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Dynamic cost benefit analysis for mental health reform

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Abstract

Purpose – This paper aims to describe the application of system dynamics to enhance traditional cost benefit analysis (CBA) in planning a significant expansion of therapy capacity for mental health treatment in the UK. The aim of the initiative is to benefit the health of individuals, reduce costs to society and the exchequer and increase employment.

Design/methodology/approach – The paper describes a conventional CBA and comments on its merits and limitations. The development and use of a system dynamics model of the situation is then described, together with how this complements and supports the conventional analysis and its outcome.

Findings – By focussing analysis on the dynamics of people flows over time, simulation is shown to assist understanding of the issue and its potential benefits. The numbers of patients expected to benefit is shown to depend on the treatment capacity, on the sources of people presenting, the number and type of treatment channels and their parameters, the success of treatment, the provision for patients moving between treatment channels, the dynamics of the labour market and employment opportunities.

Originality/value – The paper is totally original and has provided decision support to a large investment on which implementation has begun. The overall methodological conclusion is that dynamic factors are often left out of CBA because they cause too much complexity for decision makers, whereas system dynamics allows these factors to be included without masking the clarity of the case. The paper suggests that CBA and system dynamics are very complementary.

Keywords Cost benefit analysis, Mental health services, Cognition

Paper type Case study

Introduction

There have been numerous applications of system dynamics for model-based management in health in recent years. These have covered public health and health reform (Hirsch *et al.*, 2005; Homer *et al.*, 2004, 2006, 2008; Homer and Hirsch, 2006a, b; Jones *et al.*, 2006; Milstein *et al.*, 2007), capacity planning (Lacey, 2005; Lane *et al.*, 2000; Royston *et al.*, 1999; Taylor and Dangerfield, 2005), older people's services (Wolstenholme, 1993, 1996, 1999) and disease management (Dangerfield, 1999).

In particular, the authors of this paper have specialised in patient flow modelling, both at a national level to influence government policy on delayed hospital discharges

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and to assist local heath and social care communities in the UK to interpret and apply national policy frameworks for older people (Wolstenholme *et al.*, 2007a, 2008a; The NHS Confederation, 2005) and for mental health reform (Wolstenholme *et al.*, 2006, 2007b, 2008b).

This paper presents an example of the application of system dynamics modelling to support central government decision making on large-scale investment in therapies for treating mental health. It specifically focuses on the value that such modelling can add to cost benefit analysis (CBA).

A CBA is first described for planning the supply of new mental health treatments across the UK aimed at improving the quality of life for patients increasing the labour force and saving unemployment benefit payments (Observer Leader, 2006). This Improved Access to Psychological Therapies (IAPT) programme centred on detailed calculation of the costs and benefits *per capita* after full implementation of plans and then converting these to gross benefits by making assumptions about the numbers of patients benefitting. The original analysis was later broadened under the guidance of a wide Expert Reference Group, which examined and tested a range of assumptions in two trail sites. This later analysis will be referred to here as the enhanced CBA.

The development of a dynamic analysis to both explore the original hypothesis and to assist the Expert Reference Group is then explained. This subsumes the per capita coefficients of the conventional analysis into a patient flow perspective of treatment involving, treatment time, where patients originate from and where patients go after treatment. It also includes a therapist flow perspective involving their recruitment, training, case loads and the provision of multiple service channels. In this way, the modelling provides a platform for examining the transition of the plans to full implementation over time and the sensitivity of the analysis to many different assumptions about the demand and provision of services.

The original cost benefit hypothesis

In early 2006, plans were developed in the UK to assess the benefit of making cognitive behavioural therapy (CBT), as recommended by the National Institute for Clinical Excellence (NICE, 2004), widely available to treat depression and chronic anxiety. The plan suggested that investing £600 million in 10,000 therapists would enable the treatment/recovery of 800,000 people per year and create benefits to the UK exchequer and society of over £2 billion per year when fully established. The benefits would arise from extra output, reduced absenteeism, extra quality of life years, savings in medical costs associated with these conditions, increased tax payments and savings in invalidity benefits. It was known that there was an accrued backlog of around one million people on incapacity benefit (IB) due to mental illness and the CBA assumed that this level of investment and numbers treated might be expected to eliminate the backlog in seven years.

Per capita benefit coefficients were derived based on well-researched sources, averaged over six classes of mental health condition and taking account of spontaneous recovery rates. Cost coefficients were derived based on the costs of employing the number of therapists required to treat this number of people per year based on the number of people each therapist might treat. The overall net cost and benefit coefficients were then multiplied by estimates of the number of people whom it was thought might be

possible to treat with CBT to give the annual return achievable in steady state, once the new treatment system was established.

The cost benefit analysis was thorough in its derivations of the *per capita* costs and benefits of the plan. However, three issues were identified for further analysis. First, the number of people expected to benefit. No detailed analysis was included of where the people would come from and how they would progress back to work after treatment. Second, no detailed account was taken of the treatment parameters – that is the length of treatment, success rate and drop our rate. Third, the analysis was only carried out in respect of the situation after full implementation of the plan in seven years time. No account was taken of the transition to full implementation covering the build up of treatment capacity by the recruitment and training of therapists.

The enhanced CBA

In order to address the issues raised about the original CBA, a wide group of national experts and stakeholders were brought together in an Expert Reference Group and two trial sites set up to field test the approach. These groups were responsible for broadening the assumptions of the analysis.

In particular, these groups defined an alternative service configuration capable of treating 900,000 people per year. This required only 6,800 therapists, 49 days treatment time and used a 50 per cent success rate based on the field trial findings.

They also introduced the idea of having a mixed rather than single programme with two treatment channels using different types of therapists. The first channel would contain a high-intensity programme for those with greater need and the second a low-intensity programme for those with lesser needs.

A further element of the enhanced CBA was to try to assess how the programme would impact the labour market and other back to work initiatives.

The system dynamics model

The system dynamics model initially incorporated the derivation of the cost and benefit coefficients per person as in the CBA. The idea of this was to demonstrate that the derivations were reproducible in a dynamic model and to allow changes in assumptions within these calculations. However, as the project developed the focus of the Expert Reference Group centred more and more on assumptions about the numbers of people who might be treated, based on the flow of these people into and out of the proposed new service and the availability of therapy capacity. This trend resulted eventually in the *per capita* cost and benefit coefficients being fixed within the model to simplify the overall structure.

Figure 1 shows the system dynamics perspective broken down into three sectors based on both the original and enhanced CBAs. These are the treatment and recovery sector – the dynamics of where people flow to, the labour market sector – the dynamics of where people flow from and the therapist sector – the dynamics of therapist capacity which acts as a constraint on treatment.

The treatment and recovery sector allows for assumptions about waiting for treatment, length of treatment, drop out rates, recovery rates, employment rates (dependent on jobs available) and relapse rates.

The labour market sector allows for assumptions about the labour market and the flows of people into the new treatment system from those with mental health conditions in employment, from those out of work and claiming IB, both short- and long-term.

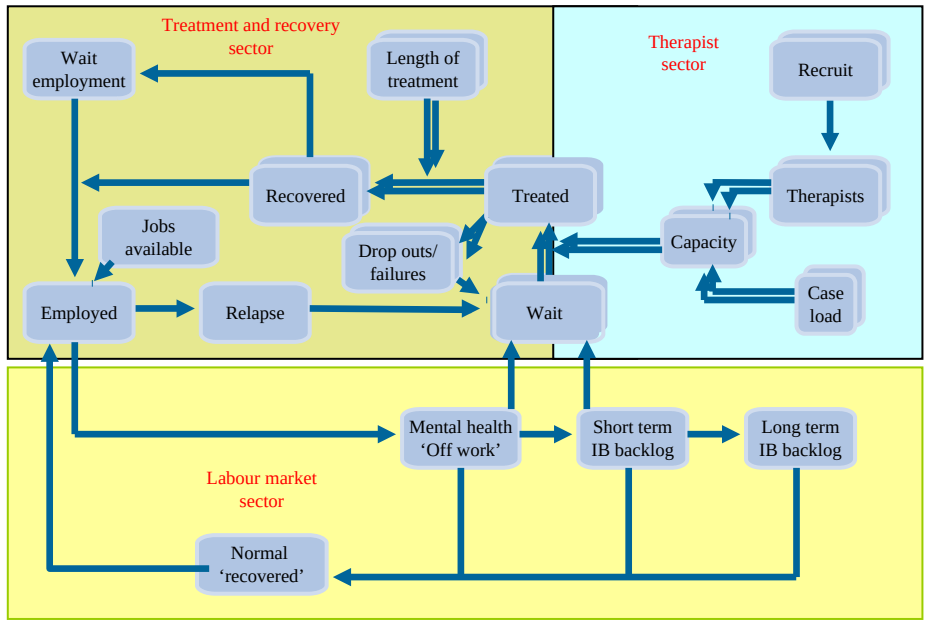

Figure 1.
Overview of the structure of the system dynamics model

The therapist sector allows for assumptions about therapist recruitment, therapist leaving and case load.

Each of these sectors raised interconnected issues.

Issues raised in the treatment and recovery sector

The main issues raised were:

- The distinction between treatment, recovery and employment. Although it was stated in the original CBA that there was a 30 per cent failure rate associated with CBT, it was not clear whether it was being suggested that 2.5 million people would be treated to achieve 800,000 recovered OR 800,000 would be treated to achieve 270,000 recovered. The benefits expressed in the CBA were based on 800,000 people recovered and back in employment, but the feasibility of using 10,000 therapists to treat 2.75 million people was questionable since the length of treatment achievable would be less than the minimum considered clinically feasible.
- The original CBA assumed that every one treated had a job to return to, whereas the perspective here suggested that some people (varying with location) might not have a job to return to and that job availability and the stigma attached to mental health treatment would conspire against people in seeking a return to work.
- The original CBA did not allow for any relapses after treatment.
- The enhanced CBA did not allow for people failing the low-intensity treatment and "stepping up" afterwards receiving the high-intensity treatment.

Issues raised in the labour market sector

The main issues raised here were:

- What would be the candidate population for the new treatment and how many people would be available for treatment? Although it was known that there was an accrued backlog of around 1 million people on IB due to mental illness with inputs and outputs of around 260,000 per year, there was limited data available about the overall flow of people with mental health problems through the labour market. For example, the number of people off work due to mental illness. Figure 2 shows a more general structure of the labour market created by one of the trial sites from which the states of Figure 1 were derived.
- How did people recover from mental illness at present? The modelling led to thinking about and determining estimates for how long people were out of work due to mental illness and their rate of return. This led to an explicit statement that the main benefit of the new system would be, not only to increase the return to work of many more people than at present, but also to speed up their rate of return. The modelling also led to the thinking that there were really two states of people claiming invalidity benefit. A short-term cohort who recovered either without treatment of from the current limited current NHS provision and a long-term cohort whose chances of returning to work diminished the longer they were in this state.
- The link to other initiatives for assisting people to return to work from both physical and mental illness. It became clear that there were overlaps between the proposed use of CBT and numerous other central and local initiatives to help people back to work. Clearly, any case for funding CBT needed to explain how it complimented these other ideas.

Issues raised in the therapists sector

Issues raised in the therapists sector were:

- The number of therapists needed in steady state? With two service channels, it was hypothesised that fewer therapists would be needed overall for a mixed programme than for a single programme.

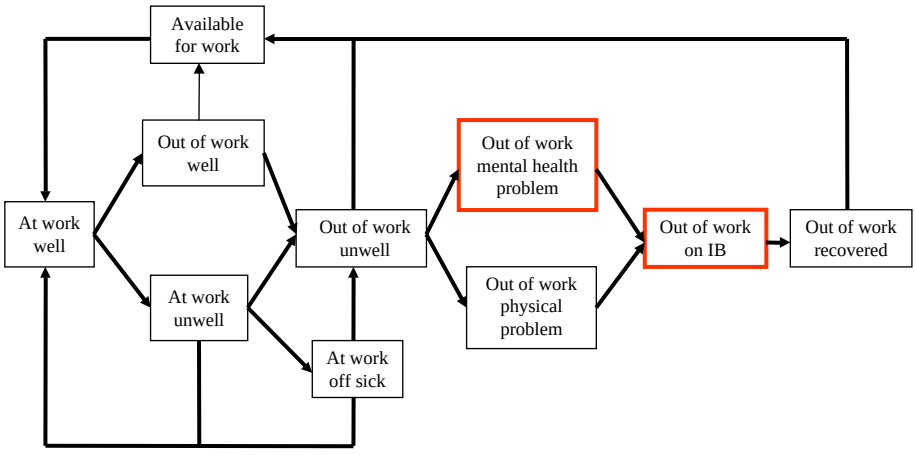

Figure 2.
A broader overview of the labour market

- The build up of therapist capacity. The original CBA focussed mainly on the steady-state situation after full implementation of the new system, but suggested that there would need to be a progressive increase in therapist recruitment and training from two sources over a seven-year period. The modelling added to this thinking by considering therapist turnover and by being able to test alternative training policies.
- The number of therapists needed beyond seven years once the accrued backlog of people in the labour market had been drawn down and a new equilibrium had been established.

Model experiments

The range of experiments carried out initially with the model fell into three groups and in each experiment the model was run for seven years in days. The groups were:

(1) Running the model to show the benefits when the programme was fully operational as a comparison with the original CBA for both single and for the mixed channel thinking, with and without step up from the low- to high-intensity channels for some of those who failed to respond to the low-intensity treatment. These runs assumed all therapists to be in place and a constant number of people per year presenting for treatment.

(2) Running the model to show a phased build up to therapist capacity over seven years for mixed treatments, again with and without step up and for a progressive drawdown of people from two states of the labour market ("off work with mental health conditions" and those people receiving "short-term invalidity benefit"). Assumptions were made here about the flow of people through the labour market. These data covered the length of time spent out of work due to mental illness and the current rates of return to work.

(3) Testing the sensitivity of the new programme to lapses after treatment and job availability.

Results from running experiments to show the benefits of the "fully operational" CBT programme

A single programme

Table I shows the number of therapists, number of people treated per annum, number of people recovered per annum, length of treatment in days and the overall net benefits per annum in £ billion to be expected from a fully operational single programme.

The first column in Table I is a direct validity comparison with the basic CBA and shows 10,000 therapists being used to treat 2.75 million people per year with a 30 per

Table I. Model results for a single programme when established

	Base run for comparison with the original CBA	Alternative 1	Alternative 2
Therapists	10,000	10,000	6,800
Numbers treated per annum	2,750,000	800,000	900,000
Numbers recovered per annum	800,000	270,000	450,000
Length of treatment in days	44	77	49
Net benefits per annum (£ billion)	2.27 (infeasible)	0.56	0.8

cent success rate, giving net benefits of £2.27 billion. As indicated earlier, this situation was considered to be somewhat infeasible since a total treatment time of 44 days is too short given the number of sessions of treatment and the associated assimilation time needed for CBT.

The second column of Table I (alternative 1) shows the much more feasible interpretation of 10,000 therapists being used to treat 800,000 people per year with a 30 per cent success rate. This result uses a minimum feasible figure for the average treatment rate of 77 days, but since only 270,000 people per year recover the net benefits per year are only 25 per cent of those indicated by the original CBA.

A better return is indicated by column 3 in Table I which gives results for the alternative service design in the enhanced CBA capable of treating 900,000 people per year.

A mixed programme

Table II shows the results for a mixed programme when fully established for alternatives 1 and 2 from Figure 1, for both "no step up" and "step up" between the programmes. These results assume a 50/50 spilt of people between the high- and low-intensity programmes and a 50 per cent failure rate from both the programmes.

Column 1 of Table II shows alternative 1 using a high-intensity channel with 77-day treatment time and a low-intensity channel with a 25-day treatment time. This configuration can treat 800,000 people per year and requires 4,700 high-intensity therapists and 1,500 low-intensity therapists. The net benefits per year of this configuration are double those from the single programme version of alternative 1 due to a higher assumed success rate and fewer therapists needed in total (6,200 compared with 10,000).

Column 2 of Table II again shows results for the mixed programme version of alternative 1, but this time assuming that people failing the low-intensity treatment will step up to the high-intensity channel. This effectively means treating 200,000 more people per year in the high-intensity programme – 1 million in total per year rather than 800,000. So, this configuration means that 6,400 high-intensity therapists are needed in total not 4,700. However, the net benefits per year are increased beyond the costs because more people receive treatment and recover.

Column 3 of Table II shows the results from alternative 2 using a high-intensity channel with 49-day treatment time and a low-intensity channel with a 25-day treatment time. This configuration can treat 900,000 people per year and requires fewer therapists in total compared with alternative 1 (3,000 high-intensity and 1,500

	Alternative 1 no step up	Alternative 1 step up	Alternative 2 no step up	Alternative 2 step up
Therapists – high/low intensity (total)	4,700/1,500 (6,200)	6,400/1,500 (7,900)	3,000/1,500 (4,500)	4,500/1,500 (6,000)
Numbers treated per annum	800,000	1,000,000	900,000	1,125,000
Numbers recovered per annum	400,000	500,000	450,000	562,500
Length of treatment (high/low intensity in days)	77/25	77/25	49/25	49/25
Benefits per annum (£ billions)	1.0	1.2	1.1	1.3

Table II. Model results for a mixed programme when established

low-intensity therapists), giving improved net benefits per year over both the single programme version of alternative 2 and the mixed programme version of alternative 1.

Column 4 of Table II shows the results assuming a step up of failures from the low-intensity channel to the high-intensity channel. This means treating 225,000 more people in the programme per year – 1.125 million in total rather than 900,000. So, this configuration means that 4,500 high-intensity therapists are needed rather than 3,000. However, the net benefits are again increased because more people receive treatment and recover.

Overall, the mixed programme results would appear to give higher benefits than the single programmes and the use of "step up" gives higher net benefits than "no step up".

Summary of first insights from the system dynamics model

Although the system dynamics model was not really used as a dynamic model at this stage the stock-flow thinking of the model surfaced some interesting insights:

- *The differentiation between people treated and recovered.* The clarification here indicated that the original net benefit claims of the CBA were unachievable since to attain 800,000 recovered people per year meant treating an unfeasibly high number of people per year.

  The mixed programme provides higher returns than the single programme and requires fewer therapists.

- *Step up.* The consequences of allowing step up between channels would require 50 per cent more high-intensity therapists.

Results from running experiments to show the benefits of a phased build up to full operation of the CBT programme over seven years

This section of the work used the system dynamics model as a dynamic model. Table II shows a similar output summary of results to Table I. However, although the number of therapists is that achieved at the end of seven years, the figures for the number of people treated per annum, the number of people recovered per annum and the overall net benefits per annum in £ billion are the average figures over seven years.

These results are again presented with and without step up and, additionally, this time for a progressive drawdown of people from two states of the labour market ("off work with mental health conditions" and those people receiving "short-term invalidity benefit"). The final three rows show the percentage reduction in these stocks for each situation modelled.

Speculative assumptions were made here by the authors about the flow of people through the labour market to provide background assistance to the Expert Group. These data covered the length of time spent out of work due to mental illness and the current rates of return to work. It was assumed that the "mental health off work" stock was 1.25 million people and had an inflow per year of 1 million people. Also that the "short-term IB" stock was 0.8 million people and had an inflow of 260,000 people per year. The calculations for these drawdown figures is a truly dynamic calculation since the drawdown is in addition to the underlying normal throughputs of the stocks.

An important general point about the results of Table III is that the overall net benefits per year of the plan appear to be reduced relative to the fully operational situation, but this is due to the progressive build up of capacity.

	Alternative 1 no step up	Alternative 1 step up	Alternative 2 no step up	Alternative 2 step up
Therapists – high/low intensity (total)	4,700/1,500 (6,200)	6,400/1,500 (7,900)	3,000/1,500 (4,500)	4,500/1,500 (6,000)
Average numbers treated per annum	530,000	640,000	628,000	760,000
Average numbers recovered per annum	260,000	320,000	314,000	380,000
Length of treatment (high/low intensity in days)	77/25	77/25	49/25	49/25
Benefits per annum (£ billions)	0.7	0.9	0.8	1.0
Change in stock of "mental health off work sick" over seven years (%)	50	50	58	58
Change in stock of "short-term IB backlog" over seven years (%)	−15	−33	−15	−33
Change in stock of "long-term IB backlog" over seven years (%)	−36	−36	−42	−42

Table III.
Model results for a mixed programme phased in over seven years and drawdown of people from the labour market

However, before discussing the Table III results in detail, it is useful to relate some of the dynamic factors underpinning them. Figures 3 and 4 show example model results supporting the results summarised in Table III. Figure 3 shows an example output of the progressive build up of high- and low-therapy capacity and people in treatment over seven years. Figure 4 shows the corresponding drawdown of the accrued labour market stocks over this period.

These graphs highlight two interesting counterintuitive factors.

The first is that the "real" short-term IB backlog is not just the one shown in Figure 1, but the sum of this and those people failing to respond to CBT treatment. (Note that the people dropping out and failing to respond cannot be placed back in the short-term IB stock because this would assume that they could be treated again.) Consequently, and particularly in the case of no step up, as was the situation in Figure 4, the real total short-term IB backlog will not be drawn down as fast as linear, static thinking might predict. It will also start to rise in periods when therapy capacity is fully utilised as shown in Figure 3.

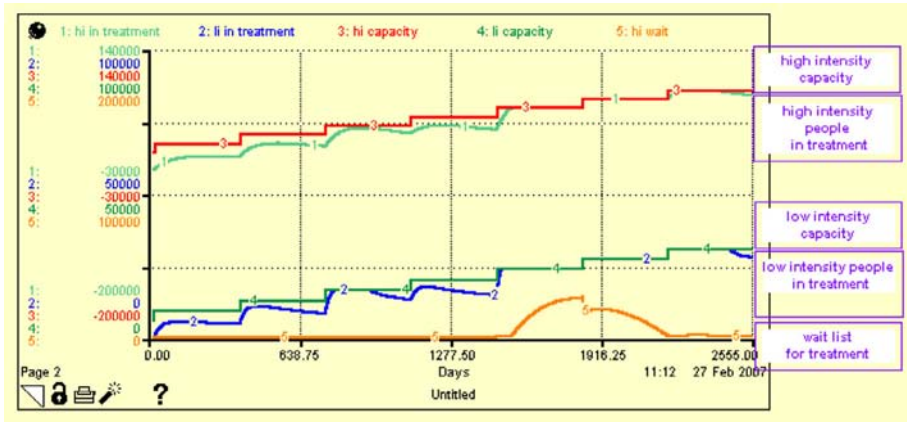

Figure 3.
Example model output showing the progressive build up of high- and low-therapist capacity, people in treatment over seven years and the wait list for treatment

Figure 4.
Example model output showing the drawdown of labour market accrued backlogs over seven years

The second factor is that although there is no direct drawdown from the long-term IB backlog, this stock will decline as an indirect consequence of the drawdown of the short-term IB stock. Since this is upstream of the long-term stock, drawdown of it will reduce the flow into the long-term stock.

Returning to Table III, column 1 shows the alternative 1 mixed model results with "no step up". The "mental health off work sick" backlog is reduced by 50 per cent, the short-term IB backlog by 15 per cent and by default the long-term IB backlog is reduced by 30 per cent.

Column 2 of Table III shows the same results as column 1, but with "step up". Here, the impact on the "short-term IB" backlog is doubled, as more people are treated per year rather than placed back into the backlog (but obviously using more therapists).

Column 3 of Table III shows the alternative 2 mixed model results with "no step up". Here, short-term IB backlog reductions are increased because this configuration allows more people to be treated than in the alternative 1 mixed model and introducing step up (column 4) permits even greater backlog reductions and more people to be treated per year (but again obviously using more therapists).

Although these results are not directly comparable with the CBA because two treatment channels and two backlogs are modelled and hence a greater total treatment rate used, it would seem that the impact of the plan on the labour market would take some time to show significant results. One reason for this is the treatment rate must not only be big enough to have an impact on the backlogs, but also on the underlying inflow rates into the backlogs. In health terms, it must be large enough to cope with both prevalence and incidence. In system dynamics terms, it must be large enough to cope with both stock correction and inertia.

Summary of further insights from the system dynamics model

The simulation results from the system dynamics model created further insights about the overall plan in addition to those given earlier:

- The annual net benefits of the plan would obviously build up progressively and on average over the seven years be less than when the programme was fully established.

- The results from the dynamic model give an indication of the time it would take to draw down the estimated accrues backlogs of people out of work in the labour market. Whilst very dependent on the assumptions about the normal build up and return to work from these stocks, the results show that significant impact could be made on the backlogs by the proposed programme. However, the impact is dependent on building sufficient therapy capacity to deal with people stepping up between treatment channels and on monitoring the true backlog, which includes those people failing treatment.
- It would appear very important to run all other return to work initiatives along side the new CBT programme.
- Structurally, the modelling suggested that the best strategy would be to reduce the expensive backlogs of claimants first and then to draw down people onto IAPT from as far "upstream" as possible in the mental health/workforce chain.
- Step up of from the low- to high-intensity programmes for those people failing the low-intensity programme gives a bigger impact in reducing the accrued labour market backlogs of people off work sick and on short-term IB benefits, but requires more therapists.
- The long-term IB backlog would beneficially decline as an indirect consequence of the programme on drawdown of the short-term IB stock.
- Care should be taken to manage therapy capacity closely when the IB backlog was significantly reduced, to match long-term capacity to the underlying flow into the backlog.

Sensitivity results

All of the foregoing results assume that all people recovering as a result of the new programme would have no relapses and return to employment. The system dynamics model allowed the impact of these factors to be tested. Whilst such results were speculative they emphasised that monitoring relapses and new job creation would be key factors to support the aims of the programme.

Conclusions on the content of the CBA

The use of system dynamics confirmed that the proposed IAPT programme had the potential to make an enormous financial net benefit to the UK economy in addition to the wellness benefits to individuals. At the time of writing, recruitment of therapists has begun. Financial benefits are being demonstrated in the trial sites and are beginning to be realised in the first wave of implementation across the UK. Taking in account the flows of people through multiple treatment channels and the labour market at local levels has allowed better understanding of assumptions and has prompted actions, particularly job-creation schemes, to counter unintended consequences.

Conclusions on the use of system dynamics to supplement CBA

It was shown possible to quickly develop a dynamic model to supplement the CBA which allows analysis and understanding to develop well beyond the CBA.

The characteristic of traditional CBA is that enormous technical and clinical research effort is put into determining the cost and benefit coefficients, but then these are often multiplied by singular estimates of the underlying resource flows.

A characteristic of system dynamics is that an enormous effort is put into studying the resource flow structure of a problem, but often little effort in converting these flows to financial outputs.

It is suggested here that dynamic CBA combines the best of both worlds by combining these characteristics. System dynamics can include the derivations of static cost benefit coefficients, but its major contribution is to take up where the CBA leaves off and to apply the coefficients to an investigation of the underlying flow structure of the issue.

The overall methodological conclusion is that dynamic factors are often left out of CBA because they cause too much complexity for decision makers, whereas system dynamics allows these factors to be included without masking the clarity of the case.

It is suggested that dynamic CBA as described here should be a prerequisite on all planning projects and starting with a CBA is an excellent way of showing the value of the system dynamics method.

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About the authors

Eric Wolstenholme is a Co-founder and the Director of Symmetric[sd] and Professor of Business Learning at London South Bank University. He has over 30 years experience in system dynamics and an international reputation in both academia and business for his work in the development and application of systems thinking and system dynamics. He has worked at board level in a number of major public and private organisations and his experience includes work in utilities, health, defence, mining, financial services and government. He has been the Head of Management Science at Bradford and Stirling Universities and Professor of Business Learning at Leeds Business School. He was the Director of COGNITUS and the Founding Editor of the *System Dynamics Review*. He has been the President of both the International Systems Dynamics

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David Monk is the Director of and a Co-founder of Symmetric[sd] and the former Head of OLM Consulting. He is responsible for the overall strategic direction of the Symmetric[sd] team. He is responsible for all commercial and partnership arrangements set up through Symmetric[sd] and is a major contributor to mental health networks in England. Most recently, he has co-authored papers on care pathways and world class commissioning with the NHS Confederation. With over 15 years' experience in the NHS, ten at senior and executive management level, Monk has a track record of partnership working including experience of involving patients and the public in major planning decision. Monk also has extensive experience of planning and managing strategic NHS initiatives relating to capacity and demand management and in this context has worked closely with local government in engaging them in NHS issues. His recent consultancy portfolio includes the continued managing of three MH CEO knowledge networks, he has worked extensively with the DH in developing its approach to regional self-determination and has facilitated a range of system dynamics projects including whole system inquires and building models to reflect new policy, e.g. Supervised Community Treatment.

David Todd is a Co-founder and the Director of Symmetric[sd] and has over eight years' systems thinking and system dynamics modelling experience crossing both work in New Zealand and the UK which he has used on a wide range of projects. He is the primary architect of the mental health stepped care simulation model, working with commissioners and service providers for over three years to support several local services redesign projects. He has used field-based models in a number of systems of care to accelerate change and he is an experienced collaborative practitioner. He also has extensive experience in project management, performance framework design and change management.