Number of new possibilities in groups of 10 cases - predictions from a sample of 30 compared with actuals

Figure 1: Mean number of new possibilities

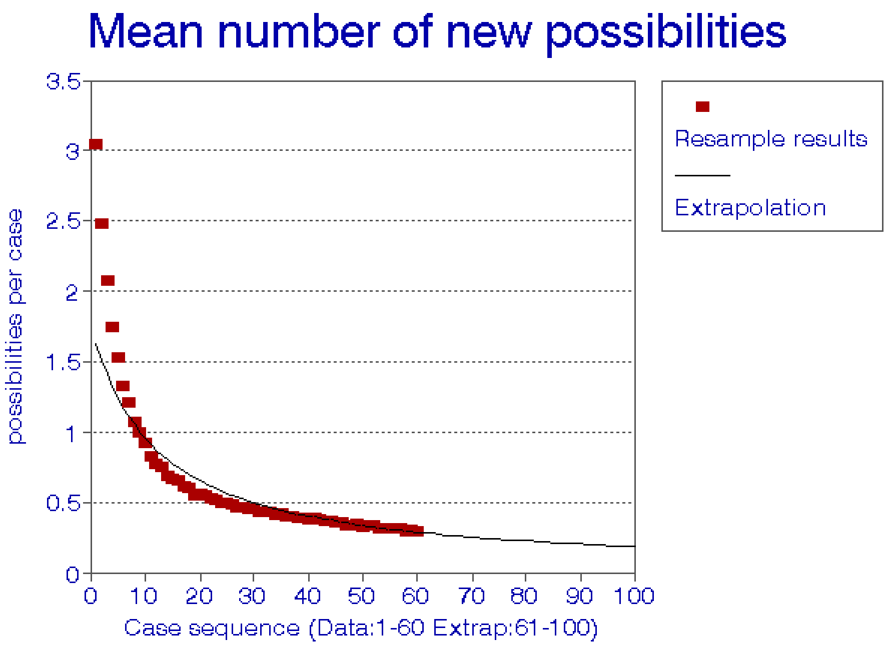

Figure 2: Mean number of new possibilities - two sets of simulated data

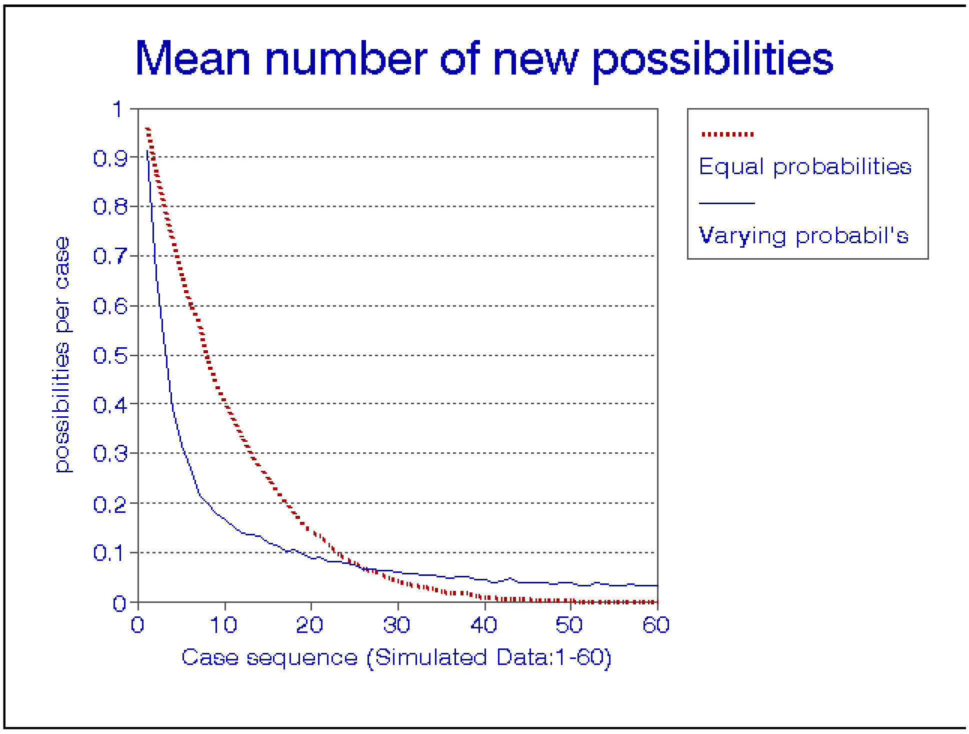

Figure 3: Number of new possibilities in groups of 10 cases

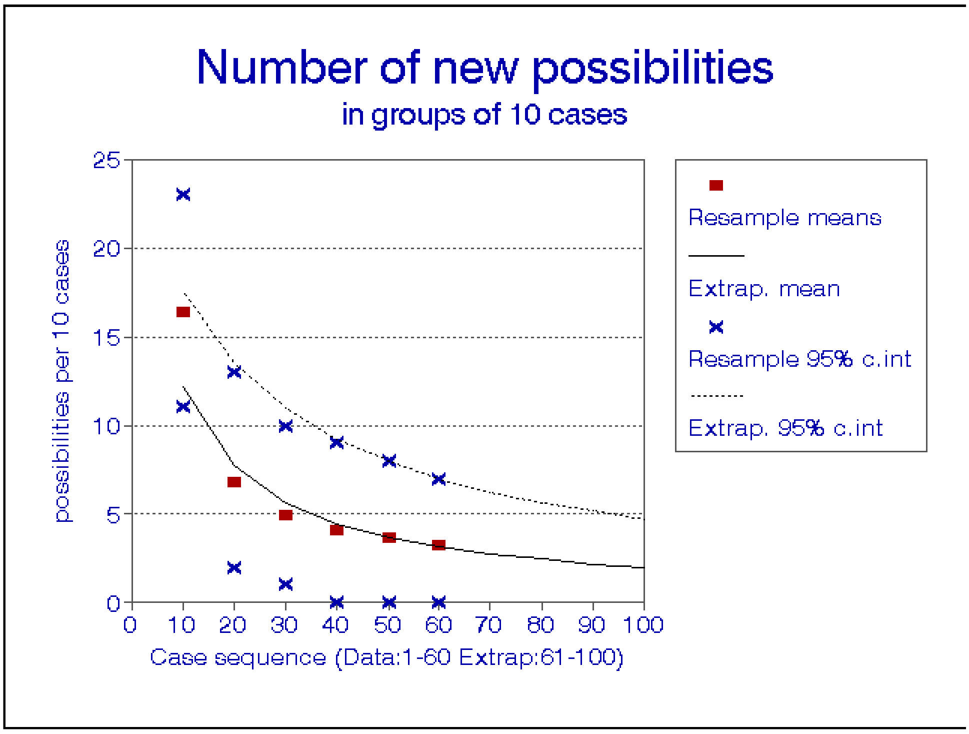

Figure 4: Number of new possibilities in groups of 10 cases - predictions from a sample of 30 compared with actuals