Anticipating extreme events in the political environment

1. Introduction

Hannay (2010) raises a number of important questions in his paper on the 'New World Disorder'. This short paper focuses on the first and more general of the points made by Hannay:

> "Neither governments, nor commentators nor academics – with only a few partial exceptions – predicted the sudden end of the Cold War in 1989-90, the subsequent dissolution of the Soviet Union and the almost coincidental collapse of apartheid. Those events …. took everyone by surprise"

The same point is made regarding the judgments of experts on the outcomes of political events by Davies (2003) and Tetlock (2006), using a wide range of examples

In economics as well as politics, the track record on prediction is extremely poor by scientific standards, especially in terms of forecasting major turning points such as recessions. Fildes and Stekle (2002) provide a general survey. Purely by way of example, in August 2008, the consensus forecasts for GDP growth in 2009 were still positive in the US, UK and the main European economies. This, it need hardly be said, was less than a month before the financial crisis deepened spectacularly in the week of 15 September 2008[1]. Needless to say, the growth outcomes for 2009 were uniformly negative as the West experienced the worst recession since the 1930s.

Hayek argued that there are inherent limits to knowledge which no amount of intellect can overcome. His 1974 Nobel lecture, for example, is entitled 'The Pretence of Knowledge'. Inherent and inescapable uncertainty pervades social and economic systems. In many ways, Hayek is an intellectual precursor of modern complex systems theory (for example, Hayek 1964).

Indeed, a fundamental reason why expert judgement so frequently fails to anticipate political developments, and in particular major changes, is that the social and economic worlds *are* complex

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[1] See, for example, Figure 4 in the *Bank of England Quarterly Bulletin*, October 2008

systems in which dynamic feedback between the component parts means that the future is inherently very difficult to predict[2].

Whilst recognising the fundamental limitations of any methodology which claims to be able to predict the future in human systems, I discuss here a framework for thinking about how we might try to anticipate extreme events, major changes in the political environment which conventional ways of thinking find very hard if not impossible to deal with. It is not by any means a panacea and it is important at the outset to state that judgement still plays a crucial role.

The key point of the approach is that it enables the full implications of judgement to be explored. In particular, it might be able to help identify the conditions under which a particular set of expert judgements might lead to an extreme event, one which would be otherwise unanticipated.

2. The methodology: an overview

Kosko (1986, 1994) develops the concept of a fuzzy cognitive map, or FCM. This is a concept which draws a causal picture between the key factors in any given situation. In particular, it allows for dynamic feedback between these factors.

Kosko states that 'an FCM stands behind every op-ed article and every political speech'. He gives an example of an article by Henry Kissinger in 1982 on the strength of the Lebanese government. In the piece, Kissinger argues that an increase in Syrian control of Lebanon and an increase in PLO terrorism both reduce the strength of the Lebanese government. However, an increase in PLO terrorism reduces the Syrian control of Lebanon. There are other factors in the model which feed into these variables, but here is a very simple example of feedback. Increases either or both of two factors weakens a third factor, but an increase in one of these two factors itself weakens the other.

By setting this up as a formal, programmed model, we can explore the relative weights of these three causal influences, and identify the conditions under which, say, the Lebanese government is weakened so severely that it would probably cease to function effectively.

The approach is still reliant on judgement in a number of key ways. First, Kissinger's judgement on the causal factors involved. His view of how the three interact may or may not have been correct, and he may have omitted a fourth factor which also was important. Second, having identified the relative

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[2] Ormerod and Mounfield (200) for example show that in most Western countries the dimensionality of the system is so high that data on annual GDP growth is indistinguishable from a random series

strengths of the three linkages which would in this model bring about the collapse of the Lebanese government (if this occurs at all), we still need to form a judgement as to how likely these relative strengths are to obtain in practice.

But the point of the approach is that it makes it possible to identify conditions in which a dramatic change – the collapse of the Lebanese government – might occur which would be difficult to do by purely verbal reasoning.

3. The methodology: an illustrative example

A somewhat more complicated example using five rather than just three factors might help to illustrate this point more fully. Ormerod and Riordan[3] (2004) analyse the possibility of the political disintegration of China. Below, I discuss a version of this model, modified for ease of exposition. This version retains many of the features of the original, but its particular structure is amended for illustrative purposes.

The key to any successful model is to simplify the problem, whilst at the same time retaining the key features. The principal feature which we wish to understand is the potential evolution of political disintegration. Ormerod and Riordan assumed that this is determined by four main factors:

- the economy
- the military
- the Party
- social unrest

Obviously, in practice there may very well be connections and feedbacks between every single pair of these variables, but as in any modelling exercise we want to simplify and concentrate on the main ones.

So, for purposes of illustration, we assume that:

1. An improvement in the economy reduces both social unrest and the level of political disintegration

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[3] A political officer in the British Embassy in Beijing 1988-91

2. An increase in the strength of the military reduces social unrest, but also weakens the economy, because the military is held to be more attached to traditional, planned ways of operating the economy

3. An increase in social unrest obviously increase political disintegration, but also weakens the economy and weakens the Party

4. An increase in the strength of the Party reduces the influence of the military, and is also postulated to reduce social unrest

5. An increase in political disintegration strengthens the military and weakens the Party

At the risk of labouring the point, different assumptions could be made about the key linkages and other factors could be added. But we can now examine in more detail the possibility of an extreme event, namely the political disintegration of China.

These statements can be set out in a chart or map, which is one of the words used by Kosko in the phrase 'fuzzy cognitive map'.
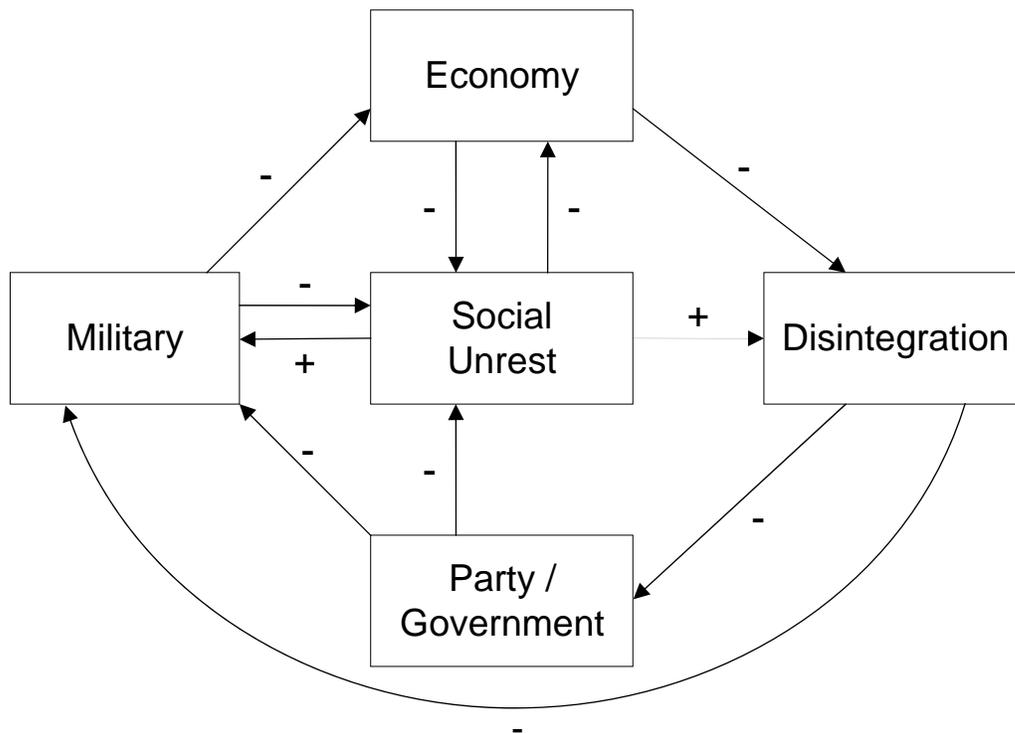

Figure 1   *Illustrative cognitive map for the political disintegration of China*

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To begin with, we keep things simple and represent each link as having equal strength (the positive connections taking the value +1 and the negative ones -1, for example). Even so, it is not straightforward to trace through the connections and see how the system evolves following a change in one of the factors.

An increase in the strength of the economy, for example, reduces both social unrest and disintegration. The reverse sequence of causation would follow if there were a negative shock to the economy. A reduction in disintegration strengthens the Party (the link between the two is posited to be negative) and weakens the influence of the military. A stronger Party in turn reduces social unrest, which then strengthens the economy. And a reduction in the influence of the military itself further strengthens the economy. However, this reduction also increases social unrest. So it seems on balance as if an improvement in the economy leads to less prospect of political disintegration, since most of the feedbacks lead in this direction, the only counter example identified is the weakening of the military leasing to an increase in social unrest.

But the feedbacks mean that it is not easy to be sure that the full implications have been discovered, that there is not some feedback which means that a shock to the economy would not be amplified but damped down in terms of its eventual implications for political disintegration. Consider, for example, a shock which weakens the influence of the military. This has the direct effect of improving the economy, but at the same time it increases social unrest, which weakens the economy and these two factors feedback on each other and reinforce the initial changes. In addition, any increase in political disintegration which follows then means that the military influence will increase. So does a weakening of the military lead to an increase in disintegration, or does the system restore itself to its initial state before the shock? Even with a simple map such as this, the existence of feedbacks, a pervasive feature of reality, mean that the consequence of changes are hard to reason through.

As is often the case in mathematics, a problem can be expressed in both geometric and algebraic ways [1] For example, Pythagoras's theorem can either be visualised as a right-angled triangle or as the algebraic expression $a^2 = b^2 + c^2$. Figure 1 is the geometric representation of the map. The concepts in the boxes represent the *level* of that variable at a point in time. The connections into it from other boxes describe how the level changes as other variables change, and connections out from it to other boxes show how changes in the variable affect the levels of other variables. In short, we have a system of linear differential equations:

$$dx/dt = Ax \qquad\qquad (1)$$

where *x* is a vector in five dimensions, *A* is a 5x5 matrix of the connections and on the right hand side *Ax* is the product of the matrix *A* and the vector *x*.

The stability properties of the system around any equilibrium solution to these equations depend in a straightforward way on the eigenvalues of the matrix A. If all the eigenvalues of A have negative real parts, equilibrium is stable. In other words, disturbances to the system away from a stable equilibrium will be absorbed. On the other hand, if all eigenvalues have positive real parts, it is an unstable equilibrium point, any initial movement away from it, no matter how small, will be amplified. The remaining case is when the real parts of some of the eigenvalues are positive and of the others negative. This makes the point a saddle point and the stable axes are in the direction of the eigenvectors corresponding to the eigenvalues with negative real part, the other eigenvectors determines the unstable axes since their corresponding eigenvalues have positive real part. In other words whether a system will absorb a disturbance or whether it will become unstable depends on the nature of the disturbance.

When the links take the values of either +1 or -1, the stability properties are indeed revealed to be complicated. One eigenvalue of *A* has a real part of 1.46, so shocks in the directions corresponding to this are not stable, they will be amplified. But the other four all have negative real parts, so that shocks here would be absorbed, and the feedbacks would prevent them from being amplified[4].

It is now time to introduce the 'fuzzy' part of the map. It might be thought that this makes analysis more complicated, but in fact it provides a practical way of judging the circumstances in which an extreme event, in this case the political disintegration of China, might happen.

Our degree of knowledge about the relative strengths of the links is low. Different experts may very well hold different views. We may feel there is more certainty about the relative strengths of the current levels of the variables – everything in the map is *relative* to everything else – but even here there may still be considerable uncertainty.

Consider for illustration the case where we do not think we have any meaningful information on either the relative strengths of the links, apart from the signs on them, or the relative initial levels of the five

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[4] When the initial conditions are not at an equilibrium point, these statements remain true provided that the initial conditions in n-dimensional space are within the attractor space of the relevant root

variables. This is the opposite extreme of the example with the map above, where we assumed we knew the values of the links with certainty.

We can solve the model numerically many times, in each case drawing the value of the links (the parameters) from a uniform random variable on $[0,1]^5$, with a similar random draw for the initial values of the variables. This enables us to form a general picture of the potential stability of the system, and in particular the stability of the political disintegration variable.

So, for example, solving the model numerically 10,000 separate times[6], we find that in 56 per cent of the cases used the system is not stable with respect to political disintegration, that initial shocks are amplified, and in 44 per cent of the cases it is stable, initial shocks being absorbed by the system.

Figure 2 gives an illustration of 20 such solutions.
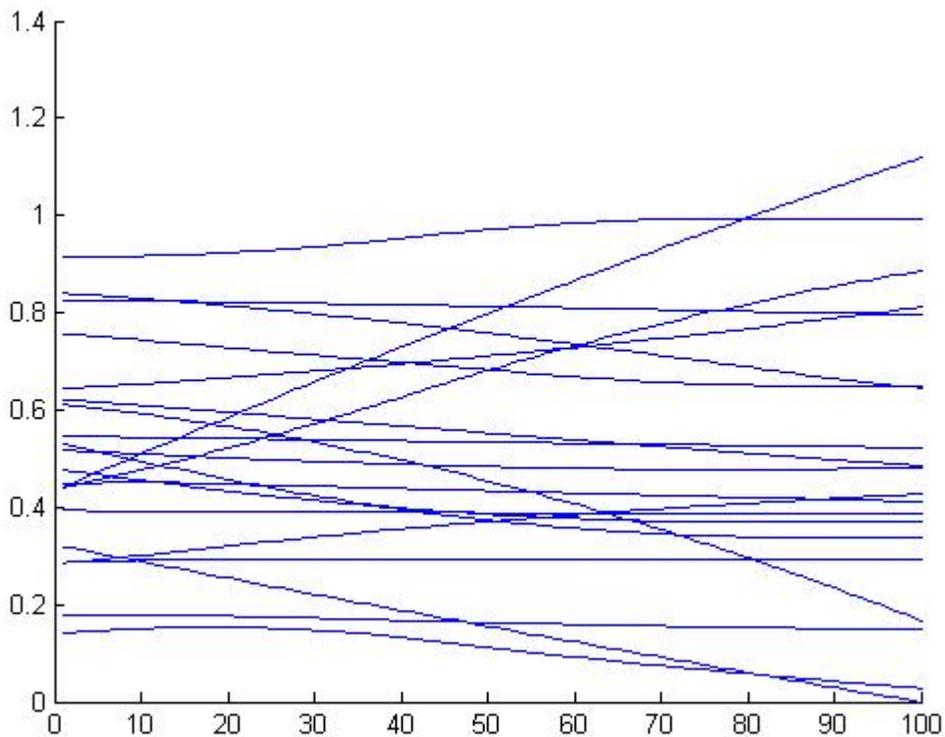
Figure 2 *Strength of political disintegration on left-hand axis, time steps in the model on the bottom axis. 20 illustrative numerical solutions for different values of the parameters and different initial values of the level of political disintegration, model is solved for 100 steps.*

At step 0 in the model, the initial starting point, the value of 'political disintegration' is set at random between 0 and 1. Each 'step' in the model represents one pass through the feedbacks to create new levels for each of the variables, given the values of the parameters (linkages). We could continue to solve the model for many more steps, but it is obvious that in some cases the value of the political disintegration variable is higher at step 100 than it is at step 0, and in others it is lower. Each solution, to repeat, involves different values of the five parameters and different initial levels of the five variables.

The next task is to identify the conditions in terms of both the relative initial levels of the variables and the relative sizes of the parameters which lead to unstable solutions in terms of political disintegration, of initial shocks being amplified.

The approach already requires judgement with respect to the factors which should be included in the map and which ones have linkages between them. Judgement can also be used to narrow the search for the conditions under which shocks can be amplified and as a result extreme events observed. In the above example, we have applied no judgement at all to the relative initial levels of the variables and the relative sizes of the parameters, both being chosen at random in the range [0, 1]. But we may very well have a view, say, on the ranges of relative initial levels of the variables, or believe that one particular link is stronger than another.

We could therefore put constraints on the initial levels and the ranges of parameters, and obtain a large number of solutions of the model with these in place.   As a simple example, suppose we thought that the impact of the economy both upon social unrest and political disintegration was always twice the levels of the set of parameters used above, then the percentage of stable solutions rises to 64 and the unstable total falls to 36 per cent.

Using a large number of solutions, we can save the results as a variable which takes the value zero, say, if the solution is stable and one of it is unstable, and also save the initial levels and the parameter values for each solution. Standard statistical techniques can then help us identify the sets of values and parameters which lead to amplification of shocks.

As has been emphasised throughout, judgment continues to play a fundamental role in this methodology, both in the construction of the map and the interpretation of the conditions in the map which lead to potentially extreme events. But the approach has the advantage of making explicit the feedbacks between the key causal factors in any particular environment. The implications of feedback rapidly become impossible to trace by purely verbal reasoning. It is the dynamic feedback, however, which creates the potential for shocks, no matter how small, to be amplified and to lead to dramatic changes.

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