Using System Dynamics to Inform Scenario Planning: A Case Study

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Abstract

Developing strategy and policy requires some understanding of both the present and the future, but operational environmental change can makes these two vastly different. Defining that which is predetermined and that which is not about the future can provide clarity and decrease the space along which the present system might evolve into its future state. Scenario planning is an approach for exploring these different possible futures. The development of scenarios is about surfacing mental models, testing them, and learning. However, the literature on scenario planning offers little in the way of guidance about how this can be done. System dynamics offers a formal process for surfacing, testing and informing mental models. This paper presents and investigates the use of system dynamics to inform scenario planning. It did this by applying the two approaches to a not-for-profit organisation. While scenarios and a dynamic model were developed, the effectiveness of this application of the approaches is questionable. The dynamic model did address issues that remained unanswered by the scenario planning approach. However, it only addressed one small part of the system explored by the scenarios. System dynamics has the ability to explore systems on a range of different scales, suggesting that this particular application may not have reaped the full benefit from integrating these approaches.

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1 Introduction

The changing nature of the world requires people to always be looking to the future. With each decision people make some forecast or estimation of the future is made so the decision may be best suited to the likely outcomes. In the short term, operational environmental change is low and forecasts can prove to be informative. However, in the medium term, uncertainty is higher, and the assumptions upon which forecasts are based are more likely to have changed.

This does not mean that people should not prepare for the future. Foresight tools exist to help people explore future possibilities and discuss their options in terms of strategy and policy development. Scenario planning is an approach used to explore what may occur over the medium term (van der Heijden, 2005). Scenario planning relies on an understanding of today to explore what might happen in the future.

System dynamics is not generally treated by the field as a tool for prediction (Featherston & Doolan, 2012). People from outside the field often believe it does attempt to predict the future and criticise it for not being accurate (Solow, 1972; Keys, 1990; Hayden, 2006). System dynamics is an approach for exploring the current structure of a system and the reasons for its behaviour. This paper shows that systems dynamics can be used to inform scenario planning and improve the rigour of the process.

2 Background

Scenarios are descriptions of different possible futures (Chermack et al., 2001). Scenarios map out a space into which the future is likely to fall (Schwartz, 1996). A common misconception about them is that they are not predictions of the future (Wack, 1985a; Morecroft & van der Heijden, 1992; Schoemaker, 1995; Morecroft, 2007). Scenarios generally have a structure (a matrix or dimensional map) or logic to their structure and a narrative accompanying them (for examples see le Roux & Maphai, 1992; Global Business Network, 1998; Randall & Goldhammer, 2006; Livesey et al., 2010).

Scenario planning is an approach designed to develop scenarios (Wack, 1985a; 1985b; Schwartz, 1996; van der Heijden, 2005). It considers decision maker's current mental models and aims to questions their assumptions and their model's limitations (Wack, 1985a; Schoemaker, 1995; Schwartz, 1996; van der Heijden, 2005).

The aim of scenario planning and scenarios are to change the mental models of decision makers (Wack, 1985a; Schoemaker, 1995), to consider new possibilities (reperceive the world) (Wack, 1985b; Senge, 1992; Schwartz, 1996) and create common language and common mental models (Schwartz, 1996) from which to begin discussing strategic options (Schoemaker, 1995; van der Heijden, 1997; 2005; Neilson & Wagner, 2000).

As with scenario planning, system dynamics is more about the process than the resulting system diagrams and dynamic model (Forrester, 1985). Focusing on the system diagrams or model detracts from the learning that occurred about the system during their development.

System dynamics is an approach designed to help understand the causes of endogenously driven, systemic behaviour (Forrester; 1961; Sterman, 2000). The approach considered decision makers' mental models, develops a dynamic hypothesis, maps out the system, and aims to develop a dynamic model to reflect the real world system, test the

hypothesis and thus understand more about the system (Forrester; 1961; Sterman, 2000).

System dynamics is also not about mimicking real data or making predictions about the future (Featherston & Doolan, 2012). However, Lane (2000) invokes Popper's (1957; 1966a; 1966b) view of technological/scientific prediction to explain how system dynamics can be used to make preliminary predictions about the future. The predictions require all of the assumptions on which the model is based to stay the same. This means the predictions are very tenuous, but explains the conditions required for them to be correct.

There is much common ground between scenario planning and system dynamics. Mental models are the first among these. However, the system dynamics literature offers a more formal and explicit method of testing and informing mental models. The subjective nature of scenario planning (at least this form of it) implies that misinformed mental models could penetrate the scenario planning process (Godet, 2000). If misinformed mental models are used in the scenario planning process, then the scenarios developed could be equally misinformed.

The approaches also both have a strong focus on learning, rather than their 'artefacts' (scenarios, system maps, and models). Their focus means that more is gained from executing the approaches rather than from the scenarios or models.

It is proposed here that system dynamics can be used to inform mental models and the scenario planning process. Furthermore, the learning focus of the two approaches provides greater benefit from their co-use or integration. It is also proposed that using the two in parallel could create a hybrid process that could also help to overcome some of the limitations of using system dynamics as a foresight tool.

The feasibility of using the two approaches together and their benefits will be explored in a study of their application to real world study.

3 The organisation

The organisation involved in this study was a not-for-profit organisation in Canberra, Australia. The organisation provides accommodation and care for people with a disability. The Canberra branch is part of a global network of care providers. The organisation has a unique philosophy where it views itself as a community of people that provide support for those with a disability to live relatively independently. This philosophy is reflected in its charter and entrenched in its culture.

The organisation relies heavily on local government funding and a supply of assistants (paid) and volunteers (unpaid). Many of the volunteers come from overseas, either as part of a gap-year or from the other communities within the organisation's network. The other sources of funding come from philanthropy and from core member fees.

The Canberra community is overseen by a board of directors, the head of which is called a General Manager. The board makes the major policy decisions for the organisation and are responsible for preparing it for the future.

4 Method

The purpose of engaging in a scenario planning exercise was to explore the different possible futures that the organisation might face. In particular the organisation was looking to expand so that it could care for more people with a disability. However, after several planning attempts, no method of expansion could be seen.

The process began with the identification of the core issue for the organisation. A series of informal interviews and meetings were then used to begin to explore how the organisation operated and its 'business idea' (van der Heijden, 2005). This information was then taken forward into the design of the combined process and how it would be executed. A workshop process was adopted because of the benefits of involving the client (Roberts, 1978) and the requirement to capture all relevant information for a modelling approach like system dynamics (Forrester, 1961).

In the first two workshops participants identified the trends and drivers of the organisations general and industry environments. The trends that were uncertain were then separated out from those that were predetermined and ranked based on impact and uncertainty. The participants then explored the eight uncertainties that had the highest impact and uncertainty and used these to develop the scenarios.

In the third workshop participants mapped the system. They were each given a scenario and chose one of the eight uncertainties to be placed in the middle of a page. They then listed the factors that influenced that uncertainty and were influenced by it. They then linked all of these factors with arrows indicating the direction of influence. Participants were asked to focus particularly on feedback in their diagram, ensuring any feedback loops were closed. Individuals with the same scenarios then got together and blended their diagrams to generate one that reflected the group's combined diagrams. Next the participants developed stock and flow diagrams based on the key stocks identified in the previous activity. A fourth workshop was also held that involved activities demonstrating how the scenarios can be used to help develop policies and strategies.

After the workshops, questions remained about the behaviour observed in the system. A dynamic hypothesis was generated and the system maps were used to understand how the system worked. Through further engagement a dynamic model explaining this behaviour was developed. This was compared to reference modes collected from the organisation.

5 Scenario planning

Out of twenty five trends and drivers identified, eight selected as the key uncertainties: those with the highest possible impact and most uncertain outcome. These are shown in Table 1.

Rank	Key uncertainty
1	New sources of assistants
2	Productivity commission report[1]
3	Decreasing funding[2]
4	Threat to sources of overseas assistants
5	Encouragement of philanthropy
6	Aging core members
7	Increasing cost with increasing number of core members
8	ACT Government relationship

Table 1: The eight key uncertainties

From these trends and drivers, the scenarios were generated. Before they were generated, participants in the workshops explored the key uncertainties, their dependencies, their interconnected nature and importance to the organisation. From these activities it became clear that there were two dimensions that were of most concern: funding and the sources of assistants. These were the axes upon which the scenarios were generated. The scenario structure can be seen in Figure 1. The narratives describing the scenarios can be found below that.

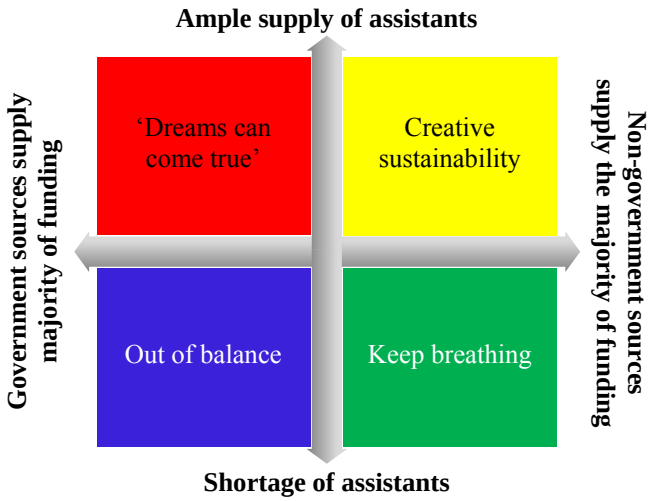

Figure 1: The scenario structure

5.1 'Dreams can come true'

Funding Source: Mostly Government
Availability of assistants: Ample

Narrative

The Australian economy has remained strong since the early 2010's despite troubles in the Euro-zone and in the USA. This growth has had high yields for the Australian government and voters, who have developed greater empathy for the needs of disadvantaged people, have driven the government to acknowledge these needs and spend more money on providing those services.

Despite this renewed interest, community service organisations are still finding their financial situation difficult. Fragmentation of the community service providing industry is seeing this money spread thinly and individual organisations realise little of the apparent increases. Furthermore, aging core community members, housing and transport facilities and a shortage of support from private philanthropists are stretching the budget further and putting strains on core community members, assistants and board members.

Voter empathy has, however, encouraged the government to promote volunteering both through the relaxing of visa lengths and cutting of delays to encourage volunteers from overseas as well as programs, such as gap years, to encourage Australian's to volunteer. The flux of volunteers provides some relief, but finances are still a sever concern.

5.2 Out of balance

Funding Source: Mostly Government
Availability of assistants: Shortage

Narrative

Voter empathy has increased but this alone has had a marginal effect on government spending or on the government's desire to develop favourable policies to make it easier for overseas volunteers to come to Australia. Instead, a healthy economy and a general increase in public spending on welfare had favourable effects on service organisations. The lack of initiative to increase volunteering by the Australian government, changes in non-Australian governments' gap-year and national service programs and the strong economy have led to a drying up of volunteers. People have also begun to work longer, which compounds the issue by draining the vital source of volunteering retirees.

To combat the shortage, organisations have tried to attract more volunteers and assistants by offering higher stipends and benefits. However, this has had little effect as these changes have not been able to compete with other sectors in the healthy economy. As a consequence, community service

[1] The Productivity Commission Report refers to the results of an investigation the Australian Government was conducting into the pay conditions of community service employees at the time. This could have a significant impact on the operating costs of the organisation.

[2] Decreasing funding refers to the supply of government funding. At the time the Australian Government was reviewing how it provided support for people with a disability, possibly resulting in a potential change in funding.

organisations are relying upon casual wages, which is a problem for community service organisations were routine is important.
Community service organisations continue to press the government and private philanthropists for more funding to deal with aging individuals and infrastructure, but only the government is responding. Despite this, government support is still minimal: an aging population in Australia has stretched the benefits of a strong economy and general budget stress continues.

5.3 Keep breathing

Funding Source: Mostly Non-government
Availability of assistants: Shortage

Narrative
Global warming and other matters of international concern have diverted the Australian government's attention and expenditure, reducing funding for social programs and community organisations. These organisations have reacted by turning to private philanthropists to fill their funding needs and who now provide most of the funds for such services. Despite this, funding is short and aging populations and infrastructure pose large threats to the survival of many firms. Government activity is, however, successful in keeping the economy buoyant and unemployment is low. This is putting further strain on community organisations who are finding it increasingly difficult to find assistants and volunteers for work. A strong Australian dollar makes working in Australia attractive, but with no government action on reducing red tape on visas and making access easier, the source of overseas assistants and volunteers is beginning to dry up too.

5.4 Creative sustainability

Funding Source: Mostly Non-government
Availability of assistants: Ample

Narrative
Contagion from other economies has led to stagnation in the Australian economy. Beginning in the mid 2010's, the Australian government tried to stimulate the economy by increasing expenditure. However, after a long period of slow growth, the Australian government was forced reduced its expenditure to try to keep a burgeoning public debt under control.
Community service organisations where among the first to feel the squeeze and have been forced to turn to private companies for the majority of their funding. The economic downturn has also affected private companies and organisations that did not have an edge in fundraising, announcement[3], and getting exposure for their benefactors do not survive. In these hard times people in the community have become sensitive to the strains on services to disadvantaged people and social responsibility has become important to many private firms who wish to get ahead.
The economic slowdown has also increased unemployment, which has made it easier for community organisations to fill positions they previously had trouble filling. Furthermore, travelling agreements with the international community allows for movement of people between the various global communities within the network; who see it as a good way to travel and see the world.

6 System dynamics

6.1 General system mapping

In the third workshop, participants created influence diagrams around the key uncertainties and grounded in the different scenarios. The different frame of the scenarios was used to try to include information in the systems mapping exercise that might not have otherwise been considered; it provided a different frame in order to stretch their thinking. The influence diagrams developed in the workshops were incomplete, showing limited feedback and instead many causal chains. The diagrams did outline the boundaries of the system and show how interrelated many of the factors in the organisation's environment are.
From the influence diagrams, stock and flow diagrams were generated. These outlined the three central stocks for the organisation: number of people in their care (core community members), number of assistants, and funds. Again, these stock and flow diagrams did not reflect much feedback, instead showing many chains of causation.
The influence diagrams provided much information about the system, but provided little for system dynamics. With the dominance of chains of causation, dynamic modelling other than system dynamics appeared to be more appropriate. System dynamics was a process designed to explore endogenous behaviour (Richardson et al. 2011) and these diagrams where indicating that little of this behaviour was internally generated. This indicated that the diagrams were incomplete, or that a system dynamics process was not appropriate.

6.2 Dynamic hypothesis

There was one question that remained unanswered in the scenario planning process. This was the reason for the misalignment between the perceived ability to grow and actual ability to grow. Despite planning processes proving on several occasions that the organisation was unable to expand their service offering and the number of core members they cared for. Through the use of the previous system maps, the

[3] Announcement was the organisation's term for advertising and publicity

workshop results, and further engagement with the organisation a dynamic hypothesis was generated.

Dynamic hypothesis: The difference between the perceived and actual ability to grow is caused by the board's confidence, which is a result of its interpretation of the organisation's budget.

6.3 Dynamic model development

To test this hypothesis further system mapping occurred. Using the information garnered from the workshops, in particular the system maps, and further contact with the organisation, a map of the system was generated. This map was constructed around the notion of confidence to occupy a new house into which they could expand. Thus, confidence was set as the central 'stock' the system. Confidence, C, lay in the range $0 \leq C \leq 1$. Confidence was set as a unitless stock and it accumulated as confidence increases (a function of budget surpluses and supporting discussion) and eroded as confidence decreases (a function of budget surpluses and confidence diminishing discussion). The stock of confidence was defined as:

$$\frac{dC(t)}{dt} = \rho C(t) - \phi(1 - C(t))$$

Equation 1: The 'stock' of board's confidence

Where,
ρ = the accumulation of confidence
ϕ = the eroding of confidence
C = 1: is complete confidence of buying a house
C = 0: is complete lack of confidence in buying a house

Another 'stock', D, was also created. D reflected the reverse of confidence: no confidence or *doubt*. D was defined as:

$$D(t) = 1 - C(t)$$

Equation 2: Doubt

D = 1: no confidence in buying a house
D = 0: complete confidence in buying a house

Therefore,

$$\frac{dC(t)}{dt} = \rho C(t) - \phi D(t)$$

Equation 3: The 'stock' of the board's confidence

The sum of the no confidence and confidence stocks is one, which can be viewed as the adoption of a positive attitude (confidence) or a negative attitude (no confidence or doubt). Confidence is accumulated by supportive discussion and the depleted through doubtful or confidence diminishing discussion. The structure of the stocks *Confidence* and *No confidence* and the *Supportive* and *Confidence diminishing discussions* can be seen in Figure 2. Some might argue that modelling a variable like confidence is arbitrary because it is difficult to quantify, but as Meadow's (2008, p.176) says in reference to the inclusion of a similar difficult to quantify variable, prejudice, 'it would have been much more unscientific to leave "prejudice" out of that study, than to try to include it'.

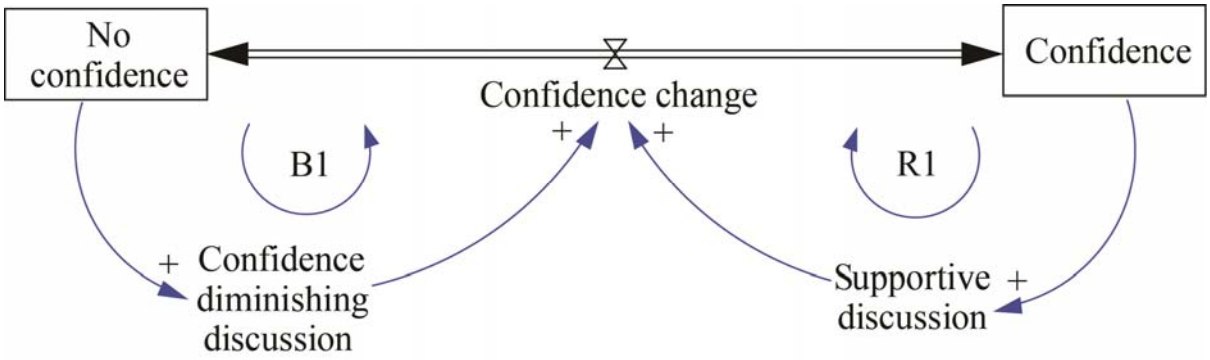

Figure 2: The basic of the confidence model

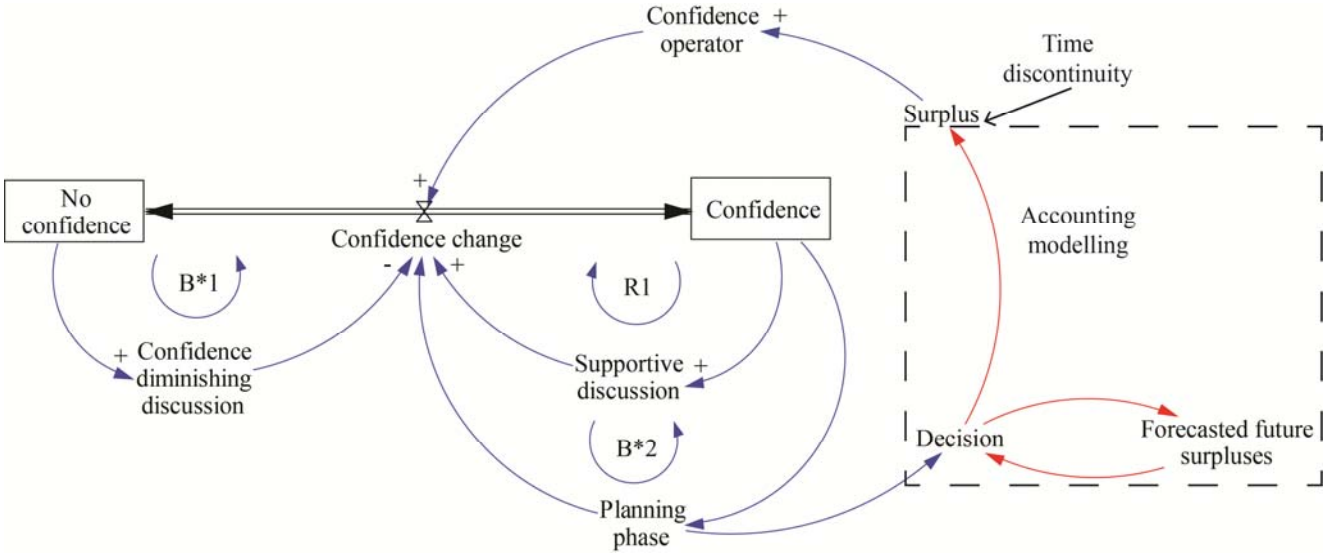

Figure 3: The confidence model

This basic structure was then built on based on the perceived influences on these stocks. They were informed by the system maps generated in the workshops and by further engagement with personnel from the organisation. The resulting model can be seen in Figure 3.

The major addition to this model is the introduction of surpluses, a major driver of confidence, the introduction of a planning phase, and the accounting modelling. The surplus was introduced because it was seen as an important driver of confidence. When the board observed surpluses it influenced their confidence to occupy a new house and their ability to afford the added care required.

The planning phase was a discrete phase that was triggered when confidence was high enough. This loop acted to drain confidence as the consequence of the decision was left to accounting models used during the planning phase.

The box outlining the accounting modelling was excluded from the dynamic model during its runs. It illustrates the impact of forecasting tools, like accounting, on the dynamics of the system. Furthermore, there is a time discontinuity in the model. This time discontinuity is because forecasting tools, like accounting models, forecast a surplus. The system can then take what can be seen as a 'possible future' run, where the forecast surpluses act on the *Confidence change* and being influencing the confidence of the board again. This could in effect be done for multiple different forecasts, creating technical predictions of the behaviour of the system.

6.4 Results of dynamic model

The model was run over the last ten years, using the data collected and information from that period. The resulting run can be seen in Figure 4.

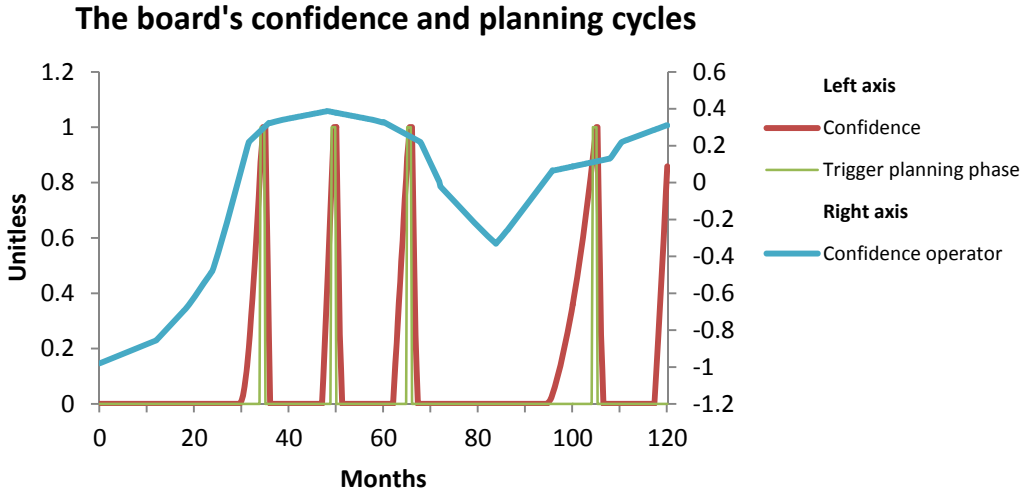

Figure 4: The model's run

6.5 Comparison to reference modes

Reference modes for the model were difficult to define, making their collection even more difficult. It was decided that the reference mode for a stock like confidence was the occurrence of planning processes, major purchases, and the occupation of a new house.

As can be seen in Figure 4, confidence has peaked once and is on the rise again. This reflects the reference mode. In late 2010 and early 2011 (months 102-114), the board undertook a planning process that reviewed its ability to take on another house. This is reflected in the peak that occurs at month 105. During this planning process, it was decided the organisation was not financially strong enough to occupy a new house. When this was realised, the organisation decided to use its current resources to purchase a new car, an asset required for outings and day activities.

The purchase of a new car was a 'fall back' from the planning phase. The confidence stock was defined as the confidence to expand and occupy a new house. However, the financial strength of the firm did not reflect this confidence. Instead, the financial resources of the organisation were used to by a new car, the ability to do so demonstrates that not all of the confidence that had accumulated was misplaced.

Furthermore, the rise which was occurring towards the end of the run reflects continued financial strength of the organisation. This rise continued a triggered a planning process early in 2012 (effectively month 122).

The planning process simulated by the model in months 34, 49, and 65 are not reflected by reality, in fact no planning phases happened over this time period. There are several reasons for this. First, the confidence operator, the translation between surplus and confidence is different for each board. The confidence operator is calibrated for the current board. Prior to month 70 there were no board members in common with the current board. To reflect the behaviour of the board over that period, the confidence operator needs to be calibrated to their decision making structures. Second, over this period while the surpluses were still high, staffing costs increased by almost a third, such instability discouraged the board from planning any expansion in the immediate future. Finally, during the time period, the board itself was experiencing internal conflict, which affected its ability to function.

These qualitatively and quantitatively mixed reference modes appear to support the model and help build confidence in its accuracy.

7 Discussion

7.1 Scenario planning

The results from the scenario portion of the workshops appeared to be quite accurate. The eight key uncertainties identified reflected the general concerns of the organisations; they generally were the considerations that 'keeps [them]… up at night' (Simpson, 1992, p.12). Participants were in general agreement about them and the scenarios. Commonly cited requirements of scenarios are that they be believable (Wack, 1985a; Morecroft & van der Heijden, 1992; Bloom & Menefee, 1994; Morecroft, 2007), reasonable (Miesing & Van Ness, 2007), and realistic (Bloom & Menefee, 1994). In a survey on the scenarios all respondents agreed that the scenarios were all three of these.

The scenarios include aspects from both the organisation's internal and external environment. This goes against what Simpson (1992, p.11) believes and what Schoemaker (1995) does, both of whom focus solely on the external environment. The scenarios incorporate the internal environment because participants did not perceive the trends and drivers to be divisible along these lines. The sources of their funding for example, as an uncertainty, clearly flouts with such a distinction: government funding is external to the organisation, and core member fees and philanthropy, while heavily influenced externally, are driven by internal activity. To be so clear cut between external and internal would have removed much of the complexity behind the organisation's operations and detracted from the scenarios.

The scenarios are in essence a combination of three different uncertainties: the availability of assistants, the availability of government funding, and the availability of funds from philanthropy. These are combined in the scenarios by dictating that the when government funding is low, the majority of funds come from philanthropy, and also dictating the reverse. This is because participants never perceived a situation possible were funding was plentiful, nor a situation where the government would let them go bankrupt. As a consequence the focus was on the source, rather than the amount and still considers their relative contribution.

The scenarios challenged the philosophy and culture of the organisation. Philanthropy is a small source of funding relative to the government. This is because their philosophy of a community does not enthusiastically encourage the organisation to see out philanthropists. However, the inclusion of the majority of funding from philanthropy as a dimension in the scenarios confronted the organisation. Participants' perception of the potential importance of philanthropy was observed to change during the workshops.

7.2 System dynamics

The basic structure of the Confidence model is similar to the Bass Diffusion Model (Bass, 1969). The main difference to the Bass Diffusion Model is the bi-flow between the stocks of *Confidence* and *Doubt* (or *No confidence*). This introduction of the bi-flow demonstrates some shortcomings with the depiction of a system. The stars (*) indicate that these loops are balancing loops for the stock of *Confidence*, but are

reinforcing loops for the stock of *No Confidence*. They are defined as balancing loops because the positive direction of flow was defined as towards the *Confidence* stock, but the method of depiction could be misleading.

The system dynamics approach demonstrated why despite their financial position having not changed the board felt that it had. The desire to grow was ever-present, but there seemed to be a misalignment between the perceived ability and their actual ability to grow. The dynamic model showed that this was because of the way confidence accumulated and increased their perceived ability to grow, despite nothing having changed in their actual ability to grow, which was reflected in their accounting models.

7.3 Discussion of the conjunction of the system dynamics and scenario planning results

When looked at together, the results from the two approaches explain the situation that the organisation is facing. The scenario planning process demonstrated that the resource restricting growth was funds. The scenarios demonstrated that other sources of funds were options for the organisation began to change their thinking about philanthropy as a feasible source of expansion.

The system dynamics process demonstrated why their perceived ability to grow changed, despite their actual- ability to grow not changing. This exemplifies the difficult position they are in: there has to be a change in the organisation's funding structure in order for them to actually grow. Furthermore, understanding the reasons for their engagement in a planning phase would assist them to avoid in engaging in them in the future because the change is only a perception, helping them to alter their decision structures.

By acknowledging these limitations, the firm can begin to develop strategies that reflect this reality. Complex systems, such as the one addressed in the scenario planning portion of the exercise, tend to be very resilient (Walker & Salt, 2006), which explains why the organisation's policies has had little effect on its ability to grow. However, with a better understanding of the system, it can begin to identify leverage points and develop policies to take action on many different parts of the system with the hope of altering its state.

7.4 Conceptual discussion of scenario planning and system dynamics

A difference between scenario planning and system dynamics is the different timeframes upon which they focus. System dynamics focuses on present systems and the reasons for their behaviour, whereas scenario planning focuses on what may happen in the future, often between 5 and 25 years. However, scenario planning relies on an understanding of today in order to be able to map out the space into which the future might fall. Furthermore, system dynamics and scenario planning are not static approaches, as a system might evolves they can be used to understand the causes for systemic behaviour in the evolved system and explore the spaces it might proceed to in the future.

The system dynamics approach addressed a question that remained unanswered by the scenario planning approach. Why the misalignment between perceived and actual ability to grow existed was unanswered by scenario planning. System dynamics was able to address such an issue.

System dynamics also offered a more formal approach to addressing mental models. While scenario planning's focus is on informing mental models (Wack, 1985a; Schwartz, 1996; van der Heijden, 2005), the approaches' literature provides little besides information collection (Schwartz, 1996) and advocacy and inquiry (Senge, 1992) as means to achieving that. However, system dynamics procedural approach of forming a hypothesis, understanding a systems structure, and testing the hypothesis provided a guide to identifying and addressing a specific, systemic problem.

The specificity of the system dynamics approach is one glaring difference between the approaches in this study. Scenario planning was used to explore the organisation's entire environment (system) and understand how it might evolve. System dynamics however, despite being capable of exploring such broad systems applications (see, for example, the Urban Dynamics Model – Forrester, 1969 - and the World Model – Forrester, 1971; Meadows et al., 1972), was applied to a very specific problem with limited system scale. This perhaps limits the conclusions that can be drawn from this study.

Perhaps as a consequence of this, the information that came from the system dynamics process did not encourage a reassessment of the scenarios. This indicates that despite the information from the system dynamics approach providing useful information for policy development, it did not cause a change in the scenarios, but instead helped to understand why the behaviour was occurring and what could be done about it in the future, essentially informing the mental models that 'filled in the gaps' left by the scenario narratives.

The main finding from this study is that as learning approaches, together they described the situation in more detail than either one individually. The learning that occurred during the scenario planning phase fed into the system diagrams and in effect acted as a problem structuring method (see Rosenhead, 1989; Eden; 1989) to identify where a system dynamics approach was needed. System dynamics then addressed a problem that was not addressed by scenario planning. It was then the combination of these results depicted a situation where the organisation was in a stalemate and began to provide a framework from which policies could be addressed to influence this.

8 Conclusions

The study did highlight how other tools can use system dynamics to inform a vision of the future. Accounting models, as forecasting tools, predict futures that system dynamics can then exhibit. While the assumptions of technological predictions still stand, if a scenario planning approach is taken by a modeller to map out a space in which the future may occur and the observed predicted behaviour is taken as just that, 'mapping out the limits', then there is value in their combination. This approach is almost taking some of the tenants of each approach to create a hybrid foresight approach. Scenario planning's approach of mapping out a system and system dynamic's ability to specify the causes of behaviour observed within a system.

Ultimately, the value of such an approach will still be the process rather than its products. Understanding the limitations of a system's future are among the learning benefits of a combined approach. More work is needed to establish a framework for such a combined approach and to understand the technical nature of its application.

However, the study had limited insights into the ability to use system dynamics for foresight work. The necessity to establish assumptions that form clauses for technological predictions was not changed.

This study has provided insight into how scenario planning and system dynamics can be combined and some of its benefits, and has alluded to how their tenants could be combined to conceptualise a novel foresight approach.

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