Integrating System Dynamics and Multicriteria Analysis: Towards Organisational Learning for Performance Improvement

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Abstract

The design, implementation and use of adequate performance measurement and management frameworks can play an important role if organisations are to succeed in an increasingly complex, interdependent and changing world. Yet, despite widespread recognition of the importance of performance assessment, there are some issues which require further study if measurement systems are to be effective in supporting the decision making process. This article argues that the integration between System Dynamics and Multicriteria Decision Analysis can address some of these issues, and ultimately contribute to improve organisational performance. To support this claim, several problems that make performance measurement systems fall short of their potential are outlined and, a discussion about how the integration of system dynamics and multicriteria analysis can help organisations overcome these problems is presented.

Keywords: Performance Measurement and Management, System Dynamics, Multicriteria Decision Analysis, Integrating methods.

1 – Introduction

The environment within which most organisations operate is changing rapidly. Organisations failing to adapt and respond to the complexity of the new environment tend to experience, sooner or later, survival problems. In this climate of change, the development, implementation and use of adequate performance measurement and management frameworks is one of the major challenges confronting organisations and can play an important role in their success.

Any review of the academic and practitioner literatures illustrates that organisational performance measurement is a subject receiving considerable attention. Indeed, some authors argue that a performance measurement revolution is taking place (see, for example, Eccles (1991) and Neely (1998, 1999)). Several factors justify this current interest; of particular importance are the growing dissatisfaction with traditional performance measurement systems and the new environment faced by most organisations.

In an attempt to address some of the criticisms of traditional systems presented by several authors (see, for example, Kaplan (1983), Lynch and Cross (1995), Banks and Wheelwright (1979), Fitzgerald and Moon (1996), Turney and Andersen (1989)), and to deal with a rapidly changing environment, several performance measurement systems (PMS) have been proposed in the last decade. The Balanced Scorecard (Kaplan and Norton, 1992), the Performance Pyramid (Lynch and Cross, 1995) and the Results and Determinants Framework (Fitzgerald et al. 1991) are only a few examples.

However, in spite of the availability of various approaches to develop PMS, it is recognised that some issues deserve further research. The identification of key performance factors (or performance drivers), a better understanding of the inter-relationships and the consideration of trade-offs between performance measures, the dynamism of organisations and the dynamism of measurement systems are only a few examples of topics where further research is required. The key argument presented in this paper is that the integration between System Dynamics (SD) and Multicriteria Decision Analysis (MCDA) can provide a useful framework in which to explore some of these issues, and consequently, to better understand and ultimately improve organisational performance.

However, we believe that if this support is to be effective, there are some technical and conceptual problems dealing with integration which have to be solved.

The paper is structured as follows. In Section 2 we discuss why PMS frequently fail in supporting the decision making process, focusing particularly on issues where the integration of SD and MCDA can be helpful. In section 3 we outline the strengths of these two approaches to show how their integration can bring new insights to inform and support performance measurement and management. An illustrative example from the health care sector is presented. Finally, in Section 4 we conclude with some closing remarks.

2 – Performance Measurement vs. Performance Management

It is widely recognised that there is no perfect PMS applicable in all contexts. The appropriateness of a specific measurement framework may depend on several factors. The organisational context and the purpose of performance measurement are only a few examples. In reality, these and other factors have led to the development of a wide variety of frameworks of different characteristics and of varying complexity. Also, there appears to be a general consensus that measurement systems should be designed, implemented and used so that they enable continuous performance improvement rather than simply control or monitor (Fitzgerald and Moon (1996), Lebas (1995), Neely et al. (1995)).

However, improving the performance of an organisation is not a straightforward task. In most of the cases, PMS do not provide decision makers with the information they most need to effectively manage performance. In reality, diverse reasons may be pointed out to justify why so many efforts to improve performance have not met with great success.

We believe that one of the major reasons why PMS fail is related with the large and complex amount of information they provide, conjointly with the absence of approaches to assist decision makers understand, organise and use such information to manage organisational performance. Neely et al. (1995), for example, argue that most PMS provide "too much data and too little analysis". Due to the limited information processing capabilities of the human brain, we believe that the use of approaches such as SD and MCDA can be very valuable to assist decision makers to understand and organise this information (usually of a conflicting nature and involving delays, feedback, non-linearities, and so on) in order to develop and implement more coherent and better informed action plans.

However, we believe that the support of these approaches can be extended beyond a better analysis and use of the information resulting from measurement. Namely, it is our belief that the integration between SD and MCDA can also provide very valuable insights to address some weaknesses in the design of performance measures and in the implementation of measurement systems.

For example, it is recognised that the identification of factors affecting performance and their relationships is one important step in PMS design. However, it is also recognised that much more has to be done in this topic (Neely (1999), Flapper et al. (1996), Bititci and Turner (2000)). From one side, the practice shows that several organisations create performance measures on an ad hoc basis (Flapper et al., 1996). From another side, with a few exceptions (for example, Kaplan and Norton acknowledge the inter-relationships), little consideration is given in the literature to the relationships between performance measures. Trying to identify factors affecting performance and their relationships, Suwignjo et al. (2000) used cognitive maps. However, we believe that cognitive maps alone do not allow participants to fully understand the interconnections between these factors due to the existence of non-linear interactions between them, delays and feedback loops. To deal with the dynamic complexity inherent in social systems and to infer dynamic behaviour, quantitative simulation is required (Senge (1990), Sterman (1989a, 1989b)). Consequently, we believe that the translation of qualitative diagrams into a simulation model using the SD approach can enrich the analysis and provide very useful insights for the design of measurement systems.

It is also recognised that there are frequently conflicting performance measures, and therefore trade-offs among these measures are inevitable. Frequently, actions taken to improve one measure may lead to a decline in other performance measures. Or, due to time delays in feedback, some actions may produce long-run effects in performance different from their short-run effects. Given that the relative importance of various policy impacts is seen differently by different stakeholders, and usually it is not possible to meet all stakeholders' aspirations, trade-offs must be made (although they are often not made explicit). Some of the most well known performance measurement frameworks (for example, the Balanced Scorecard, Results and Determinants Framework and Performance Pyramid) emphasise the need of measurement systems to make explicit the trade-offs between the various performance measures, but are vague in how to deal with these trade-offs. In reality, we can say that in the existing PMS the consideration of trade-offs between measures and the policies' evaluation process are omitted or not explicitly addressed. We believe that the use of an appropriate MCDA

procedure can be helpful in this context. The need of additional research dealing with the trade-offs among performance measures is, indeed, recognised in the literature (see, for example, Ittner and Larcker, 1998).

Another area where we believe integration can be very valuable is related with the use of performance measures to evaluate the effectiveness of different policy alternatives or courses of actions to improve performance. This is, indeed, one important purpose for which performance measures are often developed (Stiefel et al. 1997). However, to judge the effectiveness of policy alternatives without the support of appropriate tools is frequently a very difficult if not impossible task. From one side, stakeholders have different points of view of what represents good and bad performance of an action, and consequently it is likely that these stakeholders adopt a range of different measures for judging the performance of policy alternatives. From another side, the long time delays and systemic effects of actions, the fact that cause and effect are often distant in time and space and, that obvious interventions do not always produce expected consequences, also make this judgement very difficult (Senge, 1990). In addition, even in those situations where measurement systems provide information to judge actions, this information refers frequently to decisions that already have been made. Measurement systems do not explain how performance will evolve in the future. It is therefore our belief that the integration between SD and MCDA can play an important role to achieve this objective in the most effective way. From one side, SD modelling allows decision-makers to verify, through the use of 'microworlds', and consequently, in a risk-free environment, the effect of different actions on a system's performance measures over time. That is, SD enables a greater understanding of the effects of actions already implemented but also of the effects of alternative actions to be considered for implementation. From another side, the use of a MCDA approach enables the decision makers to develop an explicit evaluation process of these actions, helping decision makers to learn about the problem they face and about their own and other values and judgements (Belton, 1990).

An additional issue on which little research has been conducted is related with the dynamism of measurement systems. Although it is widely recognised that organisational performance measurement systems should be dynamic, evolving over time, most organisations have only static performance measurement systems, and much of the work that is currently ongoing in the field of performance measurement is static in orientation (Bititci and Turner (2000), Neely (1999), Suwignjo et al. (2000), Waggoner et al. (1999)). However, given that performance measures change over time as well as their importance to the stakeholders, measurement systems need to be sensitive to these changes. We believe that the SD and MCDA approaches allow decision makers to review and update systematically the measurement system, taking into consideration these changes. From one side, SD models can help decision makers gain insights of system's behaviour over time which may reveal very valuable to review and update PMS. From another side, the use of a MCDA procedure allows decision makers to review and reprioritise the weights for each performance measure, reflecting how important a performance measure is to the decision maker at a given moment in time.

Finally, it is our belief that integration may also assist the implementation of measurement systems. That is, once the measurement system has been developed it has to be implemented. There is, however, some evidence that this is not a straightforward task due to "fear, politics and subversion" (Neely et al. 2000). Given that SD and MCDA have individually proved their potential to inform and support decision making, working as a vehicle to reach consensus, ownership and commitment among decision makers, we believe that their effective use in the context of performance measurement can facilitate the implementation phase.

These are some of the issues dealing with the design, implementation and use of measurement systems which require more attention if performance assessment wants to succeed in supporting the decision making process and in improving organisational performance. In reality, taking an holistic view of the field of performance measurement, we can conclude that much of the literature and practice has focused on the design of performance measures and measurement systems, with less concern for managing performance. Certainly, the design and control of isolated measures is a valuable exercise in the sense that it informs decision makers about how the organisation is performing against goals, and it assists in identifying an organisation's strengths and weaknesses. However, it does not explain why an organisation is performing in such a way, nor what corrective actions to adopt when needed. To be efficient, measurement frameworks should enable organisations to manage, rather than simply measure their performance. That is, if performance measurement wants to lead to enduring and continuous performance improvement, then the design of measurement systems, their implementation, analysis and use should form a continuous loop (Figure 1).

Fig. 1 - Life cycle of the performance measurement and management process
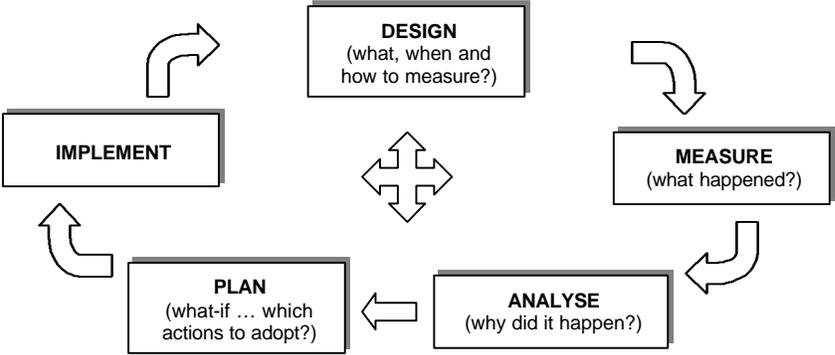
That is, a robust framework for performance measurement and management should assist the: *design* of the measurement system (this process enables decision makers to develop an integrated set of performance measures, to set targets and to define the procedures for periodic data gathering); *measurement* of key metrics (this process informs decision makers about how the organisation is performing); *analysis* of metric results (this process enables decision makers to understand why the organisation is performing in such a way and to identify the need for corrective actions); *planning* of corrective actions (this process enables decision makers to test and evaluate the effects

of alternative corrective actions in the organisation's performance, leading to better informed decisions); and *implementation* of corrective actions (once appropriate actions have been identified, this process should support their implementation). Notice, however, that the process of performance measurement and management should be iterative and not a linear sequence of steps. This is indicated by the arrows in the centre of the diagram.

In the following section we attempt to demonstrate, in more detail, how the integration between SD and MCDA can assist the different stages of the performance measurement and management process, and consequently, how the integration can help decision makers to close this loop.

3 – Integrating SD and MCDA: Towards a more effective management of organisational performance

From the previous sections we can conclude that much of the work in the field of performance measurement has focused on measuring rather than on managing performance. That is, the existing PMS tend to provide information about the performance of the organisation and whether corrective actions are required or not. However, these systems neither provide participants with tools to identify the causes of poor performance nor provide participants with tools to help them in evaluating and selecting appropriate corrective actions. Given that, in most of the cases, understanding the causes of poor performance and determining the proper action plan for performance improvement require detailed analysis of the structure of the problem under study and the consideration of trade-offs, we believe that SD and MCDA can play a major role in these phases. However, the support of these approaches can be extended to the design and implementation of measurement systems.

In this section we give a brief overview of SD and MCDA and we build on the strengths of these approaches to show how their integration can bring new insights to inform and support performance measurement and management.

3.1 – System Dynamics

System dynamics was conceived and developed in the late 1950s and early 1960s at the Massachusetts Institute of Technology by Jay Forrester. Indeed, the advent of SD is generally considered to be the publication of Forrester's pioneering book, Industrial Dynamics in 1961. Since then, significant advances have been made, and a cursory examination of the literature indicates that the number of organisations using SD models for the development of both strategic and operational policies is growing rapidly. An overview of SD can be found, for example, in Forrester (1961), Richardson and Pugh (1981) and Sterman (2000).

SD models are frequently developed and used to represent, analyse, and explain the dynamics of complex systems. The dynamics or behaviour of a system is defined by its structure and the interactions of its parts. The main goal of SD is to understand how this

behaviour is produced, and use this understanding to predict the consequences over time of policy changes on the system.

Although SD models can help decision makers in enhancing understanding of system behaviour over time, SD models do not concern themselves with the explicit evaluation of this behaviour. That is, a pattern of behaviour is frequently presented as preferable to another, based only on the modeller's intuition (Gardiner and Ford, 1980). The rationale behind the decision reached is omitted or not clearly documented. This is, indeed, a criticism to SD models (see, for example, Legasto et al. (1980) and Kadanoff quoted in Gardiner and Ford (1980)). As pointed out by Gardiner and Ford (1980, pp. 242), "the emphasis and focus [of SD models] is on developing models that show consequences, not on formally evaluating these consequences" (text in brackets added).

However, evaluating, and choosing between alternative courses of action is not a straightforward task. In the context of SD, as in many others, the decision maker is confronted with a large and complex amount of information, usually of a conflicting nature and reflecting multiple interests. Consequently, the use of an appropriate MCDA approach can be very valuable to assist decision makers organise such information in order to identify a preferred course of action (see for example, Belton 1985).

3.2 – Multiple Criteria Decision Aid

MCDA is now 30 years old, and it is an important area of Operations Research/Management Science (OR/MS). Since the first session devoted to multicriteria analysis in a scientific congress, organised by Roy during the 7th Mathematical Programming Symposium, which was held in The Hague in 1969, the field of MCDA has seen remarkable growth.[2] On one hand, important theoretical results have been achieved leading to the development of several multicriteria methods. On the other hand, the number of real world applications documented in the literature is increasing considerably. A synthesis of the main streams of thought in this field can be found in Belton (1990), Stewart (1992) or Mollaghasemi and Edwards (1997).

MCDA is designed to take explicitly into account multiple and usually conflicting objectives in supporting the decision process. In this way, MCDA methodologies can help decision makers to learn about the problems they face, and consequently to make better informed and justifiable choices. This is a view shared by many prominent researchers in the field (see for example, Belton (1990), French (1988), Goodwin and Wright (1998) and von Winterfeldt and Edwards (1986)).

That is, in the same way that one of the principal benefits arising from the use of a SD model is to enable the decision maker to gain a greater understanding of the system of interest, one of the main advantages from the use of a MCDA approach is the learning which occurs about the problem faced and the alternative courses of action. Furthermore, the use of a MCDA approach enables the decision maker to develop an explicit evaluation process, which might be used to justify and explain to others why a particular option was selected (Belton (1990) and Goodwin and Wright (1998)).

3.3 – Integrating SD and MCDA to support the performance measurement and management process

The integration of MCDA and SD is not new. Yet it has attracted only the attention of a few researchers over the last two decades, despite the recognition that integration can give rise to a new synergistic approach. To the best of our knowledge, there are no studies striving to fit the synthesised approach into the setting of performance measurement and management.

Although we can find in the earlier 70's the first attempts to integrate simulation models with multicriteria approaches, the earliest attempt to use MCDA and SD in an integrated way that we are aware of was by Gardiner and Ford in 1976. The methodology used and the results achieved are reported in Gardiner and Ford (1980). Other examples providing evidence that integration has potential to be applied in a wide variety of settings can be found in Hammond et al. (1977, 1978), Mumpower et al. (1979), Dennis et al. (1983), Gruver et al. (1984), Reagan-Cirincione, et al. (1991), Andersen and Rohrbaugh (1992), Hsiao (1998), Brans et al. (1998), Kunsch et al. (1999) and Rosas Flunger (1999).

The purpose of this section is to show that the integration of SD and MCDA can also be applied and provide very useful insights when supporting the performance measurement and management process. Particularly, we intend to discuss how this integration can support the design, implementation and use of measurement systems in health care organisations. Although this integration has potential to be applied in a wide variety of organisations, four main reasons make us believe that it can provide very valuable insights in NHS Hospital Trusts.

First, Hospital Trusts are complex systems in which several parts interact over time. Because of the breadth of activities within hospitals and the interconnectedness between them and the influences arising from the external environment, measuring and managing hospitals' performance is especially challenging. Unless some attempt is made to understand these interactions and to co-ordinate the actions of the different parts, the system will under-perform considerably. For example, within a hospital the accident and emergency (A&E) department does not exist in isolation. It cannot operate independently of the surgery department, nor of the management of elective patients, nor of the management and staffing of beds on wards. Actions in one of these parts of the system affect the others (sometimes counter-intuitively), and consequently affect the dynamics of the whole system. Moreover, the performance of the A&E department is also influenced by elements outside the boundary of hospitals including GP referrals, capacity of community care services, technology, as well as economic and social conditions. The achievement of high levels of performance by Hospital Trusts and their continuous improvement demands that these interactions be understood and effectively managed. Consequently, performance evaluation frameworks designed for hospital performance should provide decision-makers with this understanding, which is of vital importance to appropriately inform and assist decision-making.

Second, the design of any system to measure and manage performance in Hospital Trusts needs to take into account the interests of multiple stakeholders including

patients, health care professionals (clinical and nursing staff), administrative and managerial staff, purchasers (GPs fundholders and Health Authorities), as well as central government (NHS Executive). Usually, these stakeholders have different points of view of what represents good performance of Hospital Trusts. It is therefore likely that they adopt a range of different measures for judging the performance of Hospital Trusts. The large variety of points of view - either conflicting or overlapping - between stakeholders justify, by itself, the need for an integrated and coherent set of performance measures to assess the performance of NHS Hospital Trusts, as well as the need to make trade-offs between objectives when assessing the performance of Hospital Trusts. Indeed, the health care reforms in place in the U.K. have emphasised the need for trade-offs in the design of performance measurement systems, reflecting the need to take into account the interests of different stakeholders.

Third, although Hospital Trusts in U.K. have in use performance measurement systems, most of them present several weaknesses. As it has been argued (Ballantine et al. 1998), in these systems: performance measures (financial and non-financial) are usually poorly integrated; the interconnections between performance measures across performance dimensions are very difficult to establish; cause and effect relationships are very difficult to identify and consequently are not explored; specific targets or standards against which goals attainment can be measured are frequently absent; and, as a consequence of all these weaknesses, strategic decision making is deficiently supported.

Fourth, performance assessment has been stressed as central in all areas of the NHS, including Hospital Trusts (see for example, Department of Health (1997) and NHS Executive (1999)). Indeed, in the *White Paper – The New NHS: Modern, Dependable*, the Department of Health argues that the new NHS in the U.K. will be performance driven. Therefore, we believe that attempts should be made to develop and provide NHS Hospital Trusts with performance measurement and management systems which assist them in conforming with this objective, leading to continuous improvements in the health care sector.

These are some of the reasons that make us believe that the proposed methodological framework can support Hospital Trusts in measuring and managing performance. In what follows and using a simple illustrative example, we intend to discuss how can this support be concretised. Naturally, other organisations where similar conditions apply can also benefit considerably from the insights provided by the framework under consideration.

It is widely accepted that effective performance measurement systems should provide decision-makers with information about the degree to which organisational objectives are achieved and how well the organisation is performing its tasks. To get this information, an appropriate set of performance measures is required. However, the issue of which performance measures a given organisation should adopt is not a straightforward one. Although the design of performance measures has been widely discussed in the literature (for an exhaustive review of the literature see Neely et al. 1997), there is no consensus concerning the best way to develop performance measures. It is however recognised by several authors that PMS should align performance measures with the strategic objectives of the organisation (see for example, Globerson

(1985), Kaplan and Norton (1992) and Lynch and Cross (1991)). In this way, it is assured that the system will provide information on whether these strategic objectives are being successfully implemented or not, and additionally, it is assured that if corrective actions are required, measures consistent with these objectives will be adopted. Yet, despite this, it is recognised that several organisations develop performance measures on an ad hoc basis and without taking into consideration the relationships between measures. It is also recognised that even when more "structured" frameworks for performance measurement are adopted, little guidance on how the appropriate measures can be identified (Neely et al. 2000) and how to capture an holistic view of the system being assessed (Sloper et al. 1999), is provided.

The first stage in developing a performance measurement and management system should aim, therefore, to identify the strategic objectives or orientation of the organisation and the factors that are critical to its success. Strategy formulation and performance measurement design should, however, work in an interactive way. In the case of NHS Hospital Trusts let us suppose that this orientation is 'to promote effective delivery of high quality services'. We must recognise, however, that such overall objective is too broad for managers to evaluate how well it is being achieved by Hospital Trusts. It does however provide a starting point for specifying the lower-level objectives, or performance dimensions as we will refer to them, and ultimately the performance measures, that are critical to evaluate its achievement.

Performance measures are defined and used to inform decision makers about to what extent the organisational objectives are realised. This means that we need to arrive at a set of performance measures which can be assessed, preferably, on a numeric scale. When the initial performance measures elicited from the decision maker are ambiguous or ill-defined they may need to be broken down into more specific measures before measurement can take place.

For example, in the White Paper, *The New NHS: Modern and Dependable*, it is highlighted that performance measurement and management in the health care sector needs to support the following objectives: fairer provision of services, higher quality, improved value for money, greater responsiveness and thereby better health. In order to evaluate the achievement of these objectives, six dimensions of performance were defined in the *Performance Assessment Framework* (NHS Executive, 1999): 'effective delivery of appropriate health care', 'health improvement', 'fair access to services', 'efficiency', 'patient and carer experience of the NHS' and 'health outcomes of NHS health care'. That is, these are the factors which directly (or indirectly) contribute to the achievement of the overall objective stated previously.

Notice, however, that although the identification of these factors or dimensions constitutes an important step in the performance assessment process, they do not immediately present a workable framework for detailed evaluation of the performance of Hospital Trusts. To effectively and thoroughly assess, for example, if a Hospital Trust is improving the health of the population, if it is providing clinically effective health care or if it is ensuring that people's ability to obtain health care is related to their needs, these dimensions should break down further. In general, the objectives or

dimensions should be decomposed to a level where they can be easily assessed. That is, they should be ultimately decomposed into performance measures.

Performance measures provide very valuable information to evaluate how well Hospital Trusts are performing against the stated objectives. For example, to assess the 'efficiency' of a Trust, that is, the way in which a Trust uses its resources to achieve value for money, several performance measures might be defined. Day surgery rates, length of stay in hospital, unit costs and labour productivity, are only a few examples.

Several tools or facilitative processes can be used to foster creative thinking in order to identify these performance measures. We can anticipate, for example, that the use of *Post-Its* complemented with qualitative maps (structuring the ideas generated) may be very valuable at this stage.[3]

Given that in most of the cases a wide range of performance measures is generated, it can be necessary and worthwhile to bring some structure to this list of measures. The use of a hierarchy, or performance measures' tree as we will refer to it, can help in structuring these measures and can be equally useful in forming the basis of a multi-attribute value function analysis. Figure 2 is based on the High Level Performance Indicators (NHS Executive, 1999), and gives an example of a performance measures' tree that can be used to assess performance in Hospital Trusts.
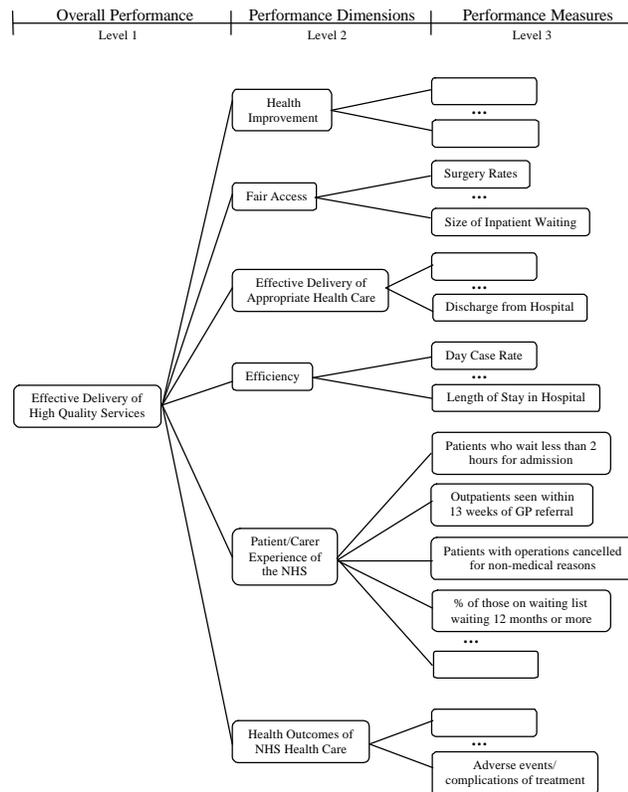
Notice that the process of identifying and structuring performance measures in this way offers several advantages. First, it assures that performance measures are designed in

line with the strategic orientation of Hospital Trusts. As a result, these measures, directly or indirectly, provide information on whether the strategy defined in stage one is being successfully implemented and, additionally, encourage behaviours consistent with this strategy (Neely, 1999). Second, going through the process helps to clarify people's thinking on the subject and on their objectives. This leads to a clearer understanding of what should be measured, why and how, and provides insights for better decisions. Third, it provides the basis of a multi-attribute value function analysis that may be carried out not only to assess how well an hospital trust is performing but also to support the decision making process if policy options need to be analysed and evaluated.

It is important to emphasise, however, that the generation of a proper set of performance measures encompassing all areas of concern is not always an easy task. This is, indeed, an iterative process which should not finish with the design of a 'first' performance measure's tree. Notice that, while this tree provides information about the links between performance measures and performance dimensions, and between these dimensions and overall system performance, it neither shows how performance measures interact with one another nor provides significant insights about possible intervention or leverage points. The use of both qualitative and quantitative SD modelling can play a very valuable role to foster this understanding.

Qualitative modelling, for example in the form of a causal loop diagram (see Figure 3), can play a fundamental role in this phase for several reasons.

First, it gives a clear picture of the different elements of the problem and the interconnectedness between them (cause and effect, feedback loops, delays and so on). This facilitates the understanding of systems behaviour and results, ultimately, in a deeper understanding of what one should care about in measuring the organisation's performance. For example, the performance measure 'waiting time' is considered a proxy measure of the Patient/Carer Experience with Hospital Trusts. Lower values reflect a better experience of patients and consequently a higher satisfaction level. Figure 3 shows how this measure interacts with other ones. For example, an increase in the admission rate will tend to lead to a decrease in the time that patients have to wait until they are seen by a doctor. Conversely, an increase in the size of the waiting list should result in an increase in the waiting time, other factors remaining constant. Notice that the use of causal loop diagrams (CLD) allows to identify feedback loops, and it is the interaction between these loops that determines the dynamics of the system. As argued by Wolstenholme (1990) "it is the analysis of such loops which facilitates understanding of how the processes, organisational boundaries, delays, information and strategies of systems interact to create system behaviour." Moreover, important delays can be represented using causal loop diagrams. Delays may be critical in the health care sector given that often trade-offs between the short- and long-run effects of policies on performance have to be considered.

Second, it allows the identification of intervention points or policy levers that can be used to control the performance of Hospital Trusts. For example, to increase the likelihood of achieving the desired level for the performance measure stated previously, a possible course of action is to reduce the duration of treatment. As can be seen in the

CLD (Figure 3), reducing the length of stay of patients in hospital would lead to an increase in the discharge rate and to a decrease in the number of patients in hospital, allowing higher admission rates and, ultimately, shorter average waiting times. However, Figure 3 also shows that while shortening the duration of treatment might lead to shorter waiting times, it also increases the likelihood of inappropriate discharges. It is, therefore, likely that some of these patients will return for further treatment either as elective patients or as emergency cases, generating in the future an increase in the waiting list. Furthermore, if it is reasonable to suppose that NHS may in part control the performance of certain variables, there are others which overall control is beyond Hospital Trusts. The CLD shows that many factors, some of which are outside the direct control of hospitals, such as GP referrals or the capacity in community care, have an important bearing on the performance achieved by a particular hospital. That is, the CLD reveals, on its own, that the measurement and management of performance in NHS Hospital Trusts is not a straightforward task. To improve performance in the health care sector a great understanding of the problem under study is required. As argued by Ballantine (1998), "control and co-ordination of a variety of activities, carried out by various organisational groups, is necessary". This section also intends to show that this control and co-ordination can be much easier if participants benefit from the insights provided by SD simulation modelling.
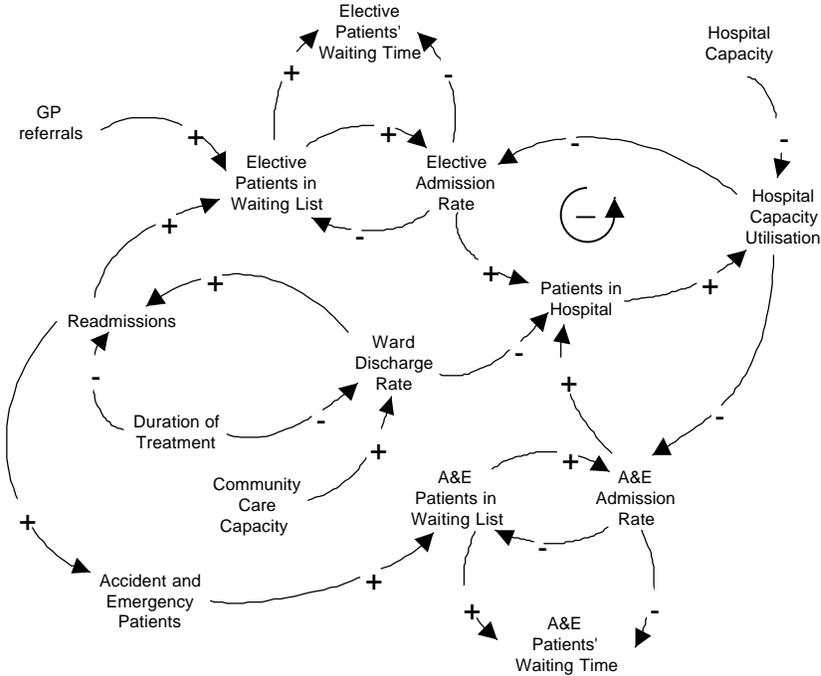
Figure 3 – Causal loop diagram

We can conclude, therefore, that the increased understanding about the feedback structure of systems provided by the CLD can be particularly helpful to the decision-makers in Hospital Trusts. From one side, in defining an integrated set of performance measures and in clarifying their interrelationships. From another side, in identifying potential intervention points where effective change can take place.

However, while CLDs (and qualitative diagrams in general) may assist users in the understanding of some relationships between measures, suggest performance measures and leverage points, they present some limitations. Therefore, they should be used as an intermediate step in the process of performance measurement and management. For example, when used alone, CLDs do not allow participants to understand the dynamic behaviour of factors affecting performance and do not allow a full assessment of the interconnections between these factors. Consequently, the translation of these diagrams into a simulation model using the SD approach may be necessary. In the context of performance measurement, this is a view also shared by Linard (1995) and Sloper et al. (1999).

Building and running a SD simulation model it is much easier to understand the process underlying performance generation and consequently, to identify the factors that are susceptible to lead changes, also called 'performance drivers'. In addition, building a simulation model of the system under consideration and defining relevant variables and the relationships between variables, might be useful for identifying performance measures that might have been omitted in the previous stages. Furthermore, some performance measures originally regarded as unimportant or overlooked might seem worthy of remark after running the simulation model. For example, waiting time of A&E patients is a performance measure often used to evaluate the effectiveness of Hospital Trusts. However, when taken alone, this measure can provide misleading information given that reductions in the delay of A&E admissions might cause delays in elective inpatient admissions and an increase in the rate of cancellations of pre-scheduled non-emergency admissions. Therefore, although the importance of a rapid response time to A&E patients cannot be underestimated, this measure must be jointly assessed with other measures. Using a SD simulation model it is possible to present evidence that waiting time of A&E patients and elective cancellations are linked and compensating measures, and as such, they should be jointly assessed (see for example Lane et al. 2000). Ignoring this kind of relationship between measures leads often to a situation where the proposed actions produce results opposite to those intended. For instance, in the previous example, due to the delay in inpatient admissions and to the higher number of patients with operations cancelled for non-medical reasons, it is likely that some of these patients would become emergency cases, generating in the future an increase in the A&E patients, making things even worse.

The development and use of a simulation model constitute, therefore, an important step in getting a thorough understanding of the relationships between measures and in getting a consistent and integrated set of performance measures. However, a simulation model may also play a vital role in testing and comparing alternative actions to improve system's performance. As exemplified previously, in some cases, if participants do not have access to a simulation model to test and design policy actions there is the danger that the selected policies will worsen the problem instead of amending it. In other cases, even if a given situation improves, as a result of adopting a given course of action, it can be only temporarily, and consequently, other policies could have been more effective. For example, Wolstenholme (1999) demonstrates through the use of SD modelling that an increase in hospital bed capacity is not the most effective solution to reduce total patient waiting times. He illustrates that, when bed capacity is increased although more patients are admitted to hospital, the effect is temporary. As soon as the new capacity is

full, the number of patients in hospital wards stabilises and the pre-hospital waiting time increases again. Furthermore, a counter-intuitive behaviour may occur as a consequence of this type of policy. For example, the additional bed capacity introduced can stimulate more demand for hospital treatment or, at least, encourage more GPs referrals to hospital.

To understand the 'dynamic complexity' inherent in these situations, a SD simulation model is required. By developing and running this model participants can understand the stock and flow structure of systems and observe the changes that occur over time in the variables of interest.

Stock and flow diagrams are usually used as a basis for developing this simulation model. As with CLDs, stock and flow diagrams show relationships among variables. However, unlike CLDs, and as can be seen in Figure 4, stock and flow diagrams distinguish between different types of variables: stocks, flows and information.
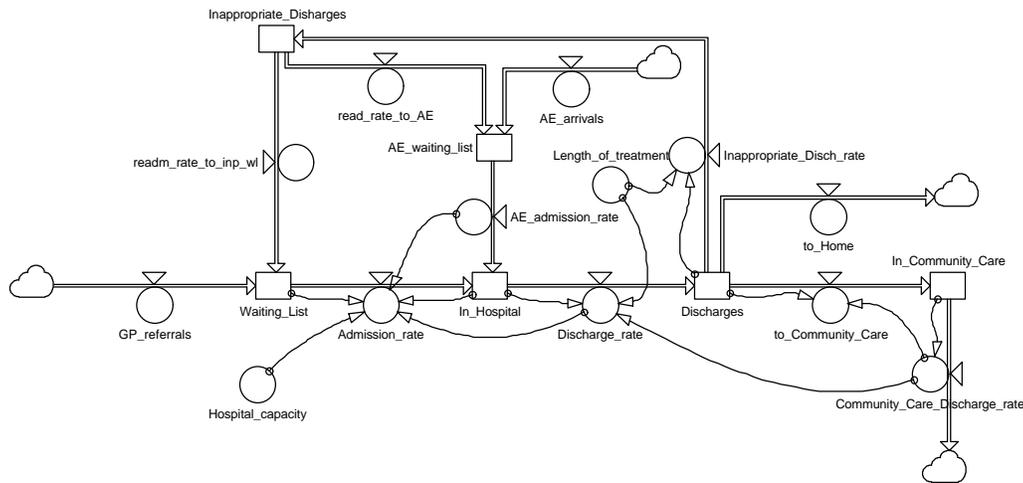
Figure 4 – Stock and flow diagram

The stock and flow diagram in Figure 4 constitutes a simplified representation of the way in which patients flow from the community into the NHS Hospital Trusts and back into the community. From the stock and flow diagram we can also see how different performance measures interact. However, one of the major advantages of this diagram is that it can be used as a basis for developing a SD simulation model which allows to represent explicitly the system's internal structure and this structure is often the underlying source of the problem. Thus, by finding and modifying this system structure we are able to improve organisational performance in the most effective way. According to Lebas (1995, pp. 28), "understanding the processes underlying performance is the only way to define the measures that lead to actions. If we understand which of the steps in the process is defective, appropriate corrective action can be identified".

Once the performance dimensions and an integrated and consistent list of performance measures have been defined, targets should be set in order to evaluate goals attainment. That is, having identified the performance dimensions and measures which the decision

makers consider to be relevant to evaluate organisational performance, the next step is to set targets and to find out how well the organisation is achieving them. These targets can be set in different ways. One possibility which we believe is useful in the case of Hospital Trusts consists in establishing targets based on a range of 'acceptable performance'. The upper limits of this range may include, for example, industry benchmarks and the lower limits may represent the worst tolerable performance for each measure (see Table 1).

Table 1 – Performance Targets

	Performance Measures					
	Surgery Rates	Size of Inpatient Waiting List	Day Case Rate	Length of Stay in Hospital	...	Adverse events
Best attainable performance						
Achieved performance						
Worst tolerable performance						

It is important to emphasise that both the publication of 'league tables' for some hospital performance measures and the increased understanding obtained with the development and use of SD models can assist decision-makers in setting these boundaries. It is important to observe that although providing valuable information to the decision-makers, this table focuses on individual measures. As a supplement to this information, an overall view of the performance of the hospital under consideration can be obtained by aggregating these measures into a single indicator of overall performance. Notice, however, that an overall view of the performance of an Hospital Trust cannot be obtained if these data are not normalised into a common scale.

That is, even when a set of measures and corresponding targets are defined, other issues have to be addressed. From one side, it is very likely that this set will be composed by multiple and heterogeneous measures of performance, which cannot easily be reduced to a single dimension. From another side, it is very likely that performance measures will conflict with each other in that the improved achievement with one measure can only be accomplished at the expense of another. MCDA approaches have proved their potential in dealing explicitly with these trade-offs and in integrating multiple heterogeneous measures into a single or a few key indicators of overall performance.

Notice that, while the focus of most performance measurement systems is on individual measures, with the use of an appropriate MCDA approach decision-makers can gain an overall view of the performance of an hospital by aggregating performance measures. Because the Multi-attribute Value Function (MAVF) approach is one of the best suited approaches to assist decisions involving a short-list of alternatives and many criteria (Belton, 1986), it is well suited in the present context.

The procedure we propose to carry out this analysis (that is, to quantify the factors in performance and to arrive to an indicator of overall performance) makes use of a hierarchical, weighted additive value-function[5] and is supported by the use of the software V·I·S·A[6]. Notice that at this stage we have identified already the performance measures and corresponding targets which the decision makers consider to be relevant to evaluate the performance of the Hospital Trust. Therefore, the next step is to find out how well the Hospital Trust performs on each of the lowest-level measures in the tree (Figure 2).

There are many possible ways to evaluate or *score* the performance of the Hospital with respect to these performance measures. A possible procedure is to compare the actual performance of the hospital trust against the targets defined in table 1 and *score* it using a normalised 0-100 global scale on which the 0 and 100 points are defined by the worst tolerable and best attainable possibility for each performance measure. The scoring process can be realised through direct rating or by using value functions. As we can see in Figure 5, scores are directly related to the nature of each measure, and when appropriate they reflect non-linearities of values scale which may exist for some measures. Figure 5 also shows how well the hospital trust performs regarding the measures 'Day case rate' and 'Size of Inpatient Waiting List'.
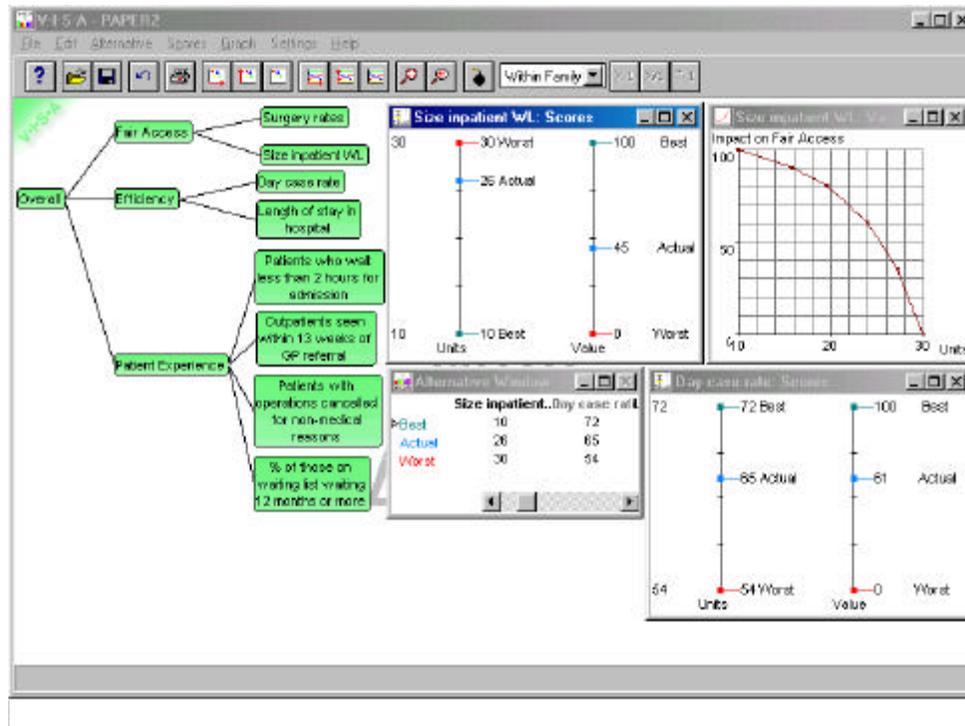
Figure 5 – Part of the V·I·S·A analysis

Having scored the performance of the hospital trust with respect to all the measures at level 3 of the performance measures tree, the next stage is to weight those measures to reflect their relative importance to the performance dimensions at level 2. As for scoring there are many possible ways of weighting performance measures. Independently of the procedure to be adopted, it is important that people do take the range over which the measure is assessed into account when assigning importance weights. The weights for the higher-level measures (performance dimensions) in the value tree are found by summing the appropriate lower-level weights. These weights can be assessed either by direct comparison of the performance dimensions at level 2 or by selective comparisons of performance measures at level 3.

Once these weights are defined, we are in a position to find out how well the hospital trust performs in each performance dimension and how it performs overall (Figure 6). This is done by using a hierarchical weighted value function.
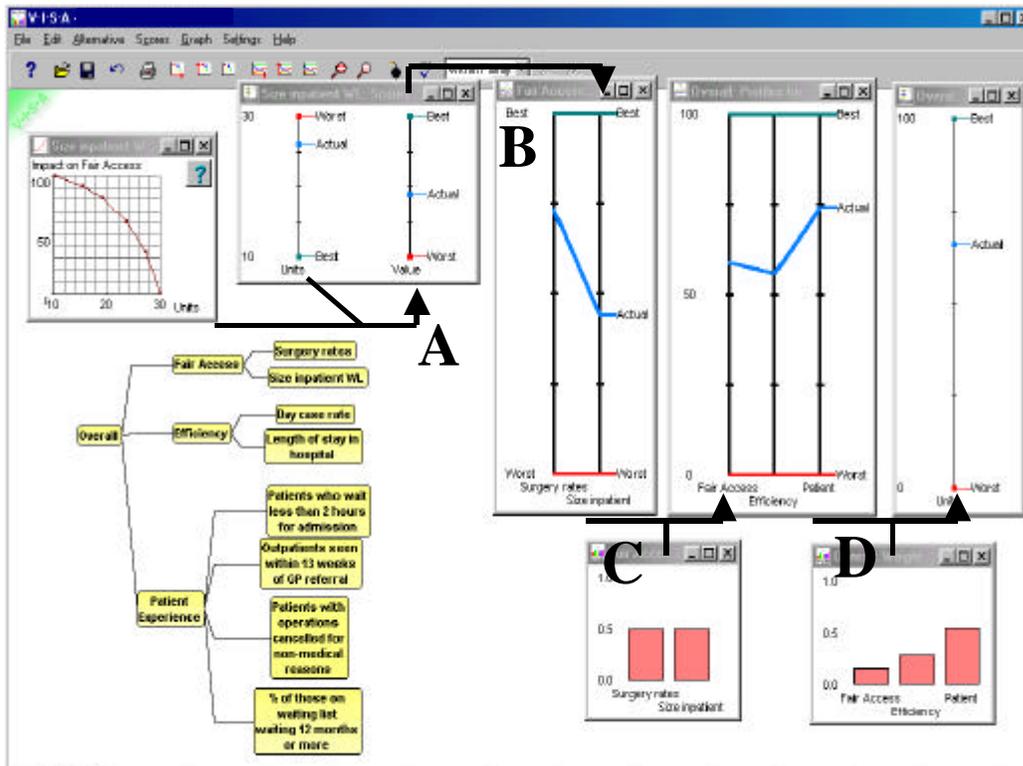
Figure 6 – Determining an indicator of overall performance using V·I·S·A

A thorough sensitivity analysis can be carried out to analyse or explore how robust the overall score obtained by the Hospital Trust is to changes in the inputs to the model, particularly to changes on priorities and values.

Notice that the procedures carried out so far using V·I·S·A, allow us to look individually at the scores on each of the performance measures (Figure 5, Figure 6 - A and B) but also to evaluate how the hospital scores in each of the performance dimensions (Figure 6 - C) and over all the performance measures (Figure 6 - D). This information is very valuable to assess how well the hospital is performing. By scoring and reporting results, decision makers can identify where performance has been strong, and where improvement is required. But, as stressed in the previous sections, this information is of little or no help in driving hospital trusts if it is seen as an end in itself. That is, although these scores allow decision makers to know how the hospital compares with the defined targets on a range of measures, and therefore to know what is working well and what is not, this does not provide a strong basis from which to manage effectively for improvement. To be effective, a performance measurement and management system should support decision making, informing decision makers, in between other things, about which are the causes of poor performance and which actions to implement to obtain effective and appropriate change. That is, about how can performance be improved.

We believe the integration can greatly assist decision makers in making a better analysis and a more effective use of the information resulting from measurement. That is, we anticipate that the support of integration can be extended beyond the design of performance measures and measurement systems and assist decision makers in testing and design policies for effective performance improvement.

Very often, the information that performance measures and measurement systems provide is not enough to assist decision makers in improving performance. Performance measures and measurement systems are, in general, very efficient in diagnosing symptoms of problems. However, to effectively manage performance, leading to continuous and lasting performance improvements, decision makers need to identify the causes of symptoms (not the symptoms themselves) and the proper corrective actions. Many PMS have fallen short of their potential because of failure to provide the decision makers with the understanding and support necessary to do this. However, identifying the causes of problems and developing appropriate solutions is frequently a difficult process for the unaided decision maker. As pointed out by Sterman (2000, pp. 27) "people generally adopt an event-based, open-loop view of causality, ignore feedback processes, fail to appreciate time delays between action and response and in the reporting of information, do not understand stocks and flows and are insensitive to nonlinearities that may alter the strengths of different feedback loops as a system evolves".

The focus on the causal structure of problems and the search for leverage points in the system are some of the strengths which make SD to be an appropriate approach to foster understanding of the process underlying performance generation and to identify the factors that are susceptible to lead changes. The use of SD can be, therefore, a very valuable exercise to assist decision makers gain a greater understanding about how the organisation is performing and why. And notice that SD modelling allows not only to understand what happened but can also provide very valuable insights about what might be about to happen next. SD simulation modelling allows to compute and plot the performance measures over time, and to predict the need for corrective actions. If warning indicators of potential problems are identified (for example, when deviations from targets are detected or undesirable behaviour is expected to occur) corrective actions can be quickly tested and implemented, averting problems. In some cases, this understanding leads by itself to the solution of a problem. In other cases, to find a solution is not so obvious and the use of a multicriteria procedure may reveal very valuable.

Using SD modelling several alternative actions can be simulated and their impact on the performance measures of the system tested. However, as stressed previously, the selection of the 'best' action plan is not straightforward. Stakeholders have different and often conflicting objectives and, as a result, trade-offs must be made. Given that the decision maker is confronted with a large and complex amount of information and given that it is likely that none of the alternative courses of action optimise all performance measures, we believe that the use of an appropriate MCDA approach can be very valuable to assist the decision process.

Suppose, for instance, that the results of measurement indicate that the hospital trust is performing poorly in which concerns the size of waiting lists for elective surgery. How can the hospital reduce waiting lists? This issue clearly involve multiple, conflicting objectives and it is very likely that there will be alternative courses of action or strategies to be considered. For example, to reduce the size of inpatient waiting lists, a possible action to implement is to reduce the length of treatment in hospital. However, this procedure would increase the likelihood of inappropriate discharges and, consequently, would increase the number of emergency re-admissions. That is, to improve one performance measure (for example, the size of waiting lists) we have to sacrifice the performance of another measure (for example, the effectiveness of treatment). Figure 7 shows two policy alternatives and some of their impacts that are to be evaluated.
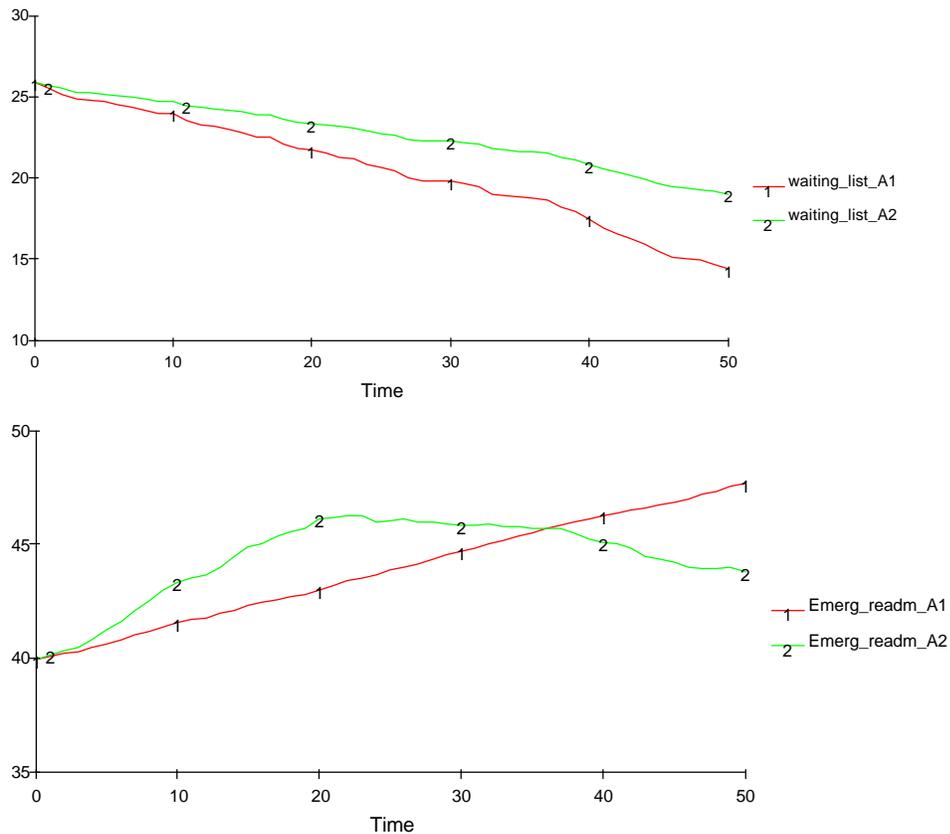

Figure 7 – Graph showing the 'size of inpatient waiting list' and '28 day emergency readmission rates' under two policy alternatives

As we can see, although both alternatives might produce an improvement in the size of the waiting list, they might increase the number of emergency re-admissions. In addition, Figure 7 provides evidence that the consequences of both alternatives are dynamic. How then, to establish criteria on which to base the evaluation of alternatives with outcomes that vary dynamically over time? Gardiner and Ford (1980), and Andersen and Rohrbaugh (1992), for example, suggest some 'curve characteristics' that can be taken into account to capture the most important aspects of the system' patterns of behaviour through time. But, do decision makers evaluate system performance

through time by consistently using a fixed set of curve characteristics? Or, do decision makers prefer to evaluate alternatives based on an overall evaluation of the system's patterns of behaviour? Work on these and other issues is being accomplished by the authors.

The integration between SD and MCDA can play, therefore, a fundamental role at this stage of the performance management process – analysis of results and planning of performance improvement strategies - for several reasons. First, SD modelling can provide insights which may be very valuable to understand why hospital trusts are performing badly. Second, using a SD simulation model several alternative corrective actions can be simulated and their impact on the performance measures of the system tested. For example, alternative plans or schemes for the allocation of resources between the different groups of patients (elective, emergency and day case patients) or between the many stages of the patient flow process, can be tested using this simulation model. Third, it is likely that none of these alternative courses of action will be able to optimise all performance measures given that some of them are conflicting. When this happens, the information resulting from running the simulation model can be passed to the multicriteria model and explicitly evaluated. That is, the alternatives to be considered for analysis and evaluation by the MCDA approach will be the different plans of action suggested by those with expert knowledge in the area and the criteria for the evaluation of these plans may initially taken to be the performance measures presented in Table 1.

Finally, it is important to emphasise that the development of the proposed framework should be a recursive process. Moreover, since the organisation's environmental conditions are constantly changing, and new strategies need to be developed to cope with these changes, the system proposed must be regularly monitored and updated.

4 – Closing remarks

Any review of the literature illustrates that performance measurement is a field attracting considerable attention, but where some issues require further study if measurement systems want to succeed in supporting the decision making process and in improving organisational performance.

Improving the performance of an organisation is not a straightforward task. Instead, it is frequently a complex and poorly defined problem. A problem which solution often requires a process of organisational learning enabling decision makers to change the way they think and act, and consequently, enabling a more effective use of the available information.

It is therefore our belief that approaches which allow decision makers to identify and understand the causes of poor performance, which allow decision makers to understand the implications of alternative courses of action before they become operational and which help them in evaluating and eventually selecting appropriate corrective actions, can provide very valuable insights when supporting the process of measurement and management.

SD and MCDA are two approaches to modelling which have individually proved their potential to inform and support decision making. We believe that the integration of these approaches, bringing together their complementary strengths, can provide a valuable tool for understanding and informing decisions about organisational performance.

However, we also believe that if this integration is to be successfully implemented some technical and conceptual problems dealing with it have to be addressed (see, for example, Andersen and Rohrbaugh 1992). To investigate theoretically and empirically the effects of integrating SD and MCDA in the context of performance measurement and how to integrate these two approaches in the most efficient and effective ways is, indeed, the main goal of the research that is being carried out by the authors at the University of Strathclyde.

Some issues which prevent organisations getting the most from their PMS were discussed in this paper. While integration may not be the solution to all these issues, we believe it brings new insights to inform and support the different stages of the performance measurement process. Namely, we believe it is worth consideration for several reasons: First, it allows the design of a measurement system aligned with the strategic objectives of the organisation. Second, the factors affecting performance and their interrelationships can be explicitly identified. Third, it provides a way of creating a consistent and integrated set of performance measures. Fourth, it offers a powerful frame in analysing the ways by which changes in system's performance occur. Fifth, trade-offs between the different performance measures and dimensions are explicitly addressed. Sixth, it empowers and involves individuals. Finally, and a consequence of all the previous reasons, this integration provides a powerful tool for organisational learning.

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[2] Perny and Tsoukiàs (1996) present the 'Theoretical foundations of MCDA'. A bibliographic survey of the activities and international nature of Multicriteria Analysis is provided by Steuer et al. (1996).

[3] Cause Maps and Causal Loop Diagrams seem to be effective tools in helping to structure in a more formal way the ideas or performance measures which have emerged with the use of Post-Its.

[4] Notice that, the need for various dimensions of performance and for different measures across these dimensions is justified by the multidimensional nature of factors that affect performance, and by the existence of stakeholders with different, and usually conflicting interests and points of view.

[5] Notice that, for an additive model to be valid it has to satisfy the independence assumptions. If this is not the case, a more appropriate model should be used.

[6] V·I·S·A (Visual Interactive Sensitivity Analysis) is a multicriteria decision support system based on a multi-attribute value function. Belton and Vickers (1990) provide and overview of the use of a simple multi-attribute value function incorporating V·I·S·A. Keeney and Raiffa (1976) and Winterfeldt and Edwards (1986) explain in detail the multi-attribute value function.