Using Scenario Planning Data in System Dynamics Model Building

Ezzat El Halabi, Matthew Doolan

The Australian National University
Research School of Engineering, Building 32
North Road, Acton, ACT, 2601 Australia
Phone +61 2 6125 5132, Fax +61 2 61252739
ezzat.elhalabi@anu.edu.au, matthew.doolan@anu.edu.au

Abstract

The main contribution of this paper is describing a traceable data analysis procedure for modelling scenarios using the results of a simplified Scenario Planning workshop. We first introduce our project where the ultimate goal is to develop a grounded model-based policy discussion tool for the Australian automotive recycling industry. We review current scenario-based model building techniques and highlight their practical gaps and then present the proposed procedure rooted in Qualitative Data Analysis approaches. We show how to update the Causal Loop Diagrams and Stock and Flow models and how to determine scenario conditions thus enabling a clear record of model building. Using an example from a real project, we highlight the main challenges of the procedure that are dealing with data scarcity, estimating new trends for variables, and deciding on the nature of the changes in the simulation models. The paper concludes by arguing how the procedure may benefit system dynamists that require a coherent and structured modelling trail or when it is more feasible to engage the stakeholders in an abbreviated Scenario Planning workshop instead of Group Model Building.

Key words

Model Documentation, Model Building, Qualitative Data Analysis, Scenario Planning, Scenarios

Introduction

One of the main challenges in applying System Dynamics (SD) is documenting the model building process, especially when grounded models need updating when new information becomes available. During the past two SD conferences we noticed at several SD model presentations that the audience inquiries centred on model usefulness almost overlooking the lack of detail on how the models were developed. While acknowledging the importance of model usefulness[1], we postulate that maintaining a visible and traceable approach is at least as important, specifically in grounded applications requiring stakeholder engagement. In this paper we focus on modelling scenarios, an integral component of SD model development, determined using the output of a Scenario Planning (SP) workshop involving a group of stakeholders.

Our project aims to develop a model-based policy discussion tool for the Australian automotive recycling industry using SD as a guiding framework. When trying to maintain a transparent modelling approach, we realised that the current model-building procedures are far from optimal and therefore needed adaptation. Our original intention was to conduct a series of Group Model Building (GMB) workshops but we soon realised that the proposition was not logistically or financially feasible. It was too difficult to get a group of stakeholders in the industry to commit several days of their time to GMB activities as they come from different enterprises spread across Australia.

Thus, we conducted a series of stakeholder interviews in late 2010/2011 to gather business process data and capture the underlying decision frameworks. Then, in order to focus the modelling effort on the most relevant problems, interview data was systemically analysed and aggregated using an adapted Qualitative Data Analysis (QDA)[2] approach (El Halabi et al. 2012). Preliminary Causal Loop Diagrams (CLD) were developed for the five emerging focus areas (El Halabi and Doolan 2012) followed by the Stock and Flow models (SFD). Last year we

[1] Within the context of grounded model building, useful models need to be relevant to the stakeholders while addressing a relevant problem context.
[2] QDA is a broad term for a method of systemic inquiry into qualitative data with the purpose to gain insights. For more information refer to Richards (2009).

designed and facilitated a SP workshop with a group of auto recyclers and representatives from industry associations (El Halabi et al. 2013) so that we could identify the model-relevant scenarios and determine the influences of each scenario on each of the five areas of the model.

The paper is structured as follows: We overview relevant literature while highlighting the practical gaps. We then present the QDA-based procedure along with an example of its application focusing on a subset of the SD model '*Workforce*' in one of the identified scenarios '*How it should be*'. In the discussion section, we contrast the procedure with the one presented in (El Halabi et al. 2012). We then talk about the pitfall we faced when devising the procedure that led us to structure in the way presented. We also explore the commonality of bias observed in three key implementation challenges. We finally emphasise the transferability of the procedure to other areas of SD model building such as policy modelling.

A Review of Current Techniques

We searched the literature for a detailed and clear procedure we could follow for using scenarios workshop outcomes to further develop our SD models. To our disappointment we could only find references to overall approaches where the specific procedures are either overlooked or simply assumed. In this section we provide an overview of relevant literature to highlight the technical gaps in current approaches.

Within the realms of SD literature, Maani and Cavana (2007) adopt Schoemaker's (1993) list for building scenarios in their Systems Thinking and Modelling method but do not demonstrate the technical aspects of integrating the scenarios elements into the SD models. Heijden (2011), while using SD within the context of quantifying the scenarios and gaining a better understanding of the scenarios, does not detail the technical aspects either. It is a similar story with Belt (2004) who employs SD, scenarios, and other approaches into her holistic Mediated Modeling paradigm. Still on the same path, Alcamo (2008) in the Environmental Scenario Analysis approach borrows from SD to help quantify the scenarios but falls short of demonstrating the procedure.

Most recently, Morecroft (2007) showcases how SD models can be run through different scenarios by changing variable values to challenge existing mental models of the users, but does not touch upon revisiting and revising the structures that underpin the models. Stowell and Welch (2012) refer to the importance of modelling scenarios further reiterating Forrester's emphasis on the usefulness of SD in decision making (Forrester 1968) but do not provide the required how-to detail. Most relevant to our work, Olabisi et al. (2010) present a real world example of using scenarios insights in SD modelling in a participatory setting. Although the authors discuss interesting scenarios/models, they do not share sufficient detail on how the models were updated.

In broader non-SD contexts, still within the systems thinking literature and relevant to our work, Williams and Hummelbrunner (2010) talk about a generic scenario technique adopted from (Schwartz 1996; Heijden 1996; et al.). They give an example of a real world application that goes to the level of systemically assessing influences on factors and estimating trends. While we acknowledge its practical implications, applying or transferring this technique into a SD context is not immediately obvious.

Furthermore, observing SD literature from a lateral view point, we notice how the term 'scenario' is employed broadly without common adherence to a norm. The term which appears under sensitivity analysis (Sterman 2000; Morecroft 2007; et al.) describes the process of varying the values of the variables to gauge model response under different circumstances. Forrest (1998) makes a theoretical distinction between the terms sensitivity analysis and scenario analysis in SD and indicates that the latter should only be used when different futures[3] are modelled through different structures. Similarly we refer to the futures determined through the SP workshop as scenarios. And while different futures may be modelled by changing the values of the variables, we believe a more consistent and thorough grounded approach to modelling would be to analyse and update the underlying models (CLDs and SFDs) where appropriate.

[3] Futures refers to plausible future scenarios that the model can be subjected to.

Building on the above, we can safely deduce that while most SD literature does a good job presenting the overall guidelines and emphasizing the importance of scenarios in modelling, there exists a practical gap for developing scenario-based models using SP data. The QDA-based procedure we propose below aims to address this gap. We would like to emphasize its work-in-progress nature. By presenting it we hope to generate discussion among SD practitioners and interested researchers for feedback and improvement.

Proposed Procedure

It is important to highlight the two required input elements for our procedure (Figure 1). The first one is the set of grounded[4] CLDs and SFDs (along with the list of the underlying variables and their causal links) used to define the focus areas of the model. The second element is the SP workshop[5] data containing the identified scenarios and the impacts of each scenario on each sector of the model as noted by the participants (Appendix 1 for a template of the scenarios matrix).

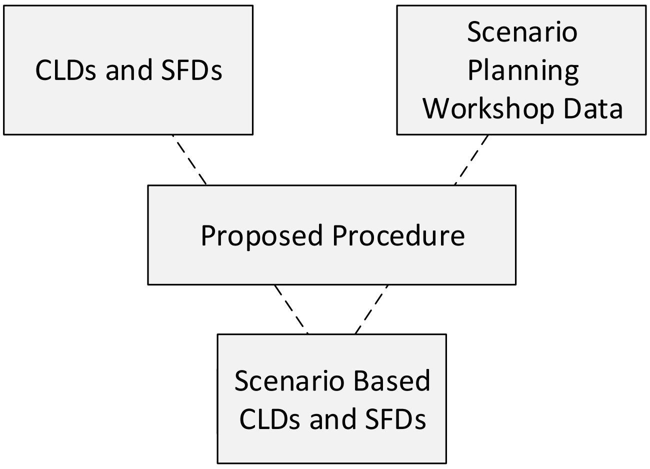


Figure 1: Inputs and Output of our Proposed Procedure

The proposed procedure is as follows:

[4] Developed from stakeholder interviews data like in (El Halabi et al. 2012) but could come from other processes like GMB.
[5] Assuming the workshop uses pre-identified focus areas to guide the SP activities and discussions. The SP results and transcribed participant notes are summarised in a table, presenting the supporting trends and the effects of each scenario on each area of the model.

For each scenario, create a tabulated memo of all areas of the model[6] in rows, and the following headings in columns (Observation, Identified Variables, Causal Links Updates, CLD Updates, SFD Updates, Justifying the SFD Updates, Main Variables Behaviour, Threads for Future Investigation). Then address[7] the headings as per the instructions in Table 1.

Observation	Summarize the transcribed notes by reiterating the following steps: 1- Review and analyse the notes given by participants and existing CLDs/SFDs. 2- Articulate the effect of the scenario on this area of the model. 3- Analyse the ramifications of changes within this area to other areas of the model.
Identified Variables	Add newly identified factors (with units) that can capture the changes.
Causal Links Updates	From the list of variables identified in this area and the current CLDs indicate the updated relationships using a simple one way causality notation. Use the approach [8] presented in (El Halabi and Doolan 2012).
CLD Updates	Shortlist the changes in the CLD and verify whether loop polarity is affected.
SFD Updates	Shortlist the changes in the SFD (adding convertors/flows/stocks, altering connectors, modifying values of transfers/flows, and/or updating the equations/values).
Justifying the SFD Updates	Justify the choice of these particular SFD updates over others. Indicate other possible updates and the reasons for not choosing them.
Main Variables Behaviour	Estimate[9] the trend (increase, decrease, level/no change) for each updated/new variable in the SFD variable. If needed specify the characteristic of the trend (rebound, oscillation, exponential).
Threads for Future Investigation	Note any observation or theory that could be tested when modelling.

Table 1 Analysis Instructions for Headings

Once the data analysis is complete, update the CLDs and SFDs with the new information by creating a new version for each scenario.

[6] Refer to Appendix 1 for the memo template.
[7] Based on the coding process from Richards (2009).
[8] Adapted from Vennix (1996).
[9] Borrowed from the 'Trend Projections' step in the scenario analysis technique presented by Williams and Hummelbrunner (2010).

An Applied Example

To help put steps 2 and 3 into perspective, an example taken from our project is presented: the '*Workforce'* sector under scenario B '*How it should be*'. The reason for focusing on this subset is because it was used as an example in (El Halabi et al. 2012) to demonstrate the approach presented in that paper. It is worthwhile to note that the CLD and SFD shown here as inputs are updated and simplified versions of the ones that feature in (El Halabi et al. 2012).

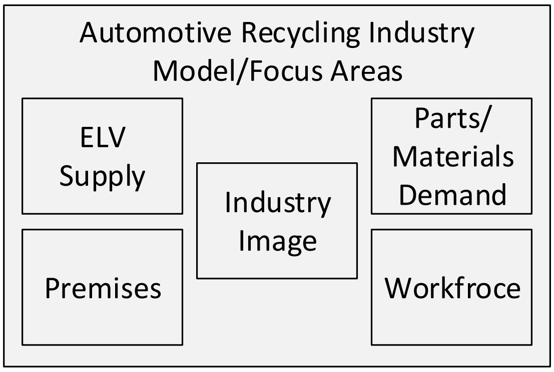


Figure 2: The Five Focus Areas Identified from Interview Data

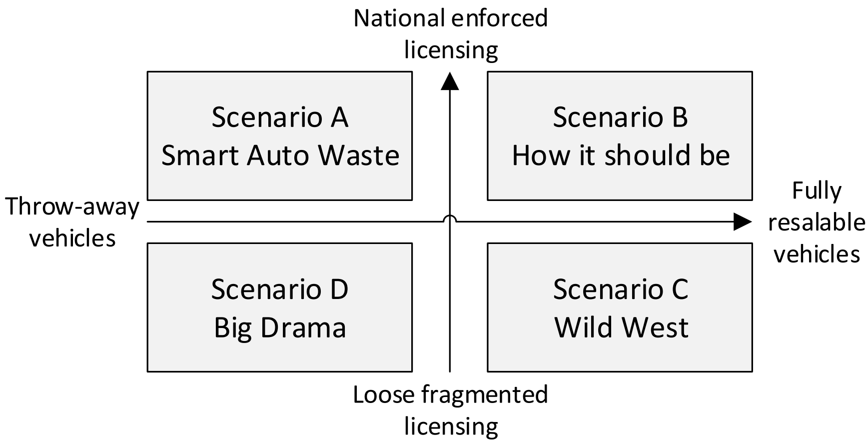


Figure 3: Four Scenarios Identified during the SP Workshop

Furthermore and for the purpose of keeping this example clear, this sector is treated as standalone while ignoring some relationships that are linked in other sectors of the overall model (Figure 2). We designed the SP workshop to meet a strict timing (three hours) and participant involvement constraints. We facilitated[10] the SP workshop in October 2012 in Sydney with a group of eleven stakeholders comprised of auto recyclers and industry

[10] Refer to (El Halabi et al. 2013) for more details about the workshop and processes followed.

associations' representatives from around Australia. Four scenarios were identified during the workshop (Figure 3). The participants, working in groups/pairs, discussed and noted the influences of each scenario on each of the five focus areas[11] identified earlier (Figure 2).

Required inputs

The first set of input is the CLD and SFD for the Workforce sector developed from stakeholder interview data as per the method presented in (El Halabi et al. 2012). The input data[12] is shown in Table 2 on the left while the output of the procedure is on the right.

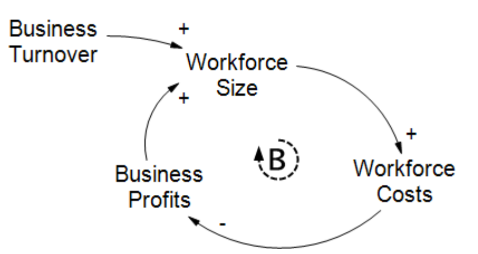
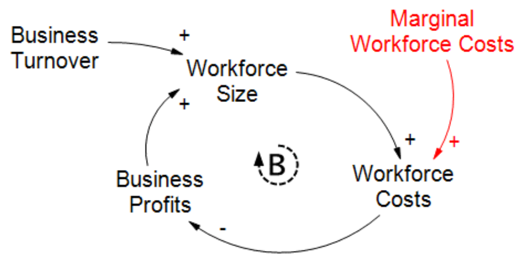
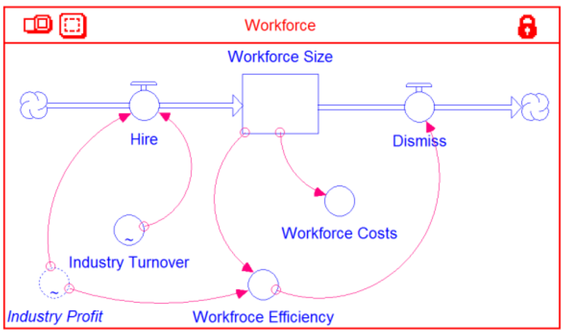
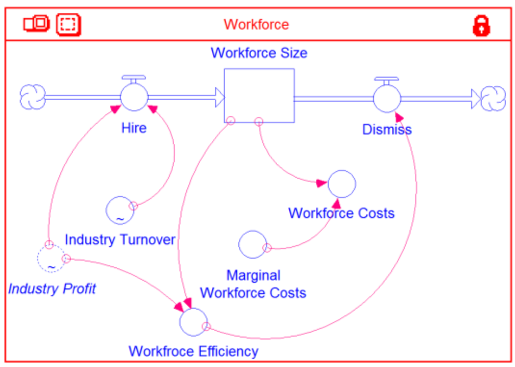
CLD and SFD Input	Output Under Scenario B
	
	

Table 2 CLD/SFD Input and Output of our Procedure

The second set of input is the SP workshop data. These include details of the scenarios identified through the workshop along with the transcribed stakeholders' notes delimiting the effects of the scenarios on each area of the model. For the sake of simplicity we select Scenario B for the labour related (Workforce) focus area:

- Scenario Title (chosen by the participants): "How it should be".
- Dimensions: "National enforced licensing + Fully resalable vehicles".

[11] Refer to (El Halabi and Doolan 2012) and (El Halabi and Doolan 2013a) for more details about these areas.
[12] Refer to Appendix 2For data descriptors including causal links, model equations, and model response.

- Stakeholder notes for the effects of this scenario on the Workforce sector: More staff required; higher wages attracting people to industry.

Applying the procedure

The resulting analysis for each heading is shown in Table 3.

Observation	Participants indicated that due to higher demand for used parts and the availability of ELVs on the market, the industry will need to grow its workforce to cope with the perceived increased demand and might have to increase wages in order to attract more people to the industry. The effect of significantly increasing wage costs may impact on industry profits in the long run.
Identified Variables	Marginal Workforce Costs (percentage).
Causal Links Updates	Add Marginal Workforce Costs, all other polarities unaffected.
CLD Updates	Shortlist the changes in the CLD and verify whether loop polarity is affected.
SFD Updates	Add Marginal Workforce Costs; Link into Workforce Costs; Change Workforce Costs equation by adding Marginal Workforce Costs to the Workforce Size; Modify 'Hire' Flow formula to match the expected behaviour.
Justifying the SFD Updates	The participants indicated that stronger demand for used parts will drive the industry to grow its workforce by hiring more staff. A similar Workforce Size response can be made through changing the equations in the 'Dismiss' flow and/or the 'Workforce Efficiency' transfer but these changes cannot be explicitly grounded in the supplied data.
Main Variables Behaviour	Hire: Increase, Dismiss: Decrease, Workforce Size: Increase (rebound), Workforce Costs: Increase (rebound).
Threads for Future Investigation	Effect of Marginal Workforce Costs on industry profits and sustainability.

Table 3 Resulting Analysis for Workforce Sector under Scenario B

Discussion

In this section the key challenges faced when devising and implementing the current procedure are highlighted before discussing the similarities and differences between this procedure and the one presented at last year's conference (El Halabi et al. 2012) and finally the transferability.

Devising and Implementation Issues

When devising this process we initially attempted to address each area of the model separately across all scenarios. The analysis was spread over five memos, one for each focus area with all four scenarios addressed within each memo as rows within the table. While in theory this may provide a coherent snapshot on the impact of different scenarios on one area of the model, in practice it proved otherwise: it was difficult to update variables in other areas of the model under the same scenario as they were spread across five separate tables. The end result for overcoming this pitfall was the proposed procedure (i.e. each scenario on a memo covering all model areas).

Moving onto the implementation of the proposed procedure, three key issues were faced. The first one is dealing with the insufficiency of SP workshop data that, hardly a limitation of the procedure itself, may be attributed to the workshop process including design and facilitation. There are two dimensions to this issue. The first one is the amount of information that the participants communicate back during the workshop using compact sticky notes that forced them to express their ideas succinctly. The other dimension is data depth. With moderating the workshop activities under strict timing conditions, participant groups/pairs were not able to engage in lengthy discussions to fully explore the influences of their assigned scenario on each focus area. We were left with some cells in the scenarios matrix having too little (single word) or no data (in one instance). We resorted to the data provided in other cells/areas and to the video recording of the group discussion to be able to deduce the effects for the areas lacking the data. In order to maintain a coherent trail of emerging ideas, we also made explicit the assumptions in the observation cell. This neither eliminated the possibility of bias nor of reaching inaccurate conclusions due to the reliance on our understanding (i.e. mental models) and interpretation of other parts of the data.

Another issue when applying our procedure is with estimating the trends for variables. Similar to the first issue and because not all the required data was available, we had to rely on deductions made from other focus areas to help determine the expected behaviour of variables. More importantly, and on a separate level, we found that merely describing the behaviour of an important variable as increasing or decreasing was insufficient to envisage its response in the model. Referring to the example in the base scenario, the main stock 'Workforce Size' was decreasing. We learnt through the workshop data and resulting analysis that it would increase under scenario B. But how can a decreasing variable be made to increase? A solution was to introduce a trend descriptor to better communicate the response of the main stock under this scenario (i.e. Workforce Size will rebound).

The last key implementation issue is dealing with the uncertainties when deciding on the updates needed in the SFDs. To reiterate, our approach is to develop scenario-based SD models by systemically analysing the SP workshop data and determining, while documenting, the required changes to the CLDs/SFDs. In the case of the SFDs it is a triple-edged problem because the modeller has to figure out, not only the relevant components to change, or the ranges of values to use, but also the appropriate mix of changes in order to get the desired model response. In the case of GMB the issue will still be present but dealt with by getting the participants to reach consensus on the required model changes. In our case, however, there is no access to the same group of participants that produced the data. The proposed procedure, while attempting to provide more visibility on the modelling process, circumvents the problem by having the modeller explain the decision behind the actioned SFD updates over those not appropriated.

To help illustrate the problem, we refer again to our example where the 'Hire' flow equation was updated to induce the required rebound behaviour in the 'Workforce Size' stock. The equations in the 'Dismiss' flow and/or the 'Workforce Efficiency' transfer could have been modified instead and would have resulted in a similar response for the main stock. The decision to modify the 'Hire' variable is justified by the adherence to the workshop data where the participants indicated the industry will grow its workforce in response to stronger demand/turnover. A different interpretation, but still valid one, could have been that the actual dismissal rate would greatly reduce (to zero) as the industry holds off dismissal. This interpretation ensues an update of the 'Dismiss' flow instead of the 'Hire' flow. Dealing with the problem of deciding on and justifying the SFD updates begs the question of how far data interpretation should go to. An interesting answer, though not optimal, comes from to the List Extension Method (Coyle 1996), which attempts to coherently identify the influencing factors of a problem: the bounds of the interpretation and analysis is reached when we start dealing with exogenous factors. In our example, either interpretations subsume endogenous factors.

From a 'scientific method' viewpoint we can see that the problem overarching the three discussed issues is the introduction of bias. We acknowledge and emphasize, however, that the purpose of SD modelling is to create useful (Sterman 2000) and relevant models, not replicable ones. The proposed procedure accords more weight to having a transparent and well documented SD modelling process. After all, the SP workshop data used as input is based on the mental models of a select group of stakeholders. Discounting the effects of different facilitators and a non-standard SP process, another group may have discussed different scenarios and generated different data even if the overall guiding theme was the same. Furthermore the SP workshop process, being a group activity, is not immune to the pitfalls of group facilitation observed in GMB such as groupthink, social loafing, and competition (Vennix 1996). In short, while the introduction of bias may be of concern, it is not specific to the presented procedure but rather to both SD and QDA paradigms that procedure is based on.

Comparison with Procedure from Last Year

Both procedures serve the goal of building transparent grounded SD models. They are also similar in terms of reiterating between steps, addressing areas sequentially, and in the use of memos and tables. From a scenarios perspective, the previous approach could be seen as developing SD models for the base scenario, hence the similarities. There are several key differences however, summarised in Table 4.

	Procedure presented last year	Procedure presented in this paper
Purpose	Extracting causal links from interview data	Updating SD models using SP data
Input	Interview transcripts	CLDs/SFDs and SP data
Analysis	Organised by theme of questioning	Grouped by scenario and organised by focus area
Output	CLDs for focus areas	Scenario-based CLDs/SFDs for focus areas

Table 4 Differences between the Procedures Presented in this Paper and in (El Halabi et al 2012).

Transferability

Finally, in terms of transferability of the procedure, it must be noted that the instructions are generic enough and therefore are applicable using different input data sets. The assumption here is that the SP data should result from a workshop where the pre-identified focus areas are used to guide the discussions and activities. To help explain this further, let us assume that we want to apply our procedure to the same example but using data from a differently[13] designed SP workshop where the *'Workforce'* sector does not feature as an area guiding the discussions. Executing our procedure would prove troublesome as more data interpretation become needed to mesh the influence areas, identified in the SP workshop, with the *'Workforce'* area. Questions will arise about whether this sector is worth modelling in the first place, whether the interview data was misinterpreted to give it so much importance, and whether the workshop participants may have simply overlooked it as a result of the aforementioned group facilitation pitfalls. Still on the topic of transferability and more substantially, our procedure can also be used to study the impact of policies/strategies on different areas of the SD model. Using the same CLDs/SFDs as the first input, the second input can be a set of policies/strategies identified either through stakeholder engagement or from anecdotes in literature (Figure 4). The effects on the SD model can then be analysed by following the same instructions[14] of our procedure.

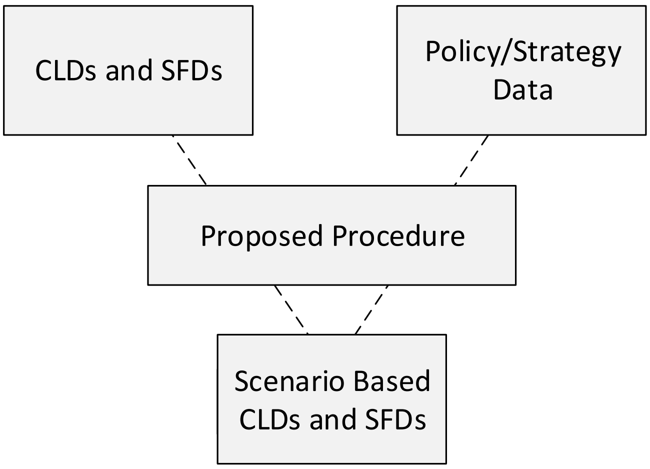


Figure 4: Another Potential Use for Our Procedure

Conclusion

There is an increasing need for more transparent and structured procedures enabling the use of SP in SD modelling. Similarly, there is a drive to document the SD model building process whether motivated by client requirements or by system dynamists wanting to develop

[13] The SP workshop activities would rely purely on the participants to structure the areas of influence instead of using the areas of influence identified from interview data.
[14] In the instructions of our procedure, replace the term 'scenario' with 'policy/strategy' where applicable.

credible grounded models. The proposed procedure in this paper aims to address a practical gap in the literature and to provide practitioners with a useful tool for developing SD models using SP workshop data while enabling a coherent and structured modelling trail.

The real world application presented in the paper indicates that the procedure can be used in contexts where it is more practical to rely on the data of an abbreviated SP workshop than having to conduct a series of costly GMB workshops. We argue that despite its shortcomings, the procedure is generic enough to transfer to other applications such as policy analysis. Future work will focus on improving the procedure, specifically when dealing with SP data scarcity, and handling uncertainties when updating the SD models.

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Bibliography

Belt, M. van den. 2004. *Mediated Modeling: A System Dynamics Approach To Environmental Consensus Building*. Island Press.

Coyle, R. G. 1996. *System Dynamics Modelling: A Practical Approach*. Chapman & Hall.

El Halabi, E., and M. Doolan. 2012. "Causal Loops in Automotive Recycling." In *Proceedings of the 56th Annual Meeting of the ISSS*. http://journals.isss.org/index.php/proceedings56th/article/view/1968.

———. 2013. "Operational Challenges in Automotive Recycling: A System Dynamics Perspective." In *Re-engineering Manufacturing for Sustainability*, edited by A. Y. C. Nee, B. Song, and S. Ong. Springer.

El Halabi, E., M. Doolan, and M. Cardew-Hall. 2012. "Extracting Variables and Causal Links from Interview Data." In *Proceedings of the 30th International Conference of the System Dynamics Society*. http://www.systemdynamics.org/conferences/2012/proceed/papers/P1293.pdf.

El Halabi, E., C. Featherston, and M. Doolan. 2013. "System Dynamics and Scenario Planning: Implementation Challenges." In *Proceedings of the the 2013 Systems Engineering and Test and Evaluation Conference*. In Press.

Forrest, J. 1998. "System Dynamics, Alternative Futures, and Scenarios." In *Proceedings of the 16th International Conference of the System Dynamics Society*. http://www.systemdynamics.org/conferences/1998/PROCEED/00095.PDF.

Forrester, J. W. 1968. *Principles of Systems*. Pegasus Communications.

Heijden, K. van der. 2005. *Scenarios: The Art of Strategic Conversation*. John Wiley & Sons.

———. 2011. *Scenarios: The Art of Strategic Conversation*. John Wiley & Sons.

IBISWorld. 2011. *Motor Vehicle Dismantling and Used Part Dealing in Australia Industry Report, F4624*. Retrieved from IBISWorld database.

Maani, K., and R. Cavana. 2007. *Systems Thinking, System Dynamics: Managing Change and Complexity*. Pearson Education New Zealand.

Morecroft, J. 2007. *Strategic Modelling and Business Dynamics: A Feedback Systems Approach*. John Wiley & Sons.

Richards, L. (2009). *Handling Qualitative Data: A Practical Guide - Second Edition.* London: Sage.

Schmitt Olabisi, L., A. R. Kapuscinski, K. A. Johnson, P. Reich, B. Stenquist, and K. J. Draeger. 2010. "Using Scenario Visioning and Participatory System Dynamics Modeling to Investigate the Future: Lessons from Minnesota 2050." *Sustainability* 2 (8): 2686–2706. doi:10.3390/su2082686.

Schoemaker, P. J. H. 1993. "Multiple Scenario Development: Its Conceptual and Behavioral Foundation." *Strategic Management Journal* 14 (3): 193–213.

Schwartz, P. 1996. *The Art of the Long View: Planning for the Future in an Uncertain World*. Reprint. Currency Doubleday.

Sterman, J. D. 2001. *Business Dynamics: Systems Thinking and Modeling for a Complex World*. McGraw-Hill Education.

Stowell, F., and C. Welch. 2012. *The Manager's Guide to Systems Practice: Making Sense of Complex Problems*. John Wiley & Sons.

Vennix, J. 1996. *Group Model Building: Facilitating Team Learning Using System Dynamics*. 1st ed. Wiley.

Williams, B., and R. Hummelbrunner. 2010. *Systems Concepts in Action: A Practitioner's Toolkit*. Stanford University Press.

Appendix 1 – Scenarios Matrix Template

		Model Sectors /Focus Areas/ Areas of Interest				
Scenarios	**Scenario Dimensions**	**Area 1**	**Area 2**	**Area 3**	**Area 4**	**Area 5**
Scenario A	**… + …**					
Scenario B	**… + …**					
Scenario C	**… + …**					
Scenario D	**… + …**					

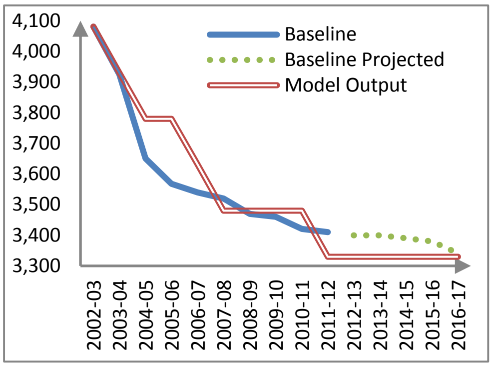
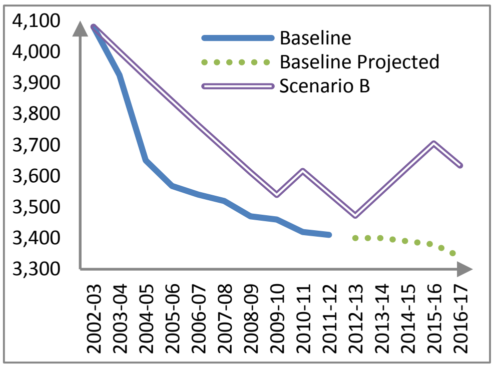
Appendix 2 – Scenario Memo Template

Scenario X: "Title"

Dimensions: … + …

	Analysis Headings							
Model Sectors / Focus Areas	Observation	Identified Variables (Codes)	Causal Links Updates	CLD Updates	SFD Updates	Justifying the SFD Updates	Main Variables Behaviour	Threads for Further Investigation
Area 1								
Area 2								
Area 3								
Area 4								

Appendix 2 – CLD/SFD Data Descriptors

	Model equations and response for the inputs	Model equations and response for Scenario B
Causal Links for the CLD	Business Turnover -> (+) Workforce Size Workforce Size -> (+) Business Costs Business Costs -> (-) Business Profits Business Profits -> (+) Workforce Size	Business Turnover -> (+) Workforce Size Workforce Size -> (+) Business Costs Business Costs -> (-) Business Profits Business Profits -> (+) Workforce Size Marginal Workforce Costs -> (+) Workforce Costs
Model Equations for the SFD*	Workforce_Size(t) = Workforce_Size(t - dt) + (Hire - Dismiss) * dt INIT Workforce_Size = 4080 INFLOWS: Hire = -100*LOGN(100*Industry_Profit/Industry_Turnover) +200 OUTFLOWS: Dismiss = if (Workforce_Efficiency <7) Then 150 Else 0 Workforce_Costs = Workforce_Size*1000 Workforce_Efficiency = (Industry_Profit/Workforce_Size)*100 Industry _Profit = GRAPH(TIME)(0.00, 251), (1.00, 265), (2.00, 265), (3.00, 263), (4.00, 254), (5.00, 256), (6.00, 250), (7.00, 250), (8.00, 240), (9.00, 245), (10.0, 250), (11.0, 254), (12.0, 257), (13.0, 257), (14.0, 254) Industry _Turnover = GRAPH(TIME)(0.00, 937), (1.00, 982), (2.00, 1003), (3.00, 1023), (4.00, 1032), (5.00, 1045), (6.00, 1054), (7.00, 1068), (8.00, 1052), (9.00, 1062), (10.0, 1082), (11.0, 1098), (12.0, 1118), (13.0, 1123), (14.0, 1119)	Workforce_Size(t) = Workforce_Size(t - dt) + (Hire - Dismiss) * dt INIT Workforce_Size = 4080 INFLOWS: Hire = -50*LN(50*Industry_Profit/Industry_Turnover) +200 OUTFLOWS: Dismiss = if (Workfroce_Efficiency <7) Then 150 Else 0 Industry_Profit = GRAPH(TIME)(0.00, 251), (1.00, 265), (2.00, 265), (3.00, 263), (4.00, 254), (5.00, 256), (6.00, 250), (7.00, 250), (8.00, 240), (9.00, 245), (10.0, 250), (11.0, 254), (12.0, 257), (13.0, 257), (14.0, 254) Industry_Turnover = GRAPH(TIME) (0.00, 937), (1.00, 982), (2.00, 1003), (3.00, 1023), (4.00, 1032), (5.00, 1045), (6.00, 1054), (7.00, 1068), (8.00, 1052), (9.00, 1062), (10.0, 1082), (11.0, 1098), (12.0, 1118), (13.0, 1123), (14.0, 1119) Marginal__Workforce_Costs = 200 Workforce_Costs = (Workforce_Size+Marginal__Workforce_Costs)*1000 Workforce_Efficiency = (Industry_Profit/Workforce_Size)*100
Model Response* (Workforce Size)		

* Data sourced from (IBISWolrd 2011).