Improving Behaviours in Defence Acquisition

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Abstract

Why do so many major defence contracts fail to deliver to the contractually agreed performance, time and cost requirements? This paper identifies the *conspiracy of optimism* as an important factor in the initiation of many projects. Using a combination of Game Theory and participatory workshops we formulate a theory on the conspiracy of optimism and test it experimentally. This work forms part of a culture and behaviour change initiative within Defence Acquisition involving the Ministry of Defence and many defence contractors, and was carried out directly for the Chief Scientific Adviser.

The Evolution of Co-operation and the Conspiracy of Optimism

The evolution of co-operation within a community has long been a subject of research within Game Theory. Since the work of Axelrod (1984) and later of Maynard-Smith (1982) on co-operation within and between species, Game Theory has proved useful in modelling phenomena observed in the biological world. Axelrod's note in (1984) that a spatial distribution of interacting players might also yield insight was taken up in earnest by Nowak and May (2000) who showed the rich and chaotic diversity of interactions which could emerge from a simple Prisoner's Dilemma interaction between the players, iterated many times across a spatial lattice. The paper by Brembs (1996) also discusses results using the iterated prisoner's dilemma, different strategies (such as tit for tat) for its use across a population of players, and how cooperation can emerge from such multiple interactions. More recently the work of Doebeli and Hauert (2004) has considered a simple 'snowdrift game' and looked at how this player to player interaction leads, across a population of randomly interacting players, to emergent Cooperation and Defection.

In some circumstances, co-operation may degenerate into "tacit collusion" or, in extremis, connivance. Bent Flyvbjerg (2003) has investigated the phenomena of cost overruns and delays in major public sector contracts mainly in the transport domain. He defines the "megaprojects paradox" as the fact that more and bigger projects continue to be built despite a consistently poor performance record. Flyvbjerg argues that often the cost estimates used in public debates and decision making are systematically and significantly deceptive. Politicians, business leaders, engineers and administrators need to persuade and to be persuaded that a particular project should be initiated, especially for high profile and costly projects. This may be easier if a consensus builds on issues of finance and feasibility. However such a consensus is often self-reinforcing and somewhat disconnected from reality. Flyvbjerg presents evidence to suggest that project promoters and forecasters believe that delusion is necessary to get projects started and deceptive forecasts are the sine qua non.

Flyvbjerg argues that the main causes of this "megaprojects paradox" are risk-negligence and the lack of accountability in the decision making process. Project promoters are happy to go ahead with highly risky projects as long as they themselves do not carry the risks involved and will not be personally held accountable for lack of performance. Although no-one has an interest in a risky and underperforming project *per se*, nevertheless project promoters who stand to gain from the mere existence of projects and who are often powerful movers in the early stages of project development, may have a self-serving interest in underestimating costs and overestimating benefits. Since the time from initial concept to in service date may be a decade long, it is possible to relegate concerns to a distant future; tactical, short term factors dominate.

Within the context of Defence Acquisition the phrase "Megaprojects Paradox" is replaced by the more evocative phrase "The Conspiracy of Optimism", a phrase used, for example, before the Defence Select Committee of the House of Commons (2003-2004). The phrase is not intended to convey anything illegal or even unethical; we show that it is simply that the optimistic strategy is the game theoretically rational response in a given acquisition context.

We aim to gain understanding of this "conspiracy of optimism" using a classical scientific approach: the combination of both theory and experiment. To gain theoretical understanding we have used Game Theory as our basis. This has been underpinned by experimental evidence from workshops using syndicates of real acquisition practitioners to work through a number of acquisition 'scenarios' in a controlled way. (These workshops have been run by Dstl in collaboration with the Directorate for Defence Acquisition of the Ministry of Defence).

The work discussed here is part of a "culture change" initiative within the MOD which seeks to work in partnership with Industry to produce an environment where cooperation is realistic and genuinely for the national good. The workshops themselves provided a very useful forum for encouraging acquisition practitioners to reflect on their own behaviour and its effect on others. However the results from evolutionary game theory indicate that this culture change initiative is very challenging. Lessons identified in this work should have quite general applicability beyond defence in the initiation of large contracts.

The Conspiracy of Optimism

In the UK Defence market, high technical innovation brings risks and uncertainties. The time from initial concept to delivery can be many years during which economic fluctuations, changes to specification and even changes to the strategic political and military environment can result in an end product radically different from the one originally envisaged. In addition there are the domestic political pressures of a national industrial policy and the personal ambition of individuals.

Within the defence community, we have identified the "Conspiracy of Optimism" as a potential source of poor behaviours in some acquisition programmes, whereby the

uncertainty of the acquisition environment can be exploited by both sides for short term gain. This has effects similar to the Prisoner's Dilemma, in which the rational strategy for any player is to defect from the common good; although this is very much at the expense of behaviour which would benefit the whole community. It is thus important to understand what causes a conspiracy of optimism, and how one might go about changing the environment within which the community operates in order to avoid it.

It seems very natural that Game Theory might provide valuable theoretical insight into the behaviours within Defence Acquisition. In order to do so, we first had to identify key 'pressure points' of the acquisition process where such game play might arise, and we discuss this aspect next.

The System Dynamics of Defence Acquisition

The acquisition cycle in MoD follows a process known as CADMID – Concept, Assessment, Demonstration, Manufacture, In-Service and Disposal. Two key decision points arise at the transition from Concept to Assessment, and from Assessment to Demonstration. These are known, respectively, as Initial Gate and Main Gate. The flow of capability from Concept to In-Service can be represented as a System Dynamics diagram as shown below, based on the 'rework cycle' originally identified by Pugh and Roberts and later developed by PA Consulting. This 'rework cycle' is widely accepted and its application in defence acquisition can be found in Annex E of the National Audit Office report (2003).

The amount of flow from "Capability Goals" to "Current Capabilities" depends on the Industrial Programme. At this stage there may be leakage from the pipe into the tank of "Unidentified Capability Gaps". The point at which the unidentified gaps become identified, and by whom, is a critical question which lies at the heart of trust and communication between integrated customer-supplier project teams. The obsolescence rate drains the current capabilities tank in a predictable way.

We have identified three potential game interactions corresponding to the System Dynamics of Defence Acquisition. These we call the 'DEC Game', the 'Bidding Game' and the 'Coming Clean Game'.

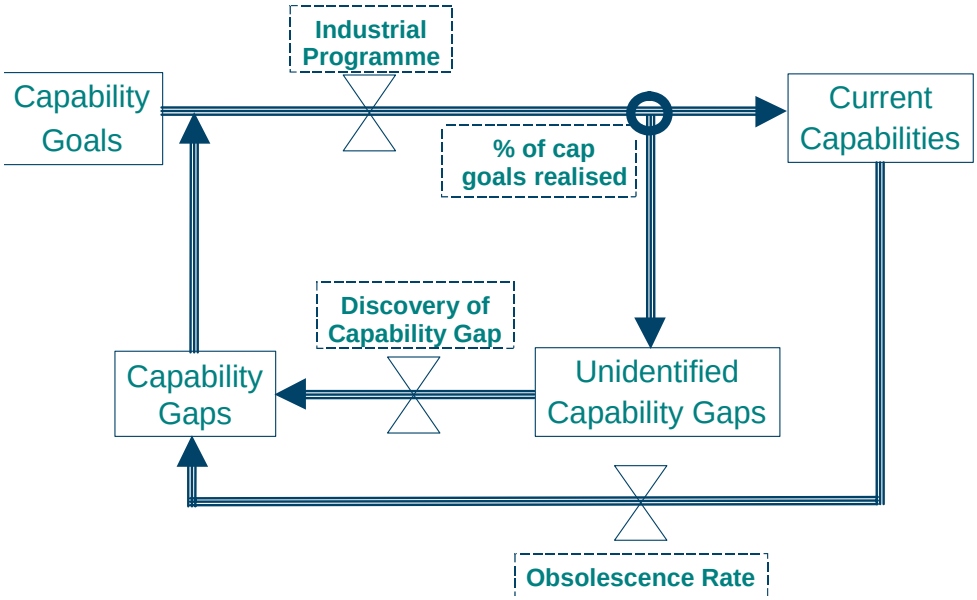
- The DEC Game relates to the strategies adopted by the Directors of Equipment Capability (DECs). The DECs are the MOD customers for capability, and they compete among themselves for budget space in the overall Equipment Plan (EP).

- The Bidding Game arises when companies compete to win contracts and MOD must ensure best value for money, subject to political constraints.

- The Coming Clean Game arises when projects go less well than expected and this has to be resolved in some way. At what stage should a project manager

announce the bad news to the wider world? This may well depend on the strategies employed by rival project leaders.

Figure 1: The System Dynamics of Defence Acquisition.



Having scoped the problem in this way, we chose to focus on a simplified Bidding Game - the interaction between the DECs (as the MOD customer for defence capability) and Industry as the supplier, in a simplified 2x2 game in order to illustrate the dominant first order dynamics.

Games between MOD and Industry

In the very broadest terms both MOD and Industry make a choice between a realistic strategy or an optimistic strategy when it comes to estimates of performance, time and cost for a given project. This was a common thread emerging during the course of a number of structured interviews with representatives from MOD and from Industry. The four different combinations of strategies are[1]:

- MOD optimistic and Industry optimistic
- MOD optimistic and Industry realistic
- MOD realistic and Industry optimistic
- MOD realistic and Industry realistic

We constructed a two player game payoff matrix corresponding to the interaction between MOD (specifically, the sponsor of the particular equipment acquisition proposal under consideration) and Industry. The game play is about how to arrive at a cost estimate from initial entry into the Equipment Plan (EP) to Main Gate. Each player may

[1] Examples of each of these broad strategy combinations occurring do exist.

choose between one of two strategies: either to be optimistic or to be realistic in their cost estimate.

Three main factors appear to influence the choice of strategy at this stage of the acquisition process:

- The desire by MOD and (to a possibly lesser extent) Industry that the programme should gain a place in the EP. This is influenced both by the absolute cost estimate and by the perceived value-for-money (VFM) at this early stage.
- The desire by Industry (i.e. individual companies) to win the bid over their rivals.
- The desire by both MOD and Industry that the position of the programme in the EP should not be jeopardised following the bidding stage. This is influenced by any difference between the MOD's budgeted provision and the size of the bid and by any changed perceptions of VFM post-bid.

Table 1 below indicates (in words) how these factors translate into perceived pay-offs to each player in the event of a particular combination of strategies being chosen. The symbols +/– are used to identify positive and negative factors.

Table 1: Perceived Pay-Offs to MOD and Industry

	MOD budgets optimistically	MOD budgets realistically
Industry bids optimistically	MOD • **Eases entry to EP (+)** • **Expectation of good VFM (+)** • **No budgetary problems post-bid (+)** Industry • **Eases entry to EP (+)** • **Wins bid over rivals (+)** • **Keeps project in EP (+)**	MOD • **Difficult entry to EP (–)** • **Perceived bad VFM pre-bid (–)** • **Positive budgetary implications post-bid (+)** • **Perception of good VFM post-bid (+)** Industry • **Difficult entry to EP (–)** • **Wins bid over rivals (+)** • **Keeps project in EP (+)**
Industry bids realistically	MOD • **Eases entry to EP (+)** • **Budgetary problems post-bid (–)** • **Danger to continuation of project (–)** Industry • **Eases entry to EP (+)** • **May lose bid to rivals (–)** • **Danger to continuation of project (–)**	MOD • **Difficult entry to EP (–)** • **Perceived bad VFM (–)** • **No budgetary problems post-bid (+)** Industry • **Difficult entry to EP (–)** • **May lose bid to rivals (–)** • **Low risk to continuation of project (+)**

The table demonstrates that it is to the advantage of both sides to adopt an optimistic strategy. Any other combination of strategies has some unattractive pay-offs for both sides:

- A realistic budgeting strategy by MOD reduces the chance of getting the programme into the EP and reduces perception of VFM.
- A realistic bidding strategy by any of the competing companies risks loss of the contract to rivals. And, even if a realistic bid wins the day, there are problems if MOD has budgeted optimistically, since the project is immediately seen to be under-funded in the EP. This in turn either puts the project itself in danger or demands painful readjustments elsewhere in the EP.

Nevertheless, although the pressures on both players push them towards an optimistic budgeting / optimistic bidding strategy, there are examples where this is not actually observed in practice. The most obvious cases are procurements that are virtually off-the-shelf, where project time and cost forecasts were closely adhered to. Self-evidently, if well-attested evidence on costs and technical risks exists, then the scope for optimism (whether deluding oneself or others or both) is correspondingly constrained and is balanced by a credibility factor. By contrast, projects characterised by more unknowns

provide a greater degree of uncertainty in cost (and time) estimation, which natural tendencies to optimism can exploit.

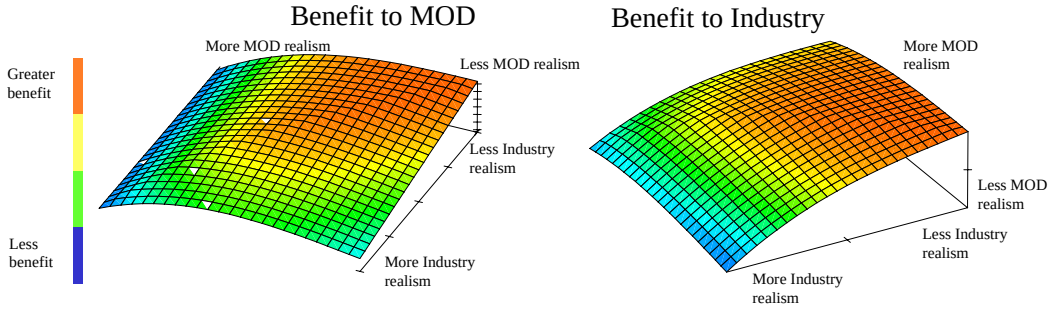
A quantified payoff matrix

Formally Table 1 is not yet a "game" in the sense of Game Theory. For this to happen, it is necessary to make the pay-off entries numerical.
To illustrate the points made thus far, we constructed numerical pay-off functions which reflected these factors, by looking at the following three stages:

- Getting into the EP
- Winning the bid
- Staying in the EP

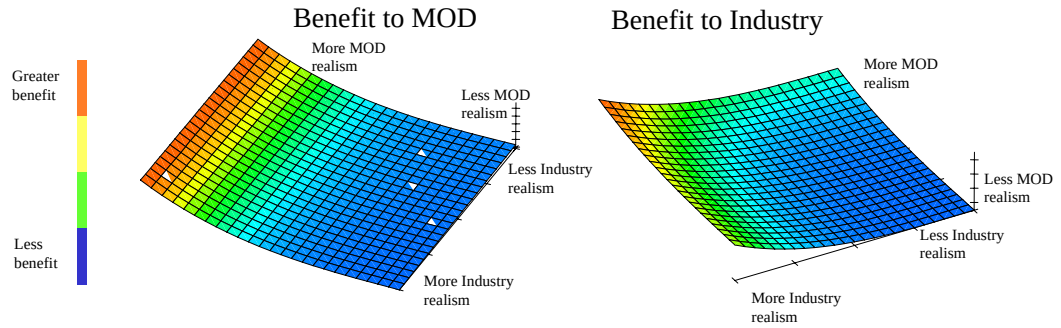
For more information on the mathematics of this process, see (Gardener and Moffat, 2006).
The information from the resultant payoff matrices can be presented graphically. For a project with a greater degree of uncertainty, the benefit to MOD and Industry of any given pair of strategies is pictured below. The left graph represents the advantage to MOD over a range of MOD/Industry possible strategies. Similarly the right graph represents Industry's perception of the same range of strategies. Both players prefer the red region to the yellow or green or blue region. What is clear is that an optimistic strategy is the most rational strategy for each party.

Figure 2: Pay-off to MOD and Industry in a situation of high uncertainty



When a project has a greater degree of certainty, then any rational strategy is much more constrained. The diagram below represents a situation where much better appreciation of costs and risks leads to less room for optimism. The red area for MOD means that it is very constrained to remain realistic, irrespective of what Industry may choose to do. The red area for Industry indicates that realism is its only strategy since this avoids the deep blue and, if MOD reciprocates realistically, it will achieve maximal benefit.

Figure 3: Pay off to MOD and Industry in situation of low uncertainty



The Community of Players

In all of this work so far, there has been no distinction between the strategy the player adopts and his or her predispositions. However in real life, we know that people are subject to bias, or to imperfect perception of another player's strategy. In some recent work, such as (Heifetz, Shannon and Spiegel, 2004) there has been an attempt to capture these effects mathematically within the general structure of a community of players interacting with each other. The basic idea is that a player's perception of his own pay-off may be different to his actual pay-off. The difference between perception and reality depends on a player's "type" which may be optimistic or otherwise. Furthermore, if a player is perceived to be achieving a good payoff, others close enough to see will copy the successful type. In this way a type propagates through the community of players at the expense of other types. If a single type becomes evolutionarily stable in certain models then by looking at the distance between the successful type and the "realistic type" one may measure how "far from reality" the system naturally falls.

The evolution of types depends on the lower level game between pairs of players. Given a pair of players, each with an allocated type, their chosen strategies will depend on three things: their type, environmental factors and their level of interest in the success or failure of the other player. Their type determines how correctly they estimate their pay-offs; the environmental factor determines a bound on the level of optimism that is sustainable; and the level of interest in the other player's success is given by the "externality factor" which works either to reinforce optimism or to block it.

The upper level game is then a 'types game' where the types of the players adjust over time during a series of interactions across the population of players, and iterate towards some final end state for the population.

In applying these insights to Defence Acquisition, our game theory work discussed earlier indicated that a conspiracy of optimism was a rational response to the acquisition context, and was fuelled by high uncertainty over the risks and cost associated with individual acquisition projects. These theoretical results were underpinned and confirmed

by a set of workshops in which high level decision-makers from industry and the MoD were asked to step through a number of such acquisition 'scenarios' and to discuss their perceptions and resultant behaviours (Williams, Gardener and Moffat, 2006).

In further analysing this conspiracy of optimism the question arises as to how tenacious this conspiracy is when applied to a community of such players (as they become when we resolve the system at a more detailed level). We have thus conducted further analysis to get some insight into this question (Moffat, Gardener, Tilley et al, 2006).
From this process we were able to indicate a number of possible ways in which the process could be improved, and desirable behaviours encouraged, to the benefit of the MoD.

Conclusions

The origins and components of the 'conspiracy of optimism' which tends to characterise the bidding stages of defence acquisition projects have been described in game theoretic language and simple, illustrative expressions have been developed to reinforce the points in a quantitative fashion. Discussion of how pay-offs may be changed to influence behaviour in desirable directions has identified *uncertainty* as a key factor. Two experimental syndicate sessions at high level have provided experimental evidence supporting the theory; the experiments themselves also contributing to the culture change initiative intended to encourage improved behaviours in acquisition.

We have, in addition, extended this to an evolutionary game theory model which is illustrative of the community of 'players' in the acquisition system. It begins to incorporate human characteristics ('types') which are longer term biases distinct from strategies. We have shown that this complex and adaptive system contains both thresholds (critical values) and regions of indeterminate behaviour.

By representing the system in this way, we have shown that it is vulnerable to the 'Invasion of Optimism', and to ensure realistic strategies, one must constrain the types of the players. This has immediate implications and raises significant questions for the real system:

- A conspiracy of optimism is much more likely, indeed one might say evolutionarily natural, in a situation of high uncertainty.
- Even in a situation with relatively little uncertainty, a conspiracy of optimism must be managed by constraining the "character types" of decision makers, particularly those in industry.
- How should a government department such as MoD influence industry in order to guarantee appropriate "character types"?
- We have taken a high level view of uncertainty. But uncertainty is itself uncertain. In what ways can uncertainty be better understood? Does better understanding of uncertainty lead to better project control and better project performance?
- What measures can be taken to render the system less vulnerable to the invasion of optimism?

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