SOME APPROACHES TO FUTURES

AND FORECASTING

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Abstract

The political changes of the last few years have produced a remarkably uncertain environment for defence planners. The well-known problem of long procurement cycles is exacerbated by the difficulty of knowing which choices are likely to be robust against future uncertainty. The problem reaches more widely than the defence sector and the UK Cabinet Office recently commissioned a major review of future technologies under the title of Project FORESIGHT. This has led to much work in other organisations to define future 'worlds'. To support such work, this paper surveys a range of futures methodologies. A taxonomy is developed for candidate approaches to thinking about the unknowable future.

Introduction

Only a fool, a charlatan or, possibly, the Chancellor of the Exchequer claims to be able to predict what will happen in the future, yet, despite the evident failures of these attempts there is an abiding interest in the future and what it might hold. The purpose of this paper is to discuss the validity and usefulness of some of the extant approaches which purport to enable us to think about the unknowable future. Let us start with some severely practical notions about why we might want to do so, apart from what might be the intrinsic interest of the topic or a desire to diminish our human fears by wanting to know what lies ahead.

The Channel Tunnel was predicated to a large extent on a 20th century way of life and could be said to carry with it an assumption that the future will be very much like the present. If one transposes the terms and asks in what ways the present is like the past one immediately sees the profound value of the study of history and realises the absurdity of assuming, even tacitly, that the future will resemble the present. The essence of futures studies is to challenge that assumption and to attempt to explore ways in which the future may be different from the present. The clear implication is that if one understood what the future might hold one might make 'better' decisions now, either in the sense of avoiding choices which are not future proof or of bringing about 'better' futures. These might be a profoundly important things to do, if they could be done properly, and the purpose of this paper is to summarise some aspects of the problem.

Turning to social and political events, the 20 years from 1900 to 1920 witnessed events which led to the collapse of 5 empires and irreversible damage to another[1]. In that context, one sometimes hears questions such as 'who, in 1900, could have predicted that by 1920 ... '? The real question is not who could have done it but whether anyone did do it. In fact a Pole named Bloch wrote a very learned book predicting that war in Europe was utterly impossible because of the complex interconnections of the financial system. At about the same time, Erskine Childers wrote <u>The Riddle of the Sands</u> about a putative invasion of Britain by Germany[2]. Here we have a case of two utterly different futures being discussed. Given the awful potential consequences of Childers' views, a policy option of reinforcing the financial system to make sure that Bloch's world would prevail would have been attractive, if it were feasible. Thus, acting to negate an unwelcome forecast and make another self-justifying would not prove one forecast to have been 'wrong' and the other 'right', it would be an act of prudence.

One is not, of course, saying that a world war could have been prevented; the point is simply to illustrate, albeit dramatically, why forecasting is important, if we can do it.

Forecasting, Prediction or Futures Studies ?

Before going much further it would be as well to define some terms. The dictionary helps a little, giving prediction a sense of telling beforehand, whereas forecast has a sense of a general assessment of a likely course of events, as in a weather forecast. We shall use predict to mean a statement that something is practically certain to happen and forecast to mean a statement that certain broad trends or sequences of

events may occur, for reasons which can be explained. A scenario is an unfolding sequence of events during a forecast.

The idea of explanation is important as it leads to an understanding of changes which might be made to bring about better futures. Thus, forecasting means to think systematically about the unknowable future in such a way as to generate understanding to support effective intervention in, or protection against, events yet to occur. Prediction is something done by racing tipsters.

To reiterate, the idea of usefulness is important; what matters is not the forecast itself but what can be done with it. If I can buy a perfectly effective umbrella which is the size and weight of a box of matches[3], I am not interested in the weather forecast whereas a farmer concerned to plough or harvest is deeply concerned with it[4].

The Futures Methodology Tree

These ideas are taken a stage further in Figure 1 to show the idea of dealing with change. On the one hand, one might react passively, after change has occurred. In some cases, it might be perfectly appropriate to do nothing, in other cases one might model the changed situation to see what could be done, or one might ask for suggestions. In other cases, one might simply monitor matters to see how things go.

To deal with change actively opens up two strategies: defence and anticipation. The defensive approach simply shares the risk with others by insuring one's car or assuring one's life.

The reactive and defensive approaches are perfectly respectable, but we shall be concerned with anticipation, either by 'analytical' or by 'judgemental' approaches.
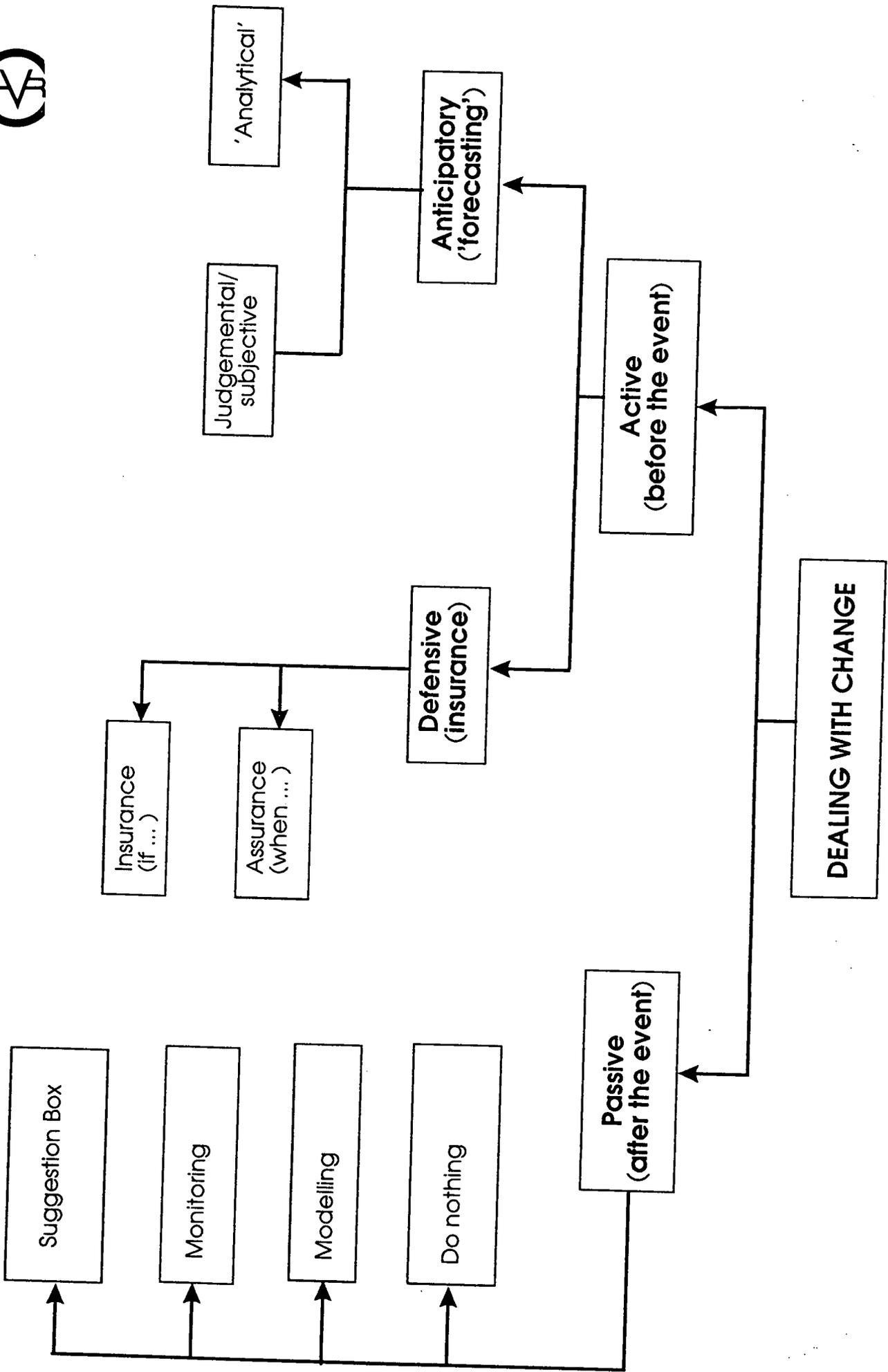
Some 'Analytical' Approaches

The analytical approaches are shown in Figure 2 and break down into three categories.

Inductive Reasoning

Analysis of patents awarded in a given field may give good insights into likely technological evolution[5]. Analysis of the ways in which something might fail is often salutary. Historical study has a long pedigree; understanding what has happened may help to illuminate the future, based on the old saying that those who fail to learn the lessons of history are doomed to repeat them[6]. Unfortunately, historians do not always agree on what the lessons are !

Graphical Methods

The graphical approaches have the attraction that they have the potential for concise explanation as well as vividness.
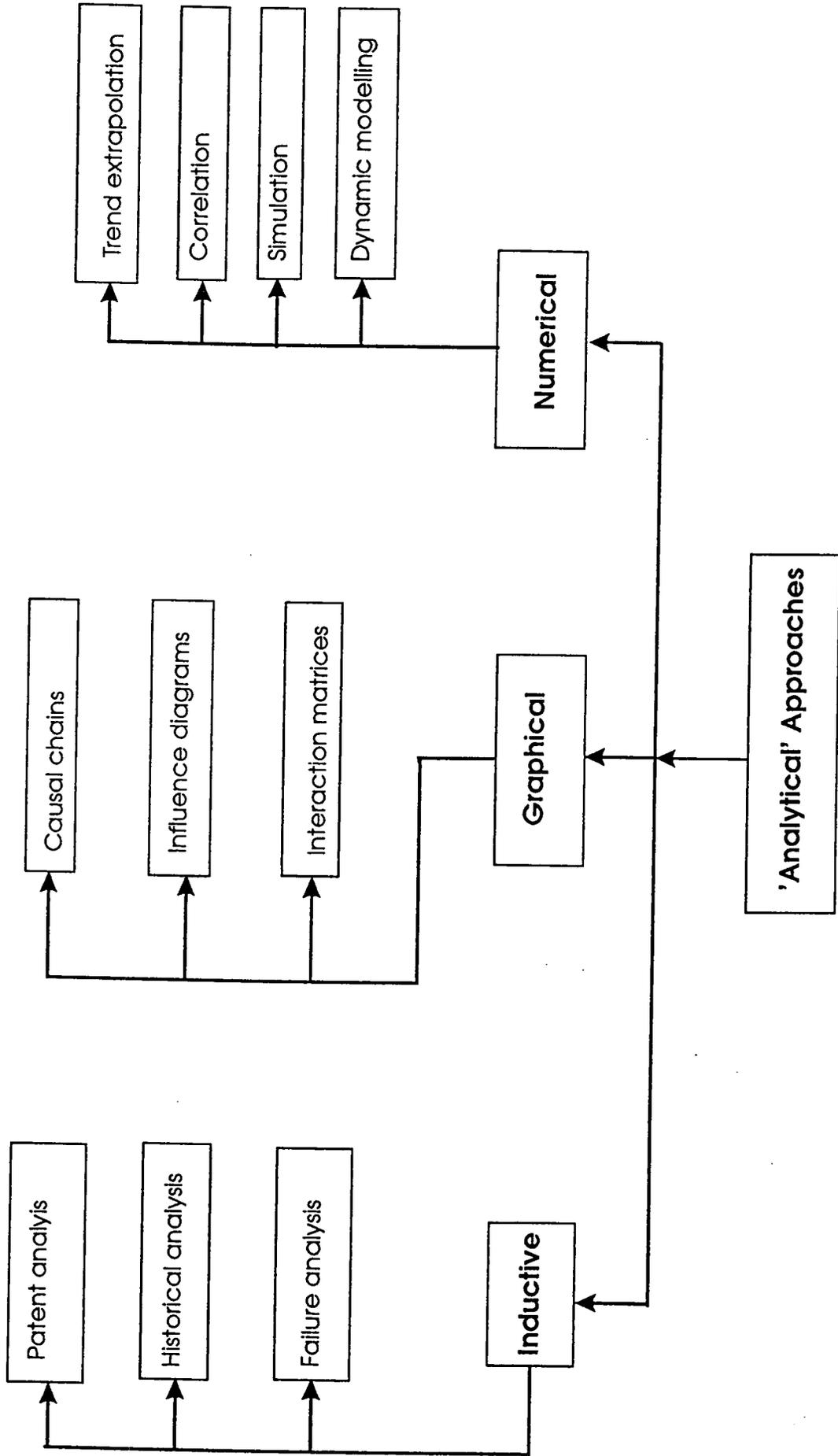
Figure 1 The Futures Methodology Tree

Figure 2 Some 'Analytical' Approaches

Figure 3 is an influence diagram[7] for the context of air traffic control. The factors in *bold italics* are pressure points at which change might occur; for instance in the *Average Aircraft Size*. The diagram allows one to think qualitatively about how such changes might interact to influence the future of air traffic control and how, indeed, some changes might be nullified by the presence or absence of change elsewhere[8]

The difficulty with influence diagrams is that they depict a problem as a mechanism. They can give good insights into problems, even at a qualitative level, but they lack the human touch. To some extent that limitation can be addressed by using another system enquiry methodology, the rich picture phase of the Soft System Methodology[9]. Because this lays more emphasis on how people act rather than on how a system works, it can give useful insights into events which might occur.

Both the influence diagram and the rich picture are, of course, fundamentally qualitative. That is their intent and they fulfil it by forcing one to think about a problem but there is a limit to what can be inferred by simply looking at a picture of a problem. The next evolution in analytical terms is, therefore, to attempt to put some kind of numbers on to a problem and that can be achieved, to some extent, by analysing causal chains, as illustrated in Figure 4, which illustrates a hypothetical case of military threat assessment[10]. Briefly, it treats two nations, an Actor and a potential Target. Examples will spring to mind. A third party, the UK's interest, is represented because it may well be that Actor A's attack on target B involves nothing to do with us, so to speak.

The following table shows some illustrative results, from which one might conclude that A is powerful and unconstrained but there is no *casus belli* at the moment. We, however, would be involved so we had better bend our diplomatic efforts to make sure nothing brews up.

Actor A against Target B

Actor freedom of action	+0.6
Actor will for war	-0.3
Actor aggressive credibility	0.6
UK interest	+1

There is obvious potential for futures work with this approach. The influences within the causal chain are not necessarily immediate so if, for instance, an unpleasant actor suddenly discovers oil, increasing its economic resources, there might be trouble in a few years time.

Numerical Approaches

To an operational research community, the group of numerical approaches has obvious attractions. Mathematically powerful techniques exist for trend extrapolation in such forms as the Treasury econometric model. In principle this is a simple idea taken to great depth by the use of hundreds of regression equations and balancing terms and heavily used in economic management[11]. The track record in terms of 'accuracy' is not spectacular, as seen every time the Chancellor presents his budget,

Constraints

Pricing Policy

Investment in ATC

+

ATC Charges

+/-

+

D_I

ATC Work Capacity

+

Airline Costs

+

+

D_E

Runways and Ground Handling Facilities

Pressure to Improve Supply

+

Perceived Supply of ATC Services

+/-

ATC Configuration

Rate of Handling Flights

+/-

+

Turn-round Time for Aircraft

−

+

+

D_S

+

−

ε

+

Delays to Passengers

−

Passenger Handling Facilities

+

+

Demand for ATC Services

+/-

+

Aircraft Requiring Ground Handling

+

−

Passenger Satisfaction

−

Aircraft Characteristics

Overflights

D_P

+

+

Passenger Numbers

D_D

−

Average Aircraft Size

+

−

+

−

Achievable Prices

D_{E2}

+

Airline Profitability

+

+

−

D_{E1}

D_A

+

Flights Scheduled

−

+

Intended Volume of Air Traffic

+

−

D_B

+

Pressure to Reduce or Smooth Demand

+

Traffic Growth

−

D_C

Number of Airlines Competing

+

Figure 3   Influence Diagram for The Context of Air Traffic Control

ACTOR ECONOMIC RESOURCES

ACTOR DEPENDENCE ON INTERNATIONAL AID

UN MILITARY CREDIBILITY

ACTOR POTENTIAL MILITARY EXPENDITURE

ACTOR RESOURCES FOR WAR

ACTOR DEPENDENCE ON TRADE

ACTOR ECONOMIC VULNERABILITY

ACTOR MILITARY CAPABILITY

UN ABILITY TO DEPLOY FORCE RAPIDLY

ACTOR PROSPERITY

ACTOR PENALTY FOR PASSIVENESS

ACTOR ACTUAL MILITARY EXPENDITURE

TARGET/ACTOR ANIMOSITY

PROLIFERATION OF WEAPONS OF MASS DESTRUCTION

ACTOR STATUS/INFLUENCE OF MILITARY

ACTOR REGIME STABILITY

NATURE/VISIBILITY OF DISPUTE

STRATEGIC IMPORTANCE OF REGION

POLITICAL GAIN FOR ACTING

REGIONAL ACCESSIBILITY

ACTOR CULTURAL/RELIGIOUS EXTREMISM

TARGET MILITARY CAPABILITY

ACTOR RATIONALITY

IMPERATIVE TO ACT

TARGET WILL

RELATIVE STRENGTH ACTOR/TARGET

SIZE OF UK EXPATRIATE POPULATION

UN EASE OF IMPOSING SANCTIONS

UN WILL FOR INTERVENTION

TARGET ECONOMIC/ NATURAL RESOURCES

REGIONAL SUPPORT FOR ACTOR

ACTOR AGGRESSIVE HISTORY

EFFECTIVENESS OF SANCTIONS

ACTOR COST ANALYSIS

ACCESS OF ACTOR POPULATION TO PUBLIC INFORMATION

1

2

3

4

5

6

7

8

9

10

ACTOR FREEDOM OF ACTION

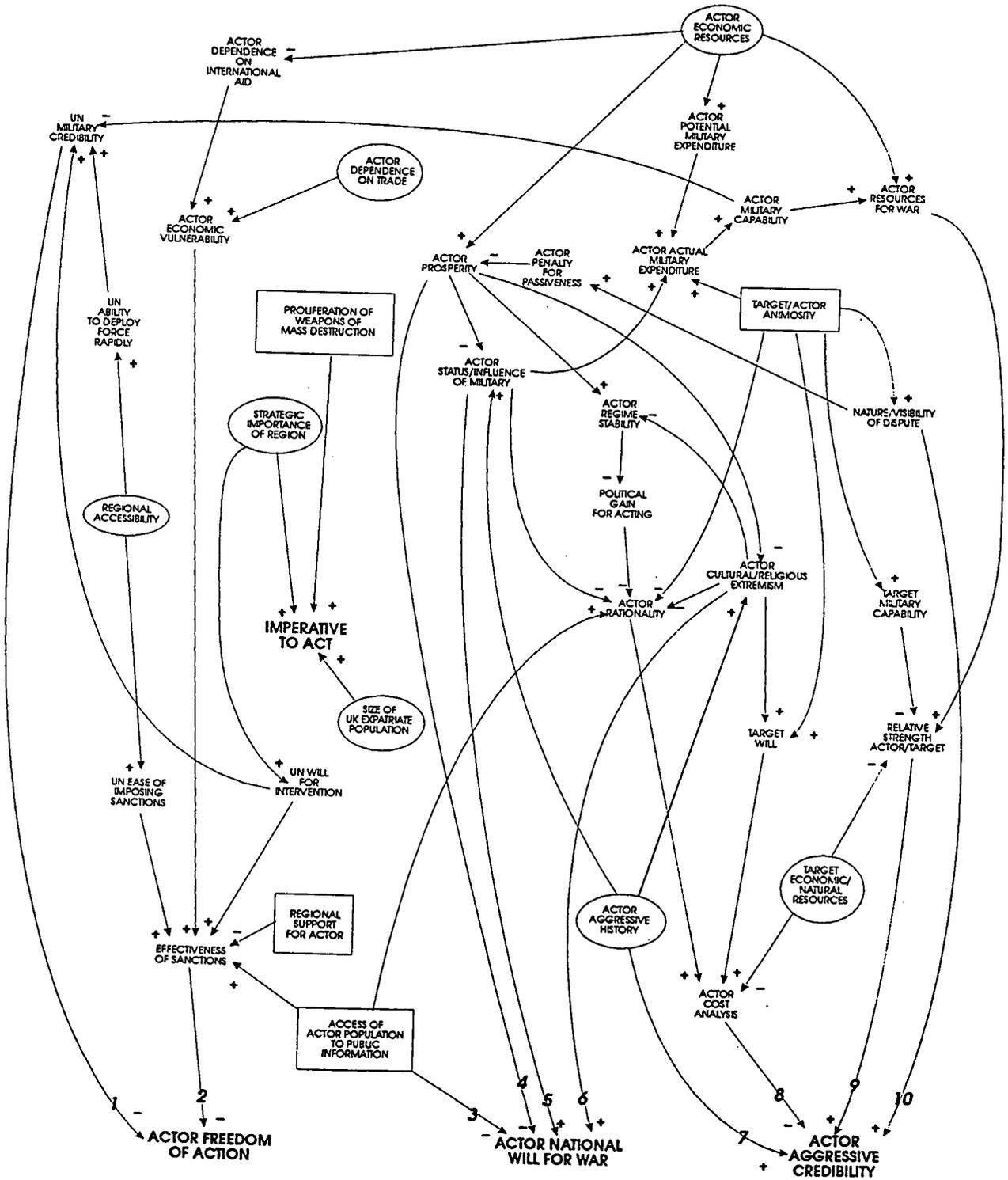ACTOR NATIONAL WILL FOR WAR

ACTOR AGGRESSIVE CREDIBILITY

Figure 4 A Causal Chain Diagram

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FIG.4

but that is inevitable with a model which treats the effects of past policy as noise to be filtered out from a model which is used to infer policy guidelines.

Apart from the difficulty that the data may be wrong, there is the fundamental point that the future has not yet been measured so what is the value of using numbers which do not refer to the problem in question?

One of the best known futures explorations was the series of world models produced by Forrester and his collaborators at MIT[12]. These models were developed at a time when it was feared that the world social and economic order (whatever that was) was about to collapse unless urgent remedial action was taken. The approach used was to postulate relationships between variables such as pollution, population, and agricultural output, very much as was done in Figure 3, though using a different diagrammatic format. These relationships were then translated into a set of difference equations so that the dynamics of the system could be simulated. Parameter values were derived from a study of the relevant literature or were estimates made by the modellers. For example, world population and average lifespan in 1970 were known reasonably accurately; the authors of these models then deduced multipliers which would decrease lifespan as, say, pollution increased. Qualitative variables, such as quality of life, were also included in the model.

The simulated dynamic behaviour for the 'base case' showed that Population would increase dramatically until, in the early part of the next century a collapse would be brought about by increasing pollution and decreasing resources. An interesting feature of the models is that they are small; WORLD1, for instance, is only 250 lines of code, parameters, comments and definitions and runs in a few seconds on a standard PC.

In essence, both the econometric and the system dynamics approaches have a similar foundation. The one says that 'if present trends continue ... ', the other 'if present behaviour continues ... '. Neither case is likely to be true for a long time span so, in a sense, both are philosophically flawed as predictors. If, however, one accepts that, as argued earlier, the purpose of forecasting is to provide indicators so that useful action can be taken, neither approach is required to make statements about the future which turn out to be true.

Summary

The techniques so far discussed all have weaknesses. The graphical tools help to structure a problem but they are difficult to work with because the mind can only absorb so much information at once. The analytical methods suffer from the inherent assumption that something continues into the future as it has in the past. To sustain that assumption for two centuries, as the world models require, is stretching matters further than many feel comfortable with. Further, the challenge of reducing economic behaviour to statistical regression, albeit mathematically sophisticated regression, is hard and to express the behaviour of mankind in difference equations is not easy, especially if one wishes to carry a sceptical scientific community along with one.

In short, both diagrams and equations risk abandoning the nuances of human understanding, so it is time to turn to methods which purport to allow subtlety to be expressed.

The Futures Methodology Tree Revisited

Figure 5 depicts methods which depend on the opinions and judgements of people.

Polling Methods

The intent of polling methods is to collect the views of people in the hope that those opinions will illuminate the future. The inherent danger is that someone asked for an opinion will usually give it, regardless of their knowledge. The track record of political opinion polls is not sparkling.

Narratives

There is a vast literature of futures studies written in the form of narrative text. The value of this type of work is that it makes one think, in other words it is intended to forecast with useful results.

Science fiction is, perhaps, written with less overtly sociological intentions and usually turns out to be a good read. Some SciFi has, however, presaged the future with uncanny accuracy; the early novels about space stations are a case in point[13].

The fundamental assumption is that the nature of the future can only be understood by using words, not by numbers or mathematics. This is soft operational research with a vengeance but perhaps the really important problems are so hard that they can only be tackled by soft methods.

The narrative is taken yet further in the extended scenario which is a logical progression of the future of the world, but written at some length. A recent example is Macrae's The World in 2020[14]. This covers a wide range of topics such as demography, social change, technology, resources and so on, on a regional basis, to project what the world might be like in 2020. The difficulty is that the book runs to 300 pages so that it is a considerable effort to read and an impossible task to revise it if one disagrees with something half way through.

A similar source is Friedman and Lebard's The Coming War With Japan[15]. This is more pessimistic as it traces out the reasons why the authors believe such a conflict might eventually come about, using some interesting techniques for assessing the relative vulnerabilities of pairs of countries to an interruption of trade between them. Once again, the difficulty is length, over 400 pages in this case.

The Economist's annual reviews, such as The World in 1996, consist of a collection of short essays by informed commentators on what might happen in the coming year; a very clear contrast with the 30-year view taken by Macrae.
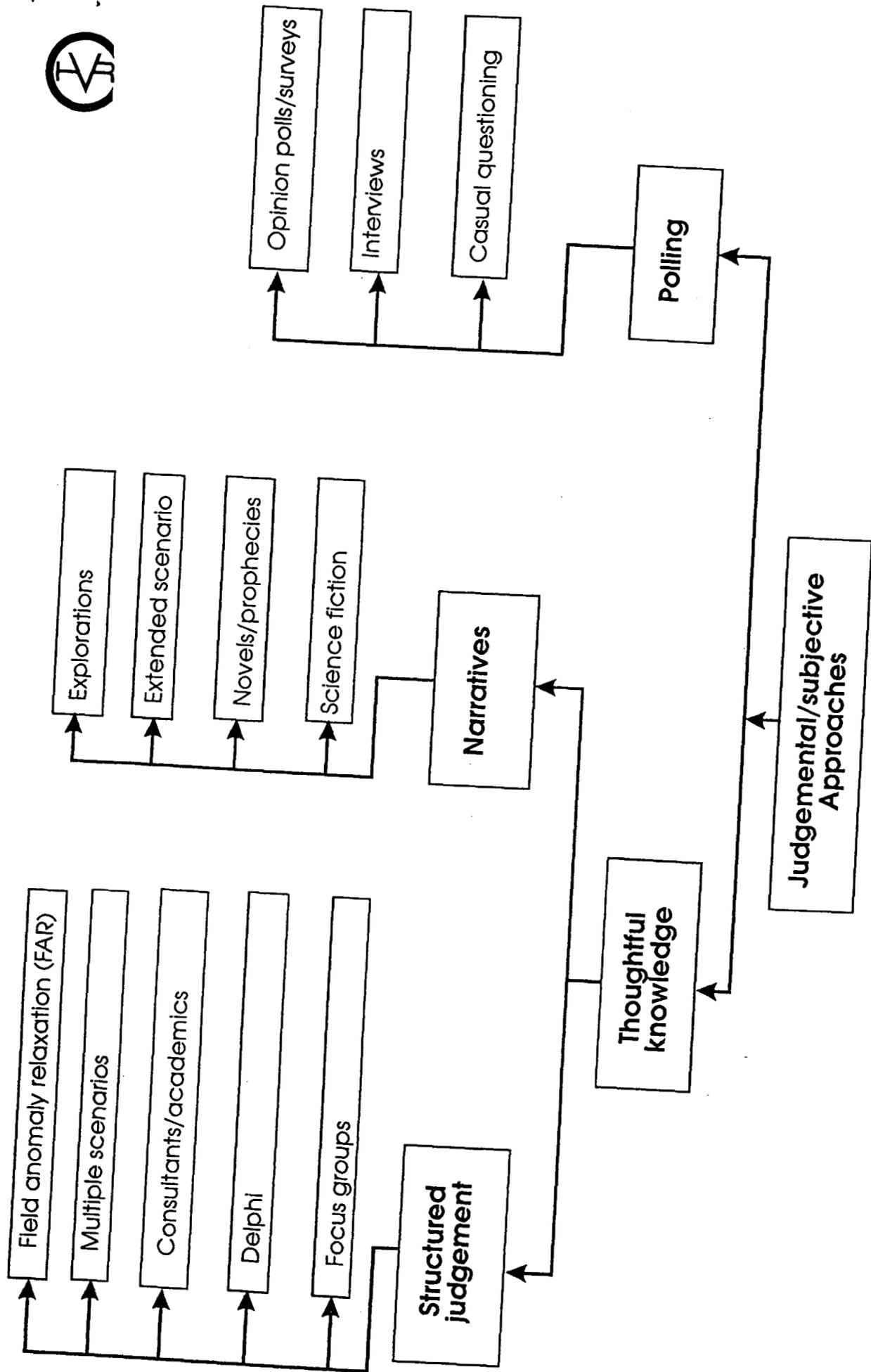
Figure 5 Judgemental/subjective Approaches

The final group of methodologies in Figure 5 apply the knowledge of groups of individuals in, perhaps, a more structured approach than the efforts of authors producing narratives.

The fundamental basis of the structured judgement approaches is that the participants are assumed to possess some special expertise in the problem domain but that a systematic approach is needed to extract that knowledge so that it can be put to use. This is seen at its most extreme with the academic consultant.

Focus groups can be seen as an up-market debating society in which a *rapporteur* records the insights generated by a group discussion. Such methods have all the advantages of bringing out human insight and all the drawbacks of a powerful individual, or a skilful debater, having a disproportionate influence.

The Delphi approach was used in a recent study into future technological developments[16]. For defence technology, about 90 questions were put concerning the dates at which it was considered that various advances might be achieved. One was also asked to assess what were the most likely obstacles to achievement, such as technological difficulty or cost. In addition, for each question the respondent was asked to rate his expertise on a scale from 1 (know practically nothing) to 5 (fully expert in all ramifications of the topic). The essence of Delphi is to feed back the first responses for second thoughts, with all the attendant risks of consensus being established about a particular answer, rather than exploring the reasons for the outliers. In this case, the second report showed, on inspection, practically no difference at all between the answers from the experts and the ignorant !

Multiple scenarios are much favoured by corporate planners in large firms. They often use econometric models with economic intelligence purchased from consultants. They are an excellent case of futures explorations for the benefit of one organisation and are supremely designed to give useful guidance so as to avoid trouble or exploit potential.

Perhaps the most interesting of the structured judgement approaches is the Field Anomaly Relaxation (FAR) approach postulated by Rhyne[17]. The fundamental point of view is that the world, be it now or in the future, cannot be described by one aspect, such as economic growth, alone; one needs to think in terms of, say, technology, social behaviour, political interactions and so on. Armed with these descriptors the world can be described in a rich and stimulating way.

The technique, though it is more than that, starts by trying to visualise *possible* futures, usually through the medium of interviews with speculative thinkers or essays written by such people. From these sources a set of 'Sectors' can be deduced[18], each of which is defined in as many levels, or 'Factors' as Rhyne terms them, as are required. An illustration is shown in Figure 6, which is part of a FAR analysis for the South China Sea region[19]. The acronym ESPARC is a word in a meta-language for thinking about the future and this idea of constructing a language is critical to being able to think about the future. Within Figure 6 it is clear that there are certain pairs of descriptors which represent fields which could not co-exist and these anomalies are eliminated, or relaxed, hence the name of the method. In Figure 7, pairs of descriptors

E	S	P	A	R	C
Economic dimension	Political stability	External power dimension	Regional coop/ alliance	Resource pressure	China's attitude
E1: Rosy growth	S1: Strong and stable	P1: Effective and Influential	A1: Close cooperation	R1: Low pressure	C1: Leader and policeman
E2: Fair growth	S2: Fairly stable	P2: Fairly influential	A2: Loose multi-lateralism	R2: Moderate pressure	C2: One of us
E3: Stifled growth	S3: Shaky	P3: Limited influence	A3: No multi-lateralism	R3: High pressure	C3: Minds own business
E4: Negative growth	S4: Unstable		A4: Enmity	R4: Crisis Situation	C4: Pushy, verbally
					C5: Forceful, militarily
					C6: Warlike

Figure 6. ESPARC sector/factor array.

	S1	S2	S3	S4	P1	P2	P3	A1	A2	A3	A4	R1	R2	R3	R4	C1	C2	C3	C4	C5	C6
E1	3	2	0	0	2	2	2	3	2	1	0	3	3	1	0	1	3	2	1	1	0
E2	3	3	1	0	2	2	2	3	3	1	0	3	3	1	0	3	3	3	1	1	0
E3	1	2	3	1	2	2	2	1	1	3	3	1	2	3	1	1	1	3	3	1	1
E4	0	1	3	3	2	2	2	0	1	2	3	1	1	3	3	1	1	2	3	3	3
S1					3	2	2	3	2	1	0	3	2	0	0	1	3	2	0	0	0
S2					2	3	2	2	3	1	0	2	3	1	0	2	3	2	1	1	0
S3					1	2	3	1	2	3	1	1	2	3	2	1	1	2	3	1	1
S4					0	1	3	0	1	3	3	1	1	3	3	1	1	2	3	3	3
P1								2	2	2	1	3	2	1	1	2	3	3	1	1	1
P2								2	2	2	1	3	3	2	1	3	3	3	2	1	1
P3								2	2	2	3	3	3	2	2	3	3	2	3	3	3
A1												3	2	1	0	1	3	2	1	0	0
A2												2	3	2	1	3	3	3	3	3	1
A3												2	3	3	2	1	1	3	3	2	1
A4												0	1	3	3	1	1	2	3	2	2
R1																1	3	1	1	0	0
R2																2	3	3	1	1	0
R3																3	1	1	3	3	1
R4																1	1	1	2	3	3

Figure 7. The ESPARC factor pair matrix.

are rated at 3 for certain to co-exist to 0, for certain not to co-exist. the assessment is made qualitatively, but experience of FAR suggests that, once one has become accustomed to thinking in the meta-language, this can be done with confidence. Certainly, the method provides an audit trail allowing the assessments to be challenged or revised. When pairs which score less than 2 are eliminated, the number of combinations comes down from thousands to a few tens and the latter are usually easily combined to give maybe 10 to 20 surviving fields. These, finally, are strung together into time lines, again by judgement supported by the meta-language, as shown in Figure 8.

In Figure 8, each letter, such as C, represents a feasible state, which is further clarified by the specific levels of the ESPARC factors which are shown below the letter. The solid lines represent evolutions about which the authors were confident, dotted lines are less likely, and the spiral line on the left is a judgement that the transition to catastrophe could only take place *via* an eternal catalyst, such as a resources shortage. Thus only two end points seem feasible and termination C seems to be reachable in only two ways.

Much more could be said about this fascinating methodology. Figure 8 immediately makes one think about whether actions exist which might steer South East Asia away from terminations A and D. Certainly, if one was at F, it would be pretty vital to avoid moving to P or to D, from neither of which is much progress possible. Clearly, such a tree would need revision as time passed but simply looking at such a diagram ought to be fruitful for a planner concerned with decisions having long futurity.

In terms of useful policy guidance, Figure 9 suggest two scenarios and three policies or investments. Y is future proof; X and Z are not. This takes us back to the Channel Tunnel. Is it future proof, or is it future creating by moving us onto a time line in a diagram such as Figure 8, and does that time line lead in an attractive direction ? Clearly, no one knows, but thinking in such a way is the essence of futures and the author's view is, that fallible humans though we be, we are imprudent to the point of recklessness not to do so.

This theme was also used in a FAR study of the Piedmont region of Virginia to identify desirable futures, to assess probable ones and to identify the gaps between the two in the hope of influencing the future in the right direction[20]. What was right was a matter for debate between sectional interests, but it seems desirable for such debates to occur.

Further Research

Practically all the methodologies mentioned are crying out for more research.

For instance, the influence diagram cum rich picture approach ought to be capable of use in conjunction with an extended scenario; perhaps as a summarising device. How might that be achieved ? More technically, the techniques for building influence diagrams are well understood (see reference 7) but drawing rich pictures is more intuitive. The work described in reference 8 suggests ways in which the influence
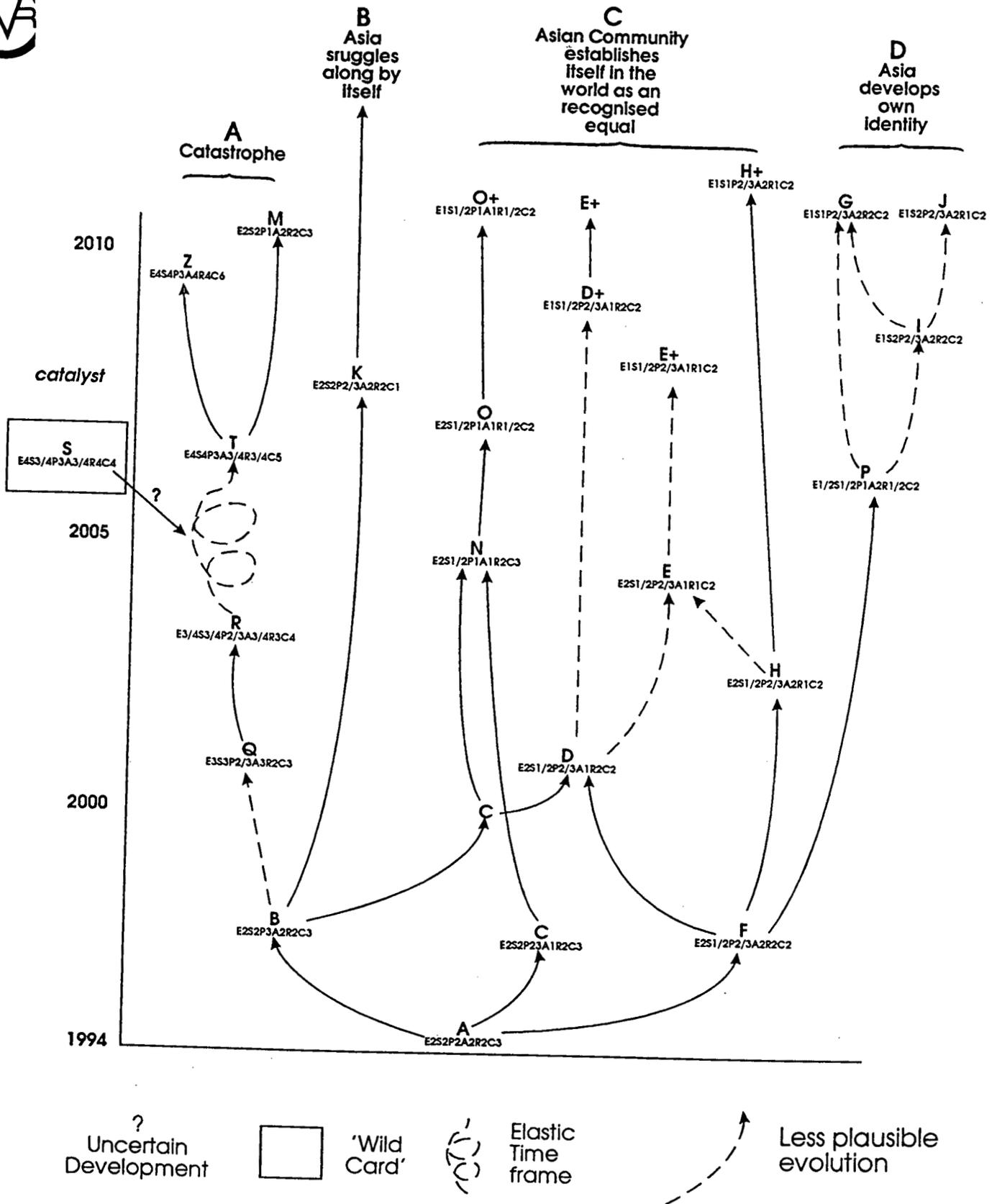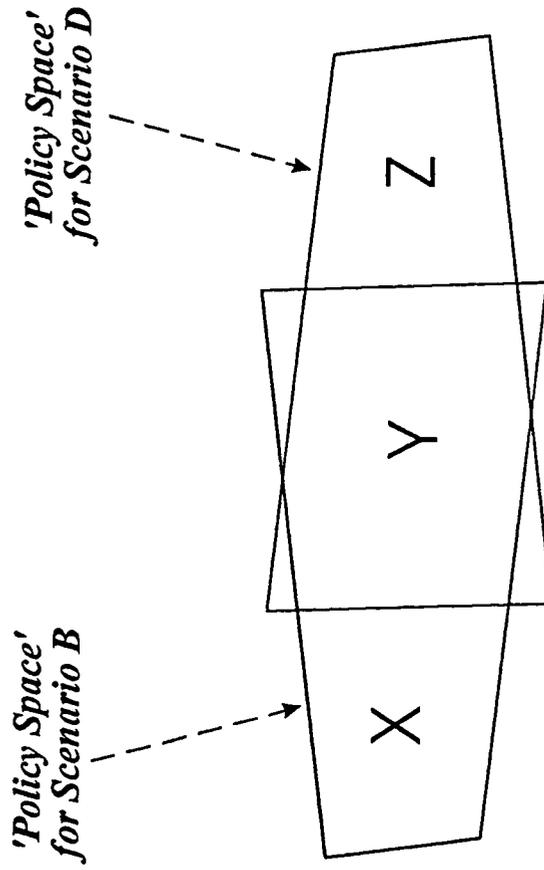
Figure 8 The South China Sea Tree

'Policy Space'
for Scenario D

'Policy Space'
for Scenario B

X   Y   Z

Figure 9 Scenario-based Policy Analysis

diagram can be the basis for drawing the rich picture but the suggested approach is by no means the last word to be said on that topic.

On another tack, the FAR approach seems to have many attractions, but demands more research into the procedure. An interesting development of the approach, EFAR or Extended FAR[21], can be used to model strategically evolutionary moves in business planning and negotiation.

Although numerous methodologies have been mentioned, little has been said about the roles of short- and long-term forecasting. Which approach is useful in which circumstances ?

The Channel Tunnel and Concorde were mentioned earlier. Are they different types of decision in terms of their vulnerability to the future and, if so, what types of futures methodology would have been appropriate in the different cases? Several times, there has been reference to 'better' decisions, but what criteria should be used in different cases ?

Many more instances suggest themselves and it would double the length of this paper to discuss them all.

Conclusion

The aim of this paper was to address the question of whether, or not, there were viable and useful approaches to the difficult issue of thinking about the unknowable future. It is concluded that such methods do exist but that, like all OR methodologies, they contain inherent assumptions to the effect that something which is known or believed now will continue into the future. Those assumptions need to be scrupulously identified and carefully borne in mind when using these stimulating and fascinating approaches to a particularly demanding problem domain.

Notes and References

[1] The five were the Russian, German, Austro-Hungarian, Ottoman and Chinese. The sixth was, of course, the British. Only the Japanese Empire emerged essentially intact from the First World War.

[2] I have been unable to track down the reference to Bloch, but Childers' book has recently been reprinted by Penguin Books.

[3] A packet of cigarettes is no longer politically correct as an analogy.

[4] See Coyle R G, Management System Dynamics, John Wiley, 1977, Chapter 10, for a model of a company which is very insensitive to errors in sales forecasts because the company's control mechanisms automatically correct for errors.

[5] For other techniques for the study of technological evolution see Jones H and B C Twiss, Forecasting Technology for Planning Decisions, Macmillan Press, 1978. For a more recent technology forecast see Loveridge D, L Georghiou and M Nedeva, United Kingdom Technology Foresight Programme Delphi Survey, Policy Research in Engineering Science and Technology, University of Manchester, 1995. The Delphi technique is discussed later in this paper.

[6] For a good modern example, see Kennedy P, The Rise and Fall of Great Powers, New York, Random House, 1987.

[7] Influence Diagrams, the techniques for building them and several other applications, are dealt with in detail in Coyle R G, System Dynamics Modelling: A Practical Approach, Chapman and Hall, 1996. The book also covers the system dynamics methodology in detail,, including the techniques of simulation and optimisation of dynamic models. It is accompanied by a disk with approximately 90 models and 100 influence diagrams.

[8] For illustrations of Influence Diagrams applied to defence problems see Coyle R G and M W D Alexander 'Two approaches to qualitative analysis of a nations'; drugs trade', System Dynamics Review, to appear 1997 and Coyle R G and C J Millar 'A methodology for understanding military complexity', Small Wars and Insurgencies, Vol. 7, No. 3 (Winter 1996), pp 360-378.

[9] Checkland P, System Thinking, Systems Practice, John Wiley, 1981 and Checkland P and J Scholes, Soft Systems Methodology in Action, John Wiley, 1990.

[10] Coyle R G and C B Clee, 'A semi-quantitative approach to threat assessment'. Unpublished paper.

[11] Sir Terry Burns, now the chief civil servant in the Treasury started his distinguished career as an econometrician working on the London Business School econometric model.

[12] Forrester J W, World Dynamics, Wright-Allen Press, 1971 and Meadows D H et al, The Limits to Growth, UK Edition by Earth Island Press, 1972.

[13] It is fun to observe that Heinlein's Starship Troopers (a good read if ever there was one) describes warriors clad in powered armour able to jump buildings with no more effort than one might climb a step. It seems that the US Army is starting to speculate about exo-skeletal battlefield armour capable of allowing soldiers to do just that.

[14] Macrae H, The World in 2020, London, Harper Collins, 1994.

[15] Friedman G and M Lebard, The Coming War With Japan New York, St Martins Press, 1991.

[16] Loveridge D and M Neveda, United Kingdom Technology Foresight Programme Delphi Survey, Policy Research in Science and Engineering, University of Manchester, 1995.

[17] Rhyne R, 'Whole-pattern Futures Projection using Field Anomaly Relaxation', <u>Technological Forecasting and Social Change</u>, 21, 331-360, 1981.

[18] The author and his students have found mind mapping to be useful in doing this. See the paper cited in the following note and Buzan T, <u>The Mind Map Book</u>, BBC Books, London, 1993.

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