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A system dynamics model to explore the impact of S&OP processes within an FMCG organisation

By

Kenneth Moodley

213572725

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Supervisor: Dr. Shamim Bodhanya

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Student Name: Kenneth Moodley

Student no: 213572725

Thesis Title: A system dynamics model to explore the impact of S&OP processes within an FMCG organisation

As the candidate's supervisor, I agree to the submission of this thesis for examination.

The above candidate has satisfied the requirements of English language competency.

Name of Supervisor: Dr. Shamim Bodhanya

Signature:

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DECLARATION

I, Kenneth Moodley, declare that:

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ii. This thesis has not been submitted for any degree or examination at any other university.

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DEDICATION

I would like to dedicate this work to the memory of:

My late father, Krishna Moodley, for his calming influence in troubled times. He has been my North Star, ever constant, un-wavering and guiding me from above.

My late grandfather and grandmother who have instilled in me a humility and work ethic that forms the basis of my character.

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ABSTRACT

The process of understanding how an organisation can continue its drive towards becoming more competitive was initiated by recognising that S&OP is one of the methodologies that underpinned the success of an organisation. It covered the operational, tactical and strategic aspects of the organisation and affected various functional teams. The impact S&OP has on the business is deemed significant for these reasons and hence ensuring that it functions as intended is vitally important to ensuring the business is making headway in the correct direction. The organisation spends large amounts of time and resources towards ensuring that the S&OP cycle is performed at the required level. It is therefore necessary to understand how effectively and efficiently the S&OP process is functioning and its impact on the organisation.

Given the complex nature of the problem and the volatile and uncertain environment, it was recognized that a suitable methodology is required to ensure these complexities are captured and understood in an adequate manner. The system dynamics methodology was identified as being suitable to this application due to its propensity to model complex problems, causal inter-relationships and feedback loops. This methodology was guided by the use of a case study approach with the empirical work being conducted within a large multinational FMCG (Fast Moving Consumer Goods) that is based within a developing country. The FMCG organisation on which this research study was conducted is known. However, due to there being a necessity to protect the confidentiality and anonymity of the organisation this approach was taken. The challenges that are faced in most developing countries are similar hence; the applicability and benefits of the study are still maintained.

The model building process involved the use of data collected primarily from the mental database of individuals via interviews and questionnaires, supported by data acquired from the numerical and written databases. This highlighted the various aspects of the S&OP process, which in turn was used to determine the sectors that would form the basis of the system dynamics model, namely: (1) organisational focus (2) demand (3) supply planning (4) factory (5) procurement (6) customer ordering (7) distribution (8) management information. The management information sector contained the business metrics that were identified as being important and hence any model developed or scenario analysis conducted would be evaluated based on these metrics.

Once the model was validated and ascertained to be fit-for-purpose, a number of policy interventions were identified and simulated. Analysis of the outputs led to the identification of two further interventions, which simulated the impact of implementing two policy changes versus one. The outputs showed that optimizing the demand and customer ordering profiles would lead to the largest reduction in variability and have a positive impact on the business metrics that were selected.

It was further identified that to implement these policy interventions there would need to be a paradigm shift in the thinking of individuals and the organisation. This view was reached due to a few themes that emerged during the study, namely: (1) behavioural issues (2) conflicting Key Performance Indicators (KPI) (3) individuals having own views of which variables are endogenous versus exogenous (4) leadership behaviour leading to conflicting messages (5) misalignment between individuals and functional teams (6) thinking in silos.

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ABBREVIATIONS AND ACRONYMS

VUCA	Volatile, Uncertain, Complex and Ambiguous
APICS	American Production & Inventory Control Society
BWE	Bullwhip Effect
CLD	Causal Loop Diagram
SCM	Supply Chain Management
S&OP	Sales and Operations Planning
FMCG	Fast Moving Consumer Goods
SKU’s	Stock Keeping Units
COM	Cores Operating Margin
A&P	Advertising & Promotions
KPI’s	Key Performance Indicators
FA	Forecast Accuracy
FB	Forecast Bias
SL	Service Level
CU	Currency Unit

CHAPTER ONE: INTRODUCTION

1.1 INTRODUCTION

The pressures facing the modern day corporate organisation are ever increasing and if any business intends on thriving, then it must continue to improve its competitiveness and to stay relevant. In order to achieve this the needs of the customer must be satisfied in an effective and efficient manner. For any FMCG (Fast Moving Consumer Goods) organisation to meet the challenge it is necessary for it to have robust processes that is able to predict what the customer demand would be and to ensure the organisation is able to supply or satisfy these needs. The S&OP (Sales & Operations Planning) process is one of the techniques used to ensure that demand and supply is understood and planned for. An effective S&OP process underpins the organisational strategy and therefore has an impact on the business, which needs to be understood.

1.2 MOTIVATION FOR THIS RESEARCH

In order to survive in the global business environment it is critical for organisations and individuals to be able to reinvent themselves to ensure they remain competitive. Being competitive in the business world means, the ability to give the customer what they want, when they want it, at the right price and quality. Organisations must do all this whilst being socially responsible in terms of doing what is right for individuals, communities and the environment. Naturally, this is easier said then done given the modern day challenges that businesses face. Global economic changes have led to a volatile economic environment in which demand changes results in instability in the Supply Chain (Rabeli, Sarmiento, & Jones, 2011). This complex environment in which leaders have to consider all factors impacting on business means that there is a need to also consider social systems if leaders indeed believe that people and their unique dynamics contribute to an organisation attaining the competitive edge.

A key focus in achieving competitiveness is that of Sales and Operations Planning (S&OP) in which the business focuses on balancing supply and demand of its products. Effective Supply Chains are typically those that are able to supply the correct product to the correct customer at the correct price and quality (Huang et al, 2007). Figure 1.1 illustrates that supply and demand is a bi-directional process and are overseen by the organisation's key stakeholders or board of directors who are responsible for setting overall strategic direction.

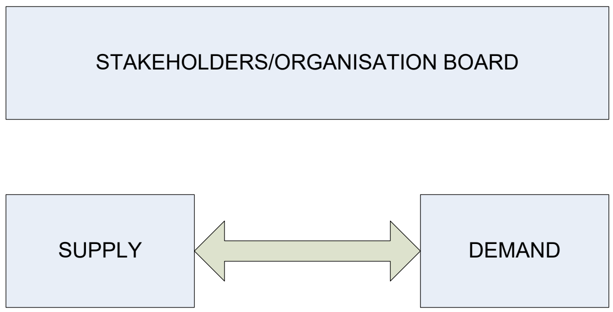


Figure 1.1: Illustration of supply and demand

The output of the S&OP process is used to guide the total supply chain, seen in Figure 1.2, to ensure customer demand is met.

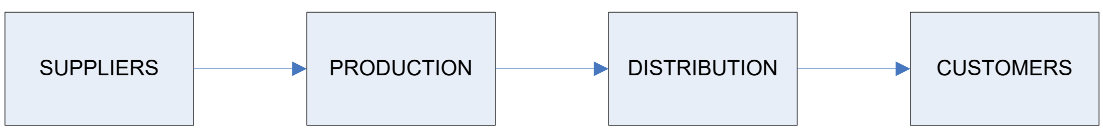


Figure 1.2: Typical end-to-end supply chain

However, when there is oscillation in demand, the supply chain suffers from a phenomenon called the Bullwhip Effect. The Bullwhip Effect is defined as the amplification in the fluctuation of orders, as we move upwards in a supply chain from retailer to the manufacturer to the supplier (Bhattacharya & Bandyopadhyay, 2011). Nevertheless, it is important to note that oscillation is driven by both endogenous and exogenous factors. Policies and decisions made by the organisational board (Figure 1.1) also contribute to demand fluctuations.

There therefore exists a need for organisational leaders and managers to understand the impact of policies and decisions to ensure that decisions are made for the benefit of the organisation as a whole.

1.3 SETTING OF THE STUDY: A CASE STUDY APPROACH

The study was guided by the use of a case study approach by using an existing problem within an FMCG organisation. The large multinational FMCG organisation is based in a developing country and has multiple product categories that it produces and sells to customers both locally as well as the export market. Whilst S&OP is in use across a number of different FMCG organisations, the empirical work was conducted in one specific organisation within a specific product range. However, the organization in question has a large number of product categories and SKU's (Stock Keeping Units) which would make building the model onerous. It is therefore more practical to apply system dynamics modeling to the problem within a specific product category and thereby ensuring that the boundaries, within which the problem resides, can be more readily identified. This also ensured that qualitative data collection from various individuals could be carried out with a smaller cross functional group versus individuals across multiple categories. It must be noted that the organisation in question wanted to protect its anonymity and hence no mention is made of the country. What has been mentioned is that it is based within a developing country.

The organisation within which this study was completed had specific requirements around protecting its anonymity and ensuring that none of the information contained in this thesis would reveal its identity.

The researcher chose to conduct this study within an organisation, which had a need to understand the impact of S&OP within the business. The intent was therefore to use system dynamics as a methodology to understand the impact that S&OP had on the overall business performance. It is worth pointing out that system dynamics is a methodology that is used to model specific problems within specific environments and hence the study is not comparative in nature. It was rather focused on using the system dynamics approach to understand the current scenario, followed by the identification and evaluation of alternatives that could improve the current scenario.

1.4 RESEARCH DESIGN

Given the complex nature of the problem that was identified and the limited work done in the use of qualitative modelling techniques, a systems thinking approach was selected as being pertinent for application. The methodology chosen is known as system dynamics and was used to guide the research design approach used. Systems thinking is a relatively new philosophy that is able to view problems in a more holistic manner versus the sometimes narrow approach that is seen (Sterman, 2000). Decision makers typically use conventional modelling approaches to divide a problem into its basic components and to then analyse and understand these parts. The number of practical applications of system dynamics to supply chain related problems is limited (Cagliano, DeMarco, Rafele, & Volpe, 2010).

System dynamics recognizes that there are many causal relationships and feedback loops that play a vital role in the outputs of the system and hence needs to be understood. In the context of the current study it is often found within the organisation that improvements are implemented but the results are not as expected. One of the possible reasons for this is that in dealing with complex problems it is not easy to identify the root cause, which once fixed will result in the entire problem dissipating. This type of problem will benefit more from a systems thinking approach that embraces a holistic view and recognizes that all elements and individuals of a system are interconnected (Sterman, 2001). With this in mind the Sterman five step methodology was utilised. System dynamics considers the impact that individual behaviour has on the system. Akkermans & Dellaert (2005) state that one needs to question how human decision making is included in the modelling of problems.

The system dynamics approach that was employed placed emphasis on the qualitative aspects of the methodology and hence had a high reliance on the mental database of stakeholders to gather information. This was done by ensuring intensive engagement was conducted with relevant individuals by making use of questionnaires and multiple interview sessions. This was additionally supported by the analysis of data gathered from both the numerical and written databases. These sources of data were used to firstly gain an understanding of the problem within its environment and then aided in the construction of stock and flow diagrams.

These diagrams were then used to build a computer simulation model using the *iThink* software. Once the model underwent the testing process and was deemed fit-for-use, various policy interventions were evaluated and recommendations made.

1.5 RESEARCH TOOLS

The approach employed revolved around data collection from the three databases, namely: (1) Mental (2) Written (3) Numerical, though the mental database was the primary source of information.

1.5.1 Mental database:

Interviews were conducted with identified individuals who represented the various functions that played a role within the S&OP cycle. These interviews were guided by the use of a questionnaire, which contained open-ended questions. This was purposefully done to elicit discussion and insights that would otherwise not be obtained. This resulted in the many opinions and perspectives of stakeholders being captured to ensure an understanding of the problem, the inherent relationships and complexities were understood.

1.5.2 Written database:

The various policies that played a role within the S&OP process were examined and led to:

- An understanding of the manner in which the S&OP process was meant to work.
- The ability to ask follow-up questions during the interview process which led to further insights and understanding. This was generally done if an interviewee mentioned a difference in reality versus the policies.
- The identification and quantification of certain variables, which was included within the model.

1.5.3 Numerical database:

The underlying inputs into the S&OP process were obtained from the numerical database of the organisation and it hence seemed reasonable to use this data as well. The data gathered led to the behaviour over time graphs that were used throughout the study and was further utilised in comparing the data and behaviour over time graphs obtained during the interview process.

These sources of information were examined and led to the development of both the stock and flow diagrams, as well as the system dynamics model on the *iThink* software. The above was supported by the existing literature that was studied during the course of this study and informed some of the decisions made.

1.6 PROBLEM STATEMENT AND RESEARCH QUESTIONS

Competition in the current business environment is more rife then ever before. In the past twenty years or so developing countries has seen a proliferation of multinational FMCG organisations enter the market. These organisations have to compete to influence the consumer to choose their product over their rivals. Whilst it is acknowledged that in order to do this, organisations have to ensure that they are able to beat their rivals on cost and quality, the reality is that consumers have become more demanding and expect to be able to purchase what they want, when they want. They further want convenience and hence do not want to be told, “Sorry we are out of stock but if you come back in a few days we will have what you want back on shelf”. Should a retailer not have the stock on the shelf when required, there is a high probability that the consumer will go to another store or purchase a substitute product. Bijvank & Vis (2011) state that if a consumer does not receive the product required the sale is lost. In fact, approximately 15% of consumers only will wait for the item required (Gruen et al, 2002). This means a loss of revenue for both the retailer and product supplier. The increased competition has further led to an increase of products and hence choice for the consumer.

The actuality is that having strong brands is not enough to guarantee a sale or consumer loyalty. The tendency is therefore for organisations to become more customer and consumer centric and to put the consumer at the heart of the organisation to ensure success. The intent of this is to ensure that On Shelf Availability (OSA) is higher than that of the competition, which usually means that the OSA should be consistently above 95%. A major contributor to lower OSA and hence sales is demand oscillation and the bullwhip effect (Yang, Proudlove, & Spring, 2004).

The starting point to ensuring that the correct products are on shelf is the organisations S&OP processes and policies. A common dynamic, as expressed earlier that can be commonly witnessed within organisations is demand oscillation, which leads to inefficiencies, and ultimately out of stocks and lost sales revenue. This further complicates the organisations ability to balance supply and demand using the S&OP process. The ability of an organization to accurately predict customer demand is a key success factor to ensuring that the organization is able to consistently have its products or services readily available (Godsel, Diefenbach, Clemmow, Towil, & Christopher, 2011). Whilst the external environment does contribute to demand fluctuations, internal policies, decisions and behaviour also contribute towards creating this imbalance between supply and demand. System dynamics states that the boundary of the model needs to be determined in a manner in which exogenous factors are included within the model boundaries. This therefore transforms exogenous factors into endogenous factors, thus ensuring a feedback loop (Morecroft, 2010).

Very often, when there are inaccuracies in demand, and oscillations are common place, individuals throughout the organisation make short term decisions to try and satisfy customers as well as to pursue internal business targets. This is known as the bullwhip effect and is caused by both operational and behavioral actions within an organization (Bhattacharya & Bandyopadhyay, 2011). Forrester (1986) states that System Dynamics modeling is a decision making tool to enable managers to understand the impact of their decisions in the short and long term. Not understanding the dynamics and relationships between the various factors normally results in the organisation getting it wrong. Some of the symptoms of this would typically be higher working capital, implementation of overtime and additional shifts, incorrect product mix, additional warehousing and transportation costs, additional production costs, etc (Kim, Jun, Baek, Smith, & Kim, 2005). This behaviour is further perpetuated by individuals being focussed on driving local functional improvement vs overall business improvements (Repenning & Sterman, 2001).

Essentially then, the aim of this research was to explore the impact of S&OP processes within an FMCG organisation by using the system dynamics modelling approach.

1.6.1 Research Questions

The aim of the study was to seek to address the problems and gaps highlighted above by answering and identifying solutions to the following questions and statements using a system dynamics simulation modelling approach. Hence, the research questions guiding this study was:

1. What are the casual relationships between S&OP policies and profitability of an organization?
2. What are the organizational variables that have an impact on the effectiveness of S&OP within an organization?
3. How do current behavioural patterns affect the organisation when compared to an S&OP process that is implemented and followed rigorously?
4. What are the key factors that if leveraged could be used to ensure alignment between current practices and organisational policies and strategies?
5. Is system dynamics modelling a suitable tool that can be used to simulate this particular supply chain problem?

1.7 OUTLINE OF THE THESIS

Chapter One comprises of this introduction to this study and starts of by providing a brief overview of the rationale for the research and the research context. It then goes on to describe the case study that this study revolves around followed by the manner in which the study was designed and the research tools utilised. Lastly, the problem statement, research questions guiding the overall study and overview of the contributions are described.

Chapter Two contains the literature review that is relevant and contributed to this study. It starts off by explaining the current global and supply chain challenges, with specific details on the demand variability challenges being faced by organisations being discussed. The Chapter then leads into defining S&OP, the bullwhip effect, why S&OP is relevant and the current shortcomings of S&OP. Once this is understood, the Chapter delves into defining system dynamics and explores the applications and relevance of system dynamics. Chapter Two concludes by discussing the shortcomings of system dynamics and the applicability of system dynamics to this study.

Chapter Three starts of by giving an overview of the approach adopted by the researcher to investigate the impact that S&OP has on the organisation selected, using the system dynamics methodology. An overview of the case study to which system dynamics has been applied is included. The Chapter then goes into the detail of explaining what was done within each of the steps of the Sterman five step process. It covers the sources of data together with the strengths and limitations of the data sources, with an explanation of how the three data sources (mental, written & numerical database) was used and the interlinks between them. It also delves into an explanation of the reliability and testing techniques used to prove if the model developed is plausible and fit-for-use as well as touch on the ethical considerations of the study.

Chapter Four explains the actions taken in building the model using the *iThink* software, followed by the testing that was conducted of the base model. The Chapter starts of by explaining the system dynamics symbols utilised. It then goes on to give an explanation of the S&OP process within the context of the organisation. This was the start of the process as it translated into the 5 000metre and 10 000metre views which led to the identification of the eight sectors, namely (1) organisational focus (2) demand (3) factory (4) supply planning (5) procurement (6) distribution (7) customer ordering (8) management information. The sectors were then captured within the simulation model with the variable inputs originating from the three sources of data mentioned previously. The testing techniques employed and the outputs achieved are discussed with this Chapter as well, with the testing techniques falling into three categories, namely (1) tests of behaviour (2) tests of structure (3) tests of learning. The Chapter then culminates in an overview of the base model.

Chapter Five contains the details behind the actual use of the model developed in Chapter Four. The model sector overview is given followed by the process followed in making use of the model to select and evaluate the alternative policy interventions identified. The scenario evaluation process was explained together with an overview of the outputs and ranking of the scenarios evaluated. The Chapter closes with the evaluation of a scenario which whilst not necessarily practical evaluates the outcome if all resources and variables were increased.

Chapter Six seeks to discuss the linkages between the literature covered in Chapter Two with the case study used. The intent is to show the connections between the literature reviewed and the results achieved using the system dynamics approach. Extracts from the literature review conducted in Chapter Two was discussed in conjunction with the outputs and learnings from the case study approach used.

Chapter Seven brings the study to a close by discussing the conclusions and recommendations that emanated from the study. The Chapter starts of by revisiting the research questions, considering the contributions and limitations of the study. It then goes on to providing recommendations to the organisation as well as recommendations for future study. Attention is then given to the considerations that must be considered in the application of system dynamics.

1.8 CONTRIBUTION

The contributions of this study can be summarised by the following bullet points:

- It was noted earlier in this proposal as well as literature studied that mention is mostly made of quantitative modelling and considerations within the supply chain environment (Kristianto, Ajmal & Helo, 2011). This study has further demonstrated that system dynamics can be applied within a supply chain environment and is able to adequately model the problem.
- The use of system dynamics as a methodology led to an in-depth understanding of the problem within the context of its environment and the impact that decisions and policies have on the business.
- Further demonstrating that system dynamics can be used as a business tool to drive improvements and ensuring alignment between policies, procedures and decisions to ensure organisational profitability
- Use of the model as a platform to improve and change individual behaviour to ensure that decisions made result in sustainable medium to long term benefits as well.

CHAPTER TWO: LITERATURE REVIEW

2.1 INTRODUCTION

2.1.1 Global & Supply Chain challenges

Global economic changes as led to a volatile business environment in which demand changes results in instability of the supply chain, which ultimately results in the supply chain being inefficient and ineffective (Rabeli, Sarmiento & Jones, 2011). There is a general feeling of uncertainty as to what will happen next amongst SC people with the current global economy and difficulties being a source of concern (Daugherty, Gawe & Caltagirone, 2010). These factors have led to organisations looking for quick fixes instead of really fixing the root cause. A successful supply chain is one that is managed in a manner, which breaks down barriers between internal and external stakeholders (Shukla, Garg & Agarwal, 2011). Huang et al (2007) further stated that effective supply chains are those that are able to supply the right product, to the right customer, at the right price and at the right quality. Given the current climate changes that we face the challenge to reduce an organisations carbon footprint is also a key business driver. Due to today's consumer being more discerning with regards to which brands and organisations they support, organisations have to ensure they understand and satisfy all consumer needs. Social networking also results in customer/consumer behaviour, which results in the supply chain having to be more reactive.

Effective and efficient supply chain management reduces lead times, costs, improves customer service and improves overall competitiveness (Shukla, Garg & Agarwal, 2011). The trend is to integrate the total supply chain resulting in one global platform as well as technological tools to increase organisational effectiveness. Organisations need to be agile to meet the customers changing needs and is a critical requirement in complex global supply chains. The balancing act however is to still be cost effective, agile, adaptable and aligned to the customer.

Martinez-Olvera (2008) discussed that current manufacturing competition goes beyond single companies and becomes a challenge for supply chains to become more efficient and effective than their competitors. The service provided to the end customer is determined by the effectiveness and efficiency of the cooperation of all of the companies in the supply chain. Fixson (2005) states that this requires each partner within the supply chain to simultaneously take into account the product and process dimensions and to properly realign their structural elements. This will ensure for a seamless operation both with internal functions and with external partners.

These challenges have resulted in supply chain management receiving ever growing interest (Stadtler, 2005). The reason for this might be that it has so many facets and that the tasks of accomplishing the aims of supply chain management are so demanding that it is more an ongoing endeavour then a single short term project. The ultimate aim of the supply chain and hence the organisation is to improve competitiveness of the organisation as a whole. This is achieved by directing the company into a sustainable, strategic position compared to its competitors (Stadtler, 2005). This can only be done if the entire structure or system is understood properly. Factors that were thought to not be interrelated are often connected and a single cause can be the reason for a large number of varied effects (Goldratt, 2004). The need for understanding of the system is further driven by decision making and policies contributing to instability and fluctuations (Rabeli, Sarmiento & Jones, 2011). Given the need for any organization to meet customer requirements they face a task that cannot be taken lightly, as failure to do would be detrimental to the long term profitability and competitiveness of the organization.

2.1.2 Demand variability challenges

It is often assumed that excess or unsatisfied demand is backordered. This is however far from reality as studies show that unfulfilled demand is lost or an alternative item or product is purchased (Bijvank & Vis, 2011). Gruen et al (2002) stated that only 15% of customers who experience a stock out would wait for the item to be on shelves again. The balance will either buy an alternate product, visit another store or do not make any purchase at all. In a changing world with customers becoming more discerning, the organisation that is able to get their product on shelf in full and on time will inevitably be more competitive, resulting in a higher market share and profitability. In order to accomplish this organisations have to have the ability to accurately forecast customer demand and ensure the supply side of the business is adequately equipped to meet demand requirements. This however is easier said then done, as forecasts are invariably wrong and leads to the organisation experiencing what is known commonly as the bullwhip effect.

Lee et al (1997) established five possible sources that may lead to the bullwhip effect:

1. The use of demand forecasting

   Organisations and their leaders have to ensure that they focus its resources towards satisfying customers within a VUCA (Volatile, Uncertain, Complex and Ambiguous) environment with limited resources. To accomplish this the organisation must be able to predict or forecast what the customer wants. Various demand forecasting techniques exist with each having a varying degree of complexity and application. Variability in any process is common place, with an organisation experiencing variability within the demand forecast as well. The amount of variability experienced is largely dependent on the forecasting technique utilised as well as the nature of the customer demand and ordering process that an organisation follows (Chen, 2000).

2. Non-zero lead time

   Across the business, there exists a multitude of activities and processes that need to be completed to ensure a product reaches the consumer. Each of these results in a certain amount of time being taken to complete and contributes towards the overall lead time. The lead times that exist has a direct correlation towards the variability experienced, with the longer the lead times the larger the variability observed (Sun & Ren, 2005).

3. Batched orders

   Batched orders describes the process of consolidating multiple orders into a single batch for production. This would lead to the lead time for the first order placed being longer then the last order placed from order placement to manufacture. The organisation in which this study has been conducted produces to stock versus following a batched order process and maintains an inventory level that is in line with its inventory holding policy.

4. Rationing game under shortage

   This general occurs when the customer demand exceeds the supply, which could be constrained for a variety of reasons such as over ordering versus forecast or capacity constraints. In this situation, the organisation attempts to apply some sort of fair share principle in which the available inventory is shared amongst the various customers, resulting in a rationing process. Note however, that the organisations can decide to give a higher weighting to a customer that is deemed more important.

5. Price fluctuations and promotions

   It has been found that unforeseen price fluctuations and promotions contributes towards increasing the bullwhip effect. Recent studies has shown that price fluctuations are one of the primary reasons for the bullwhip effect and the inefficiencies that arise as a result (Gavirneni, 2006). The context of this study is set within an FMCG organisation in which there exists a stock holding policy that is dependent on the forecast. Based on this dependency any fluctuations versus the original forecast will result in the incorrect inventory levels being available.

The Sales and Operations Planning (S&OP) process seeks to ensure that an organisation has sufficient capacity and capability to meet the demand requirements of the customer. Given that the demand forecast signal is the starting point, the importance of accuracy cannot be underestimated. Sun & Ren (2005) states that different forecasting methods play a role in supply chain management. The smoother the forecast, the smaller the increase in variability will be. Uncertain and changing demands further leads to either lost sales or increasing inventory holding to buffer against uncertainty (Kim, et al 2005).

2.2 SALES & OPERATIONS PLANNING (S&OP)

In the complex and highly competitive environment, that organisations operate within the strategy is to still be cost effective, agile, adaptable and aligned to the customer. In order for supply chains within any organisation to be resourceful, one of the basics that need to be in place is an efficient S&OP process. It provides for a highly structured approach to ensure alignment across all functions and for the business to have a single view of the targets and goals. S&OP typically looks at the zero to 24 month horizon and seeks to ensure that if this view is understood then the business and supply chain can dedicate the correct resources towards meeting the targets (Ross, 2003). Supply chains will face a multitude of challenges whilst attempting to ensure the correct resources are dedicated towards the goals. These resources will need to be ably supported by the organisation and as such, the correct policies and procedures need to be entrenched within the organisation.

Strategic and sustainable sourcing of materials is a key competitive advantage to any organisation. In order to gain this advantage it is imperative that organisations seek to develop long term strategic relationships with key suppliers in order to secure a sustainable supply of material (Daugherty, Gawe & Caltagirone 2010). In order to achieve this, a robust S&OP process with the correct policies is required to ensure long term planning effectiveness.

Obsolete inventory is a reality within the supply chain and decision makers often tend to be of the opinion that it is a necessary evil. Focus is therefore given on how to get rid of the obsolete stock but the time and energy would be better spent on determining how to prevent obsolete stock (Pay, 2010). Obsolescence is in effect the symptom of a supply chain that needs to carry high inventory to cater for business volatility in demand (Daugherty, Gawe, & Caltagirone, 2010). S&OP is one of the primary ways that this uncertainty can be understood, controlled and reduced. S&OP seeks to integrate the supply and demand aspects of the business to ensure that the supply side of the organisation has the capacity and capability to satisfy demand. Research has shown that S&OP can improve profitability by as much as 40% (Pay, 2010). Different forecasting methods play a role in supply chain management with it being acknowledged that the smoother the forecast the smaller the increase in variability (Sun & Ren, 2005). This is quantified using a forecast accuracy calculation, which is a measure of how well the organisation was able to forecast demand and is a comparison of the actual demand versus the forecasted demand for a particular period.

There is no doubt that S&OP is a necessary tool inside any organisation if the said organisation intends on competing within the market. However, as will be discussed later in this Chapter whilst the process may be well understood and described in the literature many an organisation face continuous challenges in making S&OP work effectively for them.

2.2.1 Sales & Operations Planning defined (S&OP)

S&OP is the long term planning of production levels relative to the long term changes in demand and hence sales levels. S&OP gives an indication of the approximate capacity levels required to support the production plan with the capacity normally being treated at an aggregate level (Olhager, Rudberg & Wilner, 2001).

The APICS (American Production & Inventory Control Society) dictionary defines S&OP as:

".....a process to develop tactical plans that provide management the ability to strategically direct its businesses to achieve competitive advantage on a continuous basis by integrating customer-focussed marketing plans for new and existing products with the management of the supply chain. The process brings together all the plans for the business (sales, marketing development, manufacturing, sourcing, and financial) into one integrated set of plans. It is performed at least once a month and is reviewed by management at an aggregate (product family) level. The process must reconcile all supply, demand, and new product plans at both the detail and aggregate levels and tie to the business plans. It is the definitive statement of the company's plans for the near to intermediate term covering a horizon sufficient to plan for resources and suppose the annual business planning process. Executed properly, the sales and operations planning process link the strategic plans for the business with its execution and reviews performance measures for continuous improvement." (COX & Blackstone, 2002). APICS Dictionary, Tenth ed. APICS, Alexandria, va, USA.)

The main features that one can extract from within the definition are:

- It is cross functional

  This essentially translates into all inputs being derived from individuals that sit within different functions in the organisation and spans across the teams that are responsible for the demand and supply aspects of the business. The intent is to ensure that there is robustness in the numbers and views generated and that there is alignment.

- Integrated tactical planning process

  The S&OP process stipulates the individuals that are required in certain meetings and decision making forums to ensure that the plans that are developed are done so with input from all relevant functions and therefore drives an integrated approach.

- Integrates plans in a unified manner

  As discussed above the approach involved various individuals within the same meetings, which drives the development of integrated plans in a unified manner.

- Planning horizon from zero to over 18 months

  The process ensures that a suitable timeframe is considered to ensure that the organisation is able to have a view of the future and to be able to plan and react in a proactive manner. The S&OP process within the organisation in which this study was conducted covered a planning horizon from zero to 24 months (104 weeks) in weekly time buckets.

- Bridges strategy and operations and creates value

  Given the period S&OP covers, attention is given to the very operational short term as well as the more tactical periods. Inherent in the S&OP process is the continuous discussion that should be occurring to ensure that if the operational and tactical views are achieved it would contribute towards the overall organisational strategy.

- Linked with the performance of the firm

  The S&OP process mandates that business critical KPI's are reviewed and discussions held with regards to determining how the KPI's are tracking and hence overall business performance as well as to use the demand forecast to estimate what future performance can be achieved. This would be across KPI's such as working capital, turnover and gross margin.

S&OP has two primary purposes. The first is to balance supply and demand and the second is to build a bridge between the strategic plan and the operational plan of an organisation. It attempts to ensure that both vertical and horizontal alignment across the business is achieved (Thome, Scavarda, Fernandez & Scavarda, 2012). However ensuring the S&OP process functions as designed is fraught with challenges.

2.2.2 THE Bullwhip Effect (BWE)

When there is oscillation in demand, the supply chain suffers from a phenomenon called the bullwhip effect. The bullwhip effect is a common problem which many organizations ponder over and dedicate a large proportion of energy towards resolving. It is an extensive and expensive problem faced by supply chains and has far reaching consequences.

The bullwhip effect refers to the amplification of end customer order signals whereby upstream replenishment demand and physical shipments exceed the original order quantity (McCullen & Towill, 2002). The bullwhip effect causes instability in the supply chain since any small change in customer orders received by a retailer can result in larger changes in the resulting demand placed on the factory. It costs money, wastes resources and results in a loss of market share (Wright & Yuan, 2007). The bullwhip effect results in both successive overstocking and under stocking or requiring additional capacity followed by under-utilisation (McCullen & Towill, 2002).

The bullwhip effect is often referred to as the Forrester effect. Sterman (1989) used the beer distribution game to explain the bullwhip effect as "irrational" behaviour by managers or decision makers. Individuals within supply chains frequently find themselves in stressful situations, where product shortages will lead either to lost sales or to back orders which needs to be fulfilled. Due to the environment and pressure placed on the individual, they will naturally use their opinions of what the higher priority is and make a decision based on it.

The bullwhip effect results in oscillation and a lag effect between the various parts of the total supply chain which, to place in context, extends from the material supplier to the end consumer. A phase lag effect is best described as the oscillation transferring from one part of the supply chain to the next with the lead time between the different parts of the supply chain creating a lag (Alizadeh, 2012). Forrester showed that the feedback logic employed in typical production-distribution systems actually contributes to system instability, to induce both amplification and rogue seasonality (McCullen & Towill, 2002). This essentially means that the feedback logic may trigger a decision to produce stock, but given the lead times, this would be produced and placed in inventory well after the trigger is no more. By way of an example, lets us assume that a customer places an order in Week 1 and the business cannot satisfy the total order, a production plan is triggered for the factory to manufacture, which given the leads is only completed in week 5. By the time the stock is ready the customer may have decided to get a substitute product, which results in the organisation have stock levels that are above the stock holding policy. The organisation is now overstocked. In a perfect world instantaneous production and replenishment would negate this but the realities of the business world are very different. This results in an amplification of the demand signal. The spikes in the demand signal further gives an indication that there is seasonality with the demand horizon, which is actually false. There are numerous contributing factors to the bullwhip effect with Disney & Towill (2003) showing that Vendor managed inventory (VMI) seeks to condense the timelines and reduce lead times between the various echelons within the supply chain which in turn reduces rogue seasonality. Bhattacharya & Bandyopadhyay (2011) cite at least 19 causes of bullwhip effect.

There are, however, proven solutions to the bullwhip effect for organisations to consider which will contribute towards reducing costs and improving customer service levels (McCullen & Towill, 2002). Yet the phenomenon is still widespread amongst industries across the globe. Holland & Sodhi (2004), states that an incremental decrease in batch size and order deviations can lead to substantial benefits to the organisation in the form of reductions in order variances and the bullwhip effect. These possible solutions can aid managers to prioritise work that can lead to improvements provided they are able to see the big picture and make decisions that are for the benefit the whole and not just a small part of the organisation. The cost of the bullwhip effect on organisations would be the sum of bullwhip related inventory costs and the profit margin lost due to poor stock availability. McCullen & Towill (2002) highlighted the following four principles that could aid in reducing the bullwhip effect:

2.2.2.1 Principle 1: Time compression

This involves reducing material and Information processing lead times which results in there being smaller lags between the various phases of the total supply chain

2.2.2.2 Principle 2: Information transparency

Refers to the sharing of information amongst role players, within the supply chain, which can facilitate better decision making. Information integrity and honesty between role players is a critical contributor to success.

2.2.2.3 Principle 3: Control systems

Reference is made to the systems, procedures and policies that are in place to ensure individuals operate with a predetermined framework.

2.2.2.4 Principle 4: Echelon elimination

This involves reducing the number of interfaces that exist within the supply chain to shorten lead times. The underlying premise is that the shorter the chain the smaller the oscillation across the entire chain.

2.2.3 Relevance of S&OP

Daugherty (2011) points out that most research and many of the marketing strategies treat buyer-seller exchanges as discrete events, and not as ongoing relationships. Baumann & Andraski (2010) highlight that collaboration towards improving the total supply chain is a key element towards gaining business benefits. They further highlight that CPFR (Collaborative Planning, Forecasting & Replenishment) and S&OP can be implemented in a joint manner to give added benefits, with CPRF being external collaboration and S&OP being internal collaboration. Spen & Bask (2002) reiterated that in managing the supply chain researchers have emphasised integration, the flow of information to achieve efficiency improvement and managerial and structural issues as being important to improving the efficiency and effectiveness within the supply chain. The sharing of information between organisations leads to a reduction in the effects of the bullwhip effect, which in turn results in supply chain being more agile, adaptable and aligned (Ganesh, Raghunathan & Rajendran 2008).

Demand management is commonly viewed as being a key supply chain management inter-firm process. Demand forecasting was identified as one of the significant variables for bullwhip control (Wright & Yuan, 2007). One of the key aims of the S&OP process is to ensure a robust and accurate demand forecast, which will hence contribute towards reducing the bullwhip effect on an organisation. One of the primary benefits of S&OP is that it focuses on both strategy and partially on tactical issues (Olhager, Rudberg & Wilner, 2001). One can argue, however, that given that the S&OP process typically considers the zero to 24 month horizon it is not truly focused on the full strategic horizon period.

Wright & Yuan (2007) showed that an improvement in the areas of demand forecasting and ordering policies contributes towards alleviating the bullwhip effect. It was demonstrated that a relatively slow adjustment of inventory levels combined with a slightly more rapid adjustment of supply line levels provides the most improvements. These improvements results in smaller demand oscillations, which brings greater stability to the supply chain.

Metters (1997) states that the importance and impact of the bullwhip effect to an organisation greatly varies depending on the specific business environment that they operate within. Given appropriate conditions, however, eliminating or drastically reducing the bullwhip effect can increase product profitability by 10%-30%. There is a potential link between demand profiling and S&OP. Regularly updating the demand signal as part of the S&OP process can contribute towards ensuring that products are channelled through the most appropriate supply chain route (Godsell, et al, 2010).

2.2.4 S&OP shortcomings reviewed

Very often within organizations, individuals assume that if there is a process and a formula written in a very formal looking document then everyone within that organization will follow it. However, as discussed, it is very evident that individuals are all driven by different factors and hence behave and lead differently. This difference in behavior and worldview leads to conflicting priorities within an organization. Granted that the difference in behavior has advantages and disadvantages which will not be delved into at this stage.

Chakravorty (2012) stated that identifying the correct priorities for improvement programs is required because incorrect priorities increase the probability of failure. Instead of reducing strategy to a formula with detailed planning, it was noted that the human elements of leadership, morale and almost instinctive practical understanding characterize the best leaders (Chakravorty, 2012). The attributes that drives the planning process are identified as information, procedural and alignment quality (Oliva & Watson, 2011). In addition, social elements were also identified though substantial work in this area has not been done. The quality of decision making and the resulting plans is impacted by inconsistent decision making procedures or procedures subject to the cognitive and social limitations, influences and idiosyncrasies of individuals and groups (Oliva & Watson, 2011).

Kristianto, Ajmal & Helo (2011) mention that it is common place to find the sales function not fully integrated into the planning and scheduling processes within the S&OP process. It can be seen that collaboration amongst internal and external stakeholders is therefore a key success factor. Godsell, et al (2010) states that there has long been tension between marketing and supply chain functions and it is this conflict and misalignment that is reflected in the difficulty of reconciling market segments and product characteristics when developing supply chain strategy. This leads to a sub-optimum situation in which the demand profile is inaccurate leading to a myriad of symptomatic problems within the organisation.

It is common to find that many organisations complain about forecast accuracy and the difficulties experienced with matching supply and demand. It is, however, clear that many of these organisations have the systems, tools, processes and knowledgeable people to match demand and supply yet these very same organisations still complain (Zylstra, 2005). Why? Many organisations follow different frameworks when implementing S&OP, which could contribute to the inconsistent approaches seen. One of the beliefs in most organisations is that S&OP is intended for the tactical as opposed to the strategic level (Chen- Ritzo et al, 2010a). This translates to the organisation seeking to satisfy customer demand primarily within the short term, potentially between the zero to 12 month period. This also results in there not being the relevant checks to ensure that the outputs of the S&OP process are aligned and contribute towards the overall business strategy. As discussed earlier in this Chapter another viewpoint is that organisations also have a different definition of what the strategic level means. Some organisations using the S&OP process and hence focusing on the 2 year period may very well think they are regularly looking at the strategic level whilst their environment and circumstances may dictate that a period longer then 2 years should be considered.

The forecast accuracy achieved within organisations is one of the more important variables that contributes towards the ripples that are caused within the supply chain and is a key driver of supply chain efficiency and effectiveness. The variability within customer ordering profiles that are evident causes a knee jerk reaction in the supply chain, as there is continuous pressure to satisfy the customer order. This is known as the bullwhip effect. This knee jerk decision is driven by individual behaviour based on their understanding and implementation of current policies (Wyland, Buxton & Fuqua, 2000). Lim and O' Connor (1995) further support this by stating that this is a function of over reacting by individuals. There are many contributors towards the S&OP process not functioning as stakeholders would like with the bullwhip effect being cited as one of the major sources of inefficiency within the supply chain. They further state that both operational and behavioural factors have an impact on bullwhip effect.

There is an argument, however, that an effective S&OP process is fundamental to an effective supply chain. There are those that see S&OP as counter to the current world class manufacturing and lean initiatives, even though they go hand in hand. A lot more discussion and experience is required to change the mindset in which individuals see S&OP and world class manufacturing as supportive of each other. One can argue that S&OP is in itself a world class manufacturing initiative. Using system dynamics can go a long way to changing this mindset around S&OP not being an integral part of the manner an organization goes about its business, as it can be used to answer what if questions and evaluate the benefits of decisions and policies over the short, medium and long term (Ross, 2003).

In many organisations, S&OP does not function as per the defined policies and procedures with one of the recommendations being to use technology to ensure a more robust S&OP process (Ross, 2003). A potential flaw in this recommendation is that technology will aid in ensuring that information is readily available and speed up certain processes and analysis but it will not be able to govern how people interpret policies and scenarios which then leads to a particular decision. There are various computer software applications that organizations use to model or simulate their environments in the hope that a better understanding of the environment will lead to solutions. Simulation technology is a key tool in evaluating system variation though a shortcoming is that it generally looks at quantitative analysis and not inclusive of qualitative factors. The field of system dynamics considers the social system as well. In the current business environment the difference between the leader and follower is one in which the leader is able to consider real life constraints and fluctuations within the environment and to develop solutions to address problems (Wyland, Buxton & Fuqua, 2000).

There are various approaches and techniques to reducing the bullwhip effect such as choosing the appropriate forecasting techniques (Alizadeh, 2012). Centralising customer demand can further contribute to reducing demand volatility but will not eliminate it completely (Chen, Drezner, Ryan & Simchi-Levi, 2000). The underlying principle however is to have a transparent supply chain and to understand the impact of company policies on decision making and hence the consequences on the business. Alizadeh (2012) stated that with known solutions it still takes a long time for supply chains to improve. This is largely due to the bullwhip effect and S&OP being a three dimensional problem and is hence difficult for people to conceptualise. It involves replenishment, time and geographical considerations (McCullen & Towill, 2002). Due to the multidimensional and multitude of quantitative and qualitative variables that an individual must consider it is highly improbable that anyone or even a group of people have the ability to visualize the holistic picture.

Niehhaus et al (2003) states that causes of the bullwhip effect can be divided into two groups:

- Time lags and planning
- Behavioural aspects.

System dynamics is well suited to this application as demand forecasting and ordering policies are two key methods of controlling the bullwhip effect. As stated by Chen, Drezner, Ryan & Simchi-Levi (2000) various attempts have been made to quantify the impact of the bullwhip effect but these models do not capture many of the real world complexities that are typically found in organisations. It is common to find that a host of industries are plagued by excess inventory levels and excess assets. However, the relative contribution of the bullwhip effect when compared to the factors that contribute to demand oscillation is unclear (Metters, 1997). Not understanding the dynamics and relationships between the various factors normally results in the organisation getting it wrong. Some of the symptoms of this would typically be higher working capital, implementation of overtime and additional shifts, incorrect product mix, additional warehousing and transportation costs, additional production costs, poor service levels and reduced turnover (Kim, Jun, Baek, Smith, & Kim, 2005). This behaviour is further perpetuated by individuals being focused on driving local functional improvement as opposed to overall business improvements (Repenning & Sterman 2001). There therefore exists an opportunity for system dynamics to be suitably applied to such a problem to capture the causal relationships and feedback loops that would be evident in such a problem.

Ackere, Haxholdt, & Larsen (2006) applied system dynamics to the service industry in which customers faced a scenario in which they had to make decisions on, (1) Who should they use and (2) When and for how long should they use the service provider. The system dynamics process identified the key leverage parameters of waiting time, maximum service rate, and service capacity which if controlled will make management of the system easier. It is important to note that the parameters identified also contributes to individuals perceptions of service and hence would influence the decision.

Metters (1997) highlighted that the bullwhip effect is due to a lack of systems thinking by management. The bullwhip effect is generally accepted as stemming from rational, profit maximising managers who have the best intentions when making decisions. Given they do not necessarily have the big picture in mind they cause more harm then good. The effect of the bullwhip effect can be measured by the parameters of demand variance and seasonality or the more consequential effect, which is overall business profitability. Hence, given that the focus with regards to S&OP has been largely done via quantitative models, the application of system dynamics to understand the impact of behaviors and causal links on profitability is very applicable in the context of this study.

Research into assessing product variety on the S&OP process was conducted by Wan, Evers & Dresner (2012). The work was focussed on modelling the physical system and did not consider the impact of social or behavioural aspects on performance or profitability. The article did however state that causal relationship plays a role. It further highlighted the need for practitioners to understand the impact of non-linear factors on profitability (Wan, Evers & Dresner, 2012). From studying current supply chain literature, system dynamics is well suited to this. Often it is found that the operational bounds of the mathematical models are set by fixed mathematical policies leading to a gap existing between aggregate planning theory and industrial practice (Buxey, 2003).

Demand uncertainty has a major influence on the behaviour of the supply chain and is not adequately handled by managers. Much of the uncertainty can be handled at the tactical level, as at this level there is still sufficient time to decide upon appropriate counter-measures. What is found in practice though is that the consequence of trade-off decisions is not always understood by managers. Given the propensity for individuals to also change jobs and positions there exists a need for newcomers to a role to be adequately trained. System dynamics can provide a learning laboratory to test these decisions (Van Landeghem & Vanmaele, 2002). Whilst the literature mentions behaviours having an impact on S&OP and organisational profitability, there exists an opportunity for further modelling to be done on this problem using the system dynamics framework.

Lawrence & O'Connor (2000) pointed out that the forecast is set in meetings involving personnel from the sales, marketing, production and finance departments and hence behavioural elements will have a significant impact on the forecast. Malin (1997) states that one's cultural background plays a role in one's attitude towards uncertainty. Ge, Yang, Proudlove & Spring, (2004) highlighted that a key point in a study showed that the forecasting technique used (example: weighted average, exponential smoothing, etc.) is not as important to reducing the bullwhip effect as attention given to controlling factors such as information delays and information sharing.

A common view is that new research is required in finding ways to improve supply chain co-ordination with the current economic recession/climate being cited as an area of study with regards to the bullwhip effect and S&OP. The bullwhip effect is especially prevalent in developing markets such as those found within Africa in which demand amplification is common place (Bhattacharya & Bandyopadhyay, 2011).

In the literature review, numerous authors cite behavioural elements and cross functional integration and ways of working as being a lever that contributes to the success or failure of the S&OP process. From the literature, it is also evident that more focus has been on the quantitative aspects of S&OP instead of the behavioural contributors.

2.3 SYSTEM DYNAMICS

There exists an opportunity to conduct research into determining what really happens within an organisation when compared to the S&OP policies and strategies that are meant to drive the correct decision making behaviours. This needs to be conducted whilst considering both quantitative and qualitative factors. Morecroft, Lane& Viita (1991) outlined a case study in which a system dynamics model is used to aid in strategic decision making. System dynamics can be further applied to the evaluation of strategy alternatives and their impact on overall organization profitability. There is an opportunity and requirement within organisations for linking the strategic and operational level issues (Martinez-Olvera, 2008).

A requirement is for the S&OP process to be open, transparent and participatory. This motivates individuals to be involved and to serve their stakeholders needs. However, it is often found that functional distrust and poor behaviours complicates the process. These unhelpful dynamics are not only prevalent but are also persistent in industry (Oliva & Watson, 2011). Demand uncertainty is often accounted for in the demand planning step using a combination of quantitative methods and expert judgement, which is subjective and varies within different organisations and functions (Chen-Ritzo, Ervolina, Harrison & Gupta, 2010).

The bullwhip effect is caused by both operational and behavioural actions within any organisation. It is therefore imperative that both operational and behavioural aspects be addressed in an integrated manner and approach. The bullwhip effect is the result of a lack of information and co-ordination amongst key players in an organisation (Bhattacharya & Bandyopadhyay, 2011). Bullinger, Kuhner & Van Hoof, (2002) cites low information transparency as a major weak point. With the advancements in computer hardware and software technology, building simulation models is an option that is readily available to most organizations.

Wyland, Buxton, & Fuqua (2000) state that building a simulation model is not about understanding the software but also about involving the right people and pinpointing the right information as inputs. The basic steps cited by Buxton, et al (2000) are, Problem definition, data collection and manipulation, model formulation, validation and verification, analysis and experimentation and conclusions and recommendations. This is similar to the Sterman model, which is followed when developing a system dynamics model.

The use of computer software to build models of real world systems and problems is common place. However, focus has mainly been on building models using quantitative data. Kristianto, Ajmal & Helo (2011) stated that focus is mostly made on quantitative modelling and considerations within the supply chain environment. Forrester (1986) states that whilst modelling of the physical sciences have seen advancements, modelling of the social sciences is lagging behind. System dynamics seeks to model this field by tapping into 3 areas for information (i.e. The Mental, Written & Numerical databases), with the mental database providing the most amount of input data. The new trend is a shifting focus from the physical (Science & Technology) to understanding social systems (Forrester, 1986). Angerhofer & Angelides (2000) further support this by stating that Systems Dynamics is a field that models social systems & considers the time delays of decisions and policies.

System dynamics is a discipline for seeing wholes, recognising patterns and interrelationships and learning how to structure these interrelationships in a more effective and efficient way (Huang et al, 2007). System dynamics is suitable in applications that consider the tactical and strategic level instead of the operational levels (Rabeli, Sarmiento & Jones, 2001).

2.3.1 System Dynamics defined

The systems approach or thinking originated in the physical sciences where it challenged the prevailing norms by considering instability, non-linearity, discontinuity and chaotic behaviour (Mingers & White, 2010). The fundamental principle in system dynamics states that the structure of the system gives rise to its behaviour (Sterman, 2000). This is due to the feedback loops and relationships that inherently exist between variables and within a system. Systems thinking generally include the following:

- Viewing the situation as a set of diverse interacting elements within a holistic environment.
- Recognises that the relationships or interactions between elements are more important than the elements themselves in determining the behaviour of the system.
- Acknowledges that different levels of hierarchy exist and causality exists both within and between levels.
- Accepting, especially in social systems that people will act in accordance with differing purposes or rationalities.

System dynamics modeling is essentially a digital computer aided approach for mapping managers' mental models of their system. This is converted into a simulation model to facilitate what-if experimentation that facilitates experiential learning. Simulation and simulation software has the functionality to evaluate variations, interdependencies, capture a greater level of detail than conventional modeling techniques as well as capture specific qualitative aspects (Azadeh, Layegh, & Pourankooh, 2010). Information collection during this process can be acquired from three sources viz mental, written and numerical databases. However, the key source of information is from the mental database with the content of information decreasing as one goes to from the mental, to written to numerical databases as illustrated in Figure 2.1 below. Qualitative data collected will be transformed into a format relevant for use in the software specified.

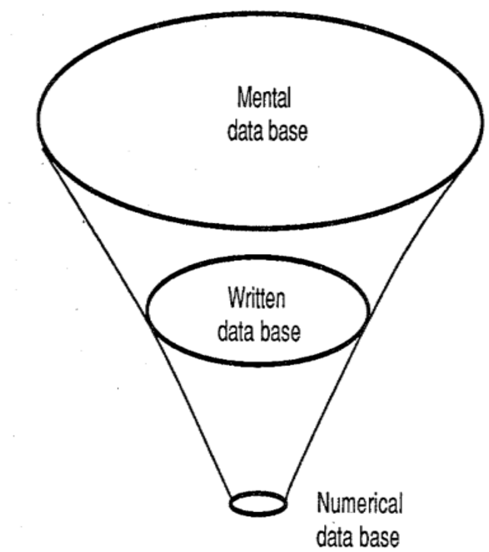


Figure 2.1: Decreasing information content in moving from mental to written to numerical databases.

Forrester, J.W. (1986). Lessons from system dynamics modelling. The 1986 International Conference of the System Dynamics Society. Sevilla, October, pg9.

It is clear from the above diagram that a high reliance is placed on the mental database for inputs in the model building process. Lune-Reyes & Andersen (2003) stated that qualitative analysis when done properly brings a high level of rigor and robustness to the model built.

System dynamics is a tool in today's high pressure environment where there is a tendency to look at solutions with short-term benefits only. It seeks to evaluate the impact of not only individual decisions or policies but a combination of one or more decisions and policies. Lyneis, Cooper & Els (2001) stated that if the consequences of individuals actions or decisions were summed up it would be less than the actual impact seen post the implementation of all actions and decisions. In other words, the sum of the individual changes and their corresponding impact is less than the actual impact experienced.

System dynamics seeks to capture the views and perspectives of individuals, develop an overview, share the big picture and thereby try to anticipate the consequences of decisions. This is done via the development and use of a model. A model is a physical representation of the real world and an aid to imagination and learning, a transitional object to assist individuals to make better sense of a partially understood problem (Morecroft, 2010). System dynamics is about feedback systems thinking, which breaks down silo thinking and narrow functional perspectives. System dynamics also models the interplay of the various feedback processes (Morecroft, 2010). Feedback systems' thinking is different from event oriented thinking because it strives for solutions that are "sympathetic" with their organisational and social environments. Solutions are not implemented in a vacuum and consideration is given to short and long term consequences. System dynamics highlights that using this approach gives thought to further factors by showing that often there is more going on then meets the eye (Morecroft, 2010).

Richardson, (2011) defines system dynamics as the mental effort to uncover endogenous sources of system behaviour. System dynamics is the use of informal maps and formal models with computer simulation to uncover and understand endogenous sources of system behaviour. System dynamics practitioners use system thinking, management insight and computer simulation to:

- Hypothesis, test and refine endogenous explanations of system change
- Use these explanations to guide decision and policy makers/making.

System dynamics is an approach that is able to compensate and repair some of the shortcomings seen in typical quantitative models. System dynamics models takes into consideration delays, bounded rationality and goal setting. Setting of model boundaries is important and system dynamics considers most factors as endogenous whilst other approaches consider key factors such as customer demand as exogenous (Akkermans & Dellaert, 2005). Whilst the external environment does contribute to demand fluctuations, internal policies, decisions and behaviour also contribute towards creating this imbalance between supply and demand. System dynamics states that the boundary of the model needs to be determined in a manner in which exogenous factors are included within the model boundaries. This therefore transforms exogenous factors into endogenous factors (Morecroft, 2010).

Compared with the more common approach of discrete event simulation, which inevitably models a system in operational detail such as every single machine, the system dynamics approach provides a means of modelling at a higher aggregated level, which results in efficient and effective modelling and time savings (Lin, Baines, O'Kane & Link, 1998). There is an erroneous assumption that the dynamics of the problem/system can be attributed to exogenous events which results in individuals not looking at the true root cause and hence not identifying the true potential for improvements. They therefore do not identify the critical leverage points that will yield the most sustainable results.

System dynamics lends itself to the development of simple causal loop diagrams, which encapsulates a portion of the business in which systemic feedback loops, systemic delays and unintended consequences are evident and highlights the real business dynamics that should be considered. Traditional simulation models are discrete-event simulation and do not take into account the hidden dynamics of a problem (Ashayeri & Lemmes, 2005). System dynamics models help to organise information in a more understandable way and link the past condition into the present one and extend the present into future alternatives through scenario development (Suryani, Chou, Hartono & Chen, 2010).

Rather then predict the future, system dynamics models tell a consistent future story of the system based on the structure as provided by managers (Cagliano, DeMarco, Rafele, & Volpe, 2010). Whilst the model is mathematical in nature, the key data that is used is qualitative in nature (Lune-Reyes & Andersen, 2003). This relates to the required data originating primarily from either the mental or the written databases. Computer based modeling makes the process of modeling simpler. The difference between the mental model and the properly conceived computer model is the ability of the computer model to determine the dynamic consequences when the assumptions within the model interact with each other (Forrester, 1971). System dynamics seeks to take the separate parts of the social system and to combine them into a computer model and to learn the consequences.

Richardson (1999) lists four areas that system dynamics looks at to achieve the required outputs:

- Computer technology
- Computer simulation
- Strategic decision making
- Feedback thinking

Computer models are sometimes based on methodologies for obtaining input data that commits the model to omitting major concepts and relationships in the psychological and human areas that is crucial in modeling social systems. With regards to computer models, the key is not to computerize the model but to have a model structure and relationship, which represents the system that is being considered. This model is a statement of the system structure (Forrester, 1971).

System dynamics is well equipped to model social systems and the problems that are experienced. Forrester, (1971) listed the characteristics of social systems as:

- Social systems are insensitive to most policy changes that people select in an effort to alter the behaviour of the system.
- Social systems all seem to have a few sensitive influence points through which the behaviour of the system can be changed
- There is usually a fundamental conflict between the short term and long term consequences of a policy change. A policy which produces an improvement in the short run (within 5 to 10 years) is usually one that degrades the system in the long run (beyond ten years)

System dynamics is able to represent the real world. It can accept the complexity, non-linearity and feedback loop structures that are inherent in social and physical systems (Forrester, 1994). Systems thinking uses causal loop diagrams (CLD) and stock-flow diagrams to enable understanding of the problem being studied within a particular environment. They highlight the relationships and interactions between the various variables. A CLD is a visual representation of how different variables are interrelated. In order to understand the structure of a system at a more detailed level a different technique is required to create the system and allow us to explore it. The stock-flow diagrams allows the practitioner to do this by visually representing the system together with the underlying mathematical equations (Marquez, 2010). In system dynamics a causally closed system is one in which the causes creating the behaviour of interest lie within the system and are known as endogenous factors (Forrester, 1994). The beer game, which is a well-known feedback based management game, can display all the typical behaviours of a coupler system. This is a common example of system dynamics in action (Mingers & White, 2010).

2.3.2 Relevance of System dynamics

Organisations are constantly challenged by problems of growing complexity and scope. Due to this challenge, supply chains and organisations are continuously seeking to model any given system with the intent of understanding and improving it. Akkermans & Dellaert (2005) highlighted three SCM (Supply Chain Management) modelling approaches that are common. These are:

- The discrete time approach

  Generally considered the more preferred approach and involves decision making and planning within specific time buckets. Analysis are done within discrete time frames and decisions are based on this. This methodology places a high reliance on planning which is based on forecasts. The S&OP process within the current organisation in which the study is being done, also focusses on forward planning based on a forecast and is managed in weekly buckets.

- The continuous time approach

  This approach requires that the supply chain is understood on a continuous basis with the chain being treated as a pipeline versus having specific touch points. It debates that consideration is not only given to the more quantitative aspects but qualitative factors such as behaviours and the impact of learning is considered. System dynamics falls within this approach and is useful in applications that explain supply chain behaviour and the impact of improvements.

- The control theory approach

  Typically used in process control approaches and applied to either continuous or discrete situations. This approach is commonly used in bullwhip avoidance applications.

System dynamics can be a useful methodology that can be used to cross fertilise these approaches to develop more robust outputs (Akkermans & Dellaert, 2005). System dynamics enables an organisation or individual to move away from trying to understand the impact of the individual actor on the system but to understand and test theories and policies to the system. It helps us understand and explain the endogenous generation of macro behaviour from the microstructure of human systems (Sterman, 1989).

Akkermans & Dellaert (2005) states that a better understanding of the complex dynamics that determine performance of supply chains has become crucial for superior performance in supply chain management. Insights from system dynamics are now more needed then they have been during the past four decades. This is especially relevant since the supply chain of today has been cut into pieces and diversified in all areas and regions due to increased complexity. System dynamics is well suited to introducing a dynamic approach to developing problem solving and developing organizational strategy. Richardson (1999) stated that as we solve the more visible problems of the physical model with the sciences and world we need to increase focus on the less physical aspects, which is potentially more critical to success. With organisations and supply chains being split and becoming more complex, it is imperative that information sharing is at the highest level to ensure success, which requires a high level of transparency and trust (Akkermans & Dellaert, 2005).

Whilst other model building methodologies focus on the ideal end state, System dynamics reveals the way in which the model was reached to describe the current state and then moves to the future state (Forrester, 1994). System dynamics hence displays how the problem under consideration is generated in the real world giving the role players an in-depth understanding of the problem and the environment in which it is found.

The linking of strategic decision making and feedback thinking is especially relevant given that the strategy and feedback worlds are complex and interdependent and makes mental simulation by individual's difficult (Richardson, 1999). The efficacy and robustness of decision strategies lies not only in the availability of outcome feedback loops but depends crucially on the nature of the feedback action between decisions and the changes in the environment which condition future decisions. This structure consists of stock & flow diagrams, information networks, time delays and non-linearity, which characterize the organisation, problem and system (Sterman, 1989). Qualitative maps can show causal relationships, feedback loops and can be used to gain buy in and hence change behaviour (Rouwette & Vennix, 2006).

The literature further highlights that typical behaviours and reward systems make "fire fighting" an ingrained cultural norm. Changing this type of behaviour and thinking will require policy changes to ensure strict control and milestone gates are maintained (Repenning, Goncalves & Black, 2001). It is found that individuals too often do not look at cause and effect. When they do, the assumptions are that the cause is closely linked in terms of time and space to the effect. This could lead to incorrect conclusions on root cause and hence on what to fix (Repenning & Sterman, 2001). Bianchi & Bivona, (2002) further highlighted that should decisions be made to drive one success factor without consideration of the others the result will be a longer term failure or loss. The key here is that the interaction of a number of small events could have a high overall impact on the organisation (Repenning & Rudolph, 2002).

Morecroft, Lane, & Viita (1991) showed how a system dynamics model was used to aid in strategic decision making. Oliva & Sterman (2001) applied system dynamics modeling to service quality within the service industry and identified both qualitative and quantitative factors that impacts service. System dynamics was used to model the interactions between all these factors and to understand their impact. It explores how boundedly rational decisions often lead to unintended long term consequences. Organisations often work in a conflicting and suboptimal manner, in the sense of overall performance (Bullinger, Kuhner & Van Hoof, 2002).

The literature has also highlighted that qualitative analysis when done properly brings a high level of rigour and robustness to the model building process and hence the final model built (Lune-Reyes & Andersen, 2003). System dynamics adds causal factors such as human bounded rationality, information delays, managerial perceptions, etc to the more traditional supply chain management rules (Cagliano, DeMarco, Rafele, & Volpe, 2010).

Change and change management is a key component of many of today's industry leading organisations who look for better methods to compete. System dynamics can be used as a change management tool to get buy in for decisions (Wyland, Buxton & Fuqua, 2000). Senge & Sterman, (1990) stated that for new policies to come into effect, individuals must go through their own learning process, as this is essential to the change management process.

Forrester as repeatedly stated that managers must be involved in the modeling process and the mental models of managers must be accessed. The involvement also helps when implementing changes as there is now buy in. This approach is called group or participative modeling (Rouwette & Vennix, 2006). The more involved the individual the higher the propensity for buy in and behavioural change. It is therefore important to involve stakeholders at various levels within the organization. However, it is important to note that involving stakeholders in the process and utilizing their mental database as inputs does not guarantee success. The mental models of individuals are not powerful on their own but rather needs to be harnessed into a more holistic view. The use of system dynamics and a computer model is able to provide this (Ledet & Paich, 1994).

It was also noted that the new generation of employee's job hop frequently. This means that labour turnover will result in churn within the business and supply chains. A system dynamics learning laboratory will hence be useful as a teaching tool to new decision makers who join the organization (Martinez-Olvera, 2008). Some of the benefits of learning labs as stated by Senge & Sterman (1990) include:

- Shortening the learning curve for new managers
- Improving communication skills
- Creating an atmosphere for organisational learning
- Clarifying and testing assumptions
- Making mental models explicit

Cross-functional integration among different departments represents an important aspect of organisational structure in terms of the types of lateral relationships and the degree of collaboration that exists between the different functions. It is stated that those organisations that are able to integrate specific functions in line with their strategy generally have a better performance (O' Leary-Kelly & Flores, 2002). Studies show that increased integration between sales & marketing and operations helps to reduce overall operational costs and hence organisational performance. Often demand uncertainty and business strategy variables are seen as exogenous variables (O' Leary-Kelly & Flores, 2002). This, however, implies that these leverage points are seen as out of the control of the organisations and hence a mind-set of helplessness could set it. System dynamics states that it can be modelled as an endogenous variable.

Guo, et al, (2001) emphasized the applicability of system dynamics as an appropriate approach to analysing the interactions and impact of various policies on the problem or case study selected. System dynamics is further able to model a problem, evaluate alternatives as well as what needs to be done to prevent the negative future states from occurring. Whilst there has been numerous studies highlighting the applicability of system dynamics, it is by no means the perfect methodology and there is room for further applications to consider other research areas such as inventory control or queuing theory (Akkermans & Dellaert, 2005).

2.3.3 Further applications of System Dynamics

Kanungo & Jain (2008) demonstrated how system dynamics is used to model relationships between various variables that relate to the implementation of a new email system with the intent to understand why no productivity improvements were observed. The authors cite company policy and individuals own unique understanding of that policy as important in how the new email system and its use is controlled to ensure overall improvements.

Minami & Madnick (2009) focused on using system dynamics to develop a model to assist in understanding the impact and interactions of various dynamic feedback processes and delays relating to decision making with regards to accident prevention. Lyneis & Madnick, (2008) applied system dynamics in evaluating safety policies to understand their ability to reduce safety accidents. System dynamics models are based on the concept of having feedback loops which also ensures causal factors are considered. The model was validated and used to test various scenarios. The key benefit of the model is that individual policies can be tested as well as the model having the ability to test multiple policies and their impact simultaneously.

Kunc, (2008) used system dynamics to simulate the tensions between short term (market demand & profitability) and long term (organisational structures and professional development) issues. The purpose was to enable managers to understand the dynamics and impact on budgets and policies. The model was also used as a dynamic tool by managers for decision making and included a graphical user interface.

Coyle, (1992) applied system dynamics to determining the best deployment policy of aircraft carriers. A model was developed with no data being available hence placing a high reliance on expert opinions with the model being validated by comparing the results against common sense and mental databases. As often demonstrated the ability of system dynamics to extract inputs from the mental database of individuals is critical in ensuring a robust model.

System dynamics was used to build a model and run simulations to determine the impact of policies and strategic decisions as well as determine the limitations to key KPI's with regards to evaluating e-commerce strategies on business performance (Bianchi & Bivona, 2002).

System dynamics has therefore proven useful to test alternatives, enabling managers to plan for success in a proactive manner instead of encountering problems, which are a surprise and results in further oscillations. It is also useful in detecting reinforcing and balancing loops. The above literature shows that system dynamics models have been developed in a wide range of applications and can therefore be further utilized in a supply chain environment.

2.3.3 System dynamics shortcomings reviewed

There exists within any organization a need to understand the interdependencies in a model. Again, it was noted that the model structure is important to ensure all causal loops are included in the model (Oliva & Sterman, 2001). System dynamics can be seen as a top down approach if the correct involvement is not ensured throughout the project. Recent developments in System dynamics include the prominence of generic structures or archetypes and efforts on behalf of system dynamics to become less isolated and to link more to other disciplines (Mingers & White, 2010). Stadtler, (2005) states that not only is the underlying mathematics a concern but focus needs to be given to inter disciplinary research. Statistical design would aid in improving the acceptance of the system dynamics models by other disciplines (Akkermans & Dellaert, 2005). This work needs to be extended to further cross functional problems.

There therefore exists an opportunity to further apply system dynamics modelling to further problems within the supply chain environment. The use of system dynamics in supply chain modelling has been very limited but with the increased complexity that organisations are facing recently system dynamics is gaining in popularity. Uncertainty is evident in all aspects of the supply chain making the application of system dynamics to supply chain related problems very applicable (Ashayeri & Lemmes, 2005).

Daugherty, Gawe & Caltagirone, (2010) highlighted that cost will always be a primary influence in business decisions and hence system dynamics as a tool will need to demonstrate its usefulness. There is therefore a need to quantify the impact of modeling a social system and evaluating the impact of policy on decisions made on the overall supply chain efficiency and effectiveness.

Repenning & Rudolph, (2002) stressed that there could be a loss of richness when qualitative data is translated into a mathematical model which needs to be considered when undertaking the task of building a system dynamics model. Model validation to ensure that the model represents reality is therefore a key step in ensuring qualitative data is adequately captured within the model. The literature suggests that system dynamics can be more powerful if quantitative methods from other approaches are included in the system dynamics approach (Akkermans & Dellaert, 2005).

Computer simulation is a valuable aid for gaining insight into and making predictions about the behaviour of a system or problem. Simulation is considered to be synonymous with discrete event simulation, which results in a shadow being cast on system dynamics models as they rely heavily on the qualitative data found in the mental models of stakeholders. However, there are other types of simulation that exist, with system dynamics being one type that has considerable unrealised potential (Lin, Baines, O'Kane J & Link, 1998).

2.3.3 Applicability of Research topic

Due to the differences in complexity and environment that exist globally and within organizations the "one size fits all" approach to developing business and supply chain strategy is not the best option (Godsell, Diefenbach, Clemmow, Towill & Christopher, 2010). Lapide (2006) further states that supply chain excellence requires a context specific approach based on a strategic framework and set of underlying principles, and not a set of generic answers. The implication is that problems, decisions and behaviours in one product category are not necessarily acceptable to other categories.

It is well understood that the demand planning and hence the S&OP process is a critical business process that influences all aspects of the supply chain and business profitability. The demand planning and management process has in recent times become more complex due to the changing environment, which has become more unpredictable, fragmented and dynamic. This places further pressure on managers to manage dynamically and be able to make decisions that are best for the entire organisation and not just a small business function (Ashayeri & Lemmes 2005).

Cagliano, DeMarco, Rafele, & Volpe (2010) highlighted that the number of practical applications, of system dynamics to supply chain related problems that can be found in current literature is limited. Angerhofer & Angelides, (2000) suggested incorporating system dynamics and Operations Research (OR) for further research within a supply chain environment. It is also highlighted that operations research is ineffective if applied to isolated problems. Fugate et al (2009) states that in operations and supply chain management, within-firm and across-firm integration has been shown to positively influence firm performance. They further state that firms need to manage and respond to the increasing complexity of markets, suppliers and investors. Barratt (2004) states that very few organisations have achieved the broader-reaching integration that consistently develops multi-functional plans that are executed in a coordinated fashion.

Malhotra & Sharma (2002) shared the view that very little empirical research has been done on functioning integration approaches and a detailed understanding of interdepartmental integration based on micro-level has yet to be established. Pagell (2004) therefore states that a comprehensive understanding of cross-functional integration is lacking in the literature. Raman and Watson (2004) state that in the current business environment with increased competition and globalisation creating further challenges and opportunities, and fostering further differentiation firms will struggle even more with ensuring integration.

System dynamics can be cross fertilised with other supply chain approaches to ensure a more holistic approach is taken to problem solving. Data driven approaches assume that more and better quality information will lead to better decisions. However, one needs to question how human decision making is included (Akkermans & Dellaert, 2005). Sterman, (1989) suggests that future work should apply system dynamics to other dynamic decision tasks. The supply chain environment provides ample opportunity for the application of system dynamics.

System dynamics forces users to view a manufacturing system at a relatively aggregated level of detail. This is conducive to the evaluation of strategic changes to a system. Unfortunately, the current literature suggests that system dynamics appears to not have been applied to its full potential in evaluating strategy scenarios (Lin, Baines, O'Kane & Link, 1998).

2.1 CONCLUDING REMARKS

This Chapter has highlighted the literature that is available across the S&OP and system dynamics niche areas, within the context of the business environment. The review supports the need for a study such as this as there is reason to believe that the application is suitable and will add value. This research is aimed at utilising system dynamics and determining its relevance to this particular application given that the theories discussed in the literature show it as having the ability to align individuals towards a common goal by ensuring the correct policies are in place.

Often policies generate excellent results quickly, but if implemented for a long time, they prove to be detrimental. The opposite is also true. Most strategies, which are beneficial in the long term usually, have negative effects in the short term. Before taking action or implementing a policy, the long terms effects of the policy should be understood. The following Chapter will give details into the methodology that was used for this study, the modelling building and use of the model, linking of the study to the literature followed by the conclusions and recommendations.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 INTRODUCTION

The preceding Chapter dealt with the literature review to ensure that an extensive understanding of the key topics was acquired. The literature review was hence centred on System dynamics, Common Supply chain challenges, The Bullwhip Effect, Sales & Operations Planning and the modeling of physical systems versus social systems. This Chapter explains the methodology that was followed during this research study. The applicability of system dynamics to this study is explained together with an explanation of the System dynamics methodology, followed by the case study it was applied to. The Chapter then goes on to explain the activities taken behind each step in the methodology. Given the nature of system dynamics, its reliance on accessing the mental models of the various role players and that System dynamics modeling focuses on modeling a problem, the data to complete a model was extremely limited. It is for this reason that this study follows a very specific approach and is reliant on a qualitative approach to gather data.

3.2 SYSTEM DYNAMICS

I utilised the System dynamics modeling methodology to model the problem within the context of the environment that it resided in. The methodology enabled me to fully understand the system and its characteristics. It is important to note that System dynamics modeling is focused on modeling a problem versus modeling a system. There is a subtle difference in this statement. Traditionally individuals would model a physical system and then use it to test various "what if" scenarios. System dynamics on the other hand models a problem and considers both quantitative and qualitative or behavioural aspects. System dynamics recognizes that system behavior is not imposed from the outside but rather from within the boundaries of the problem and that the system behavior is a function of the interactions of the variables within the model (Richardson, 2011).

Another fundamental reason for applying System dynamics to this particular problem is that frequently one finds that individuals will follow policies, which they assume will lead to problem resolution. This is done in conjunction with the individual's dependence on using their intuition or gut feel to determine solutions to complex behavior (Forrester, 1994). System dynamics enables an organisation to move away from trying to understand the impact of the individual on the system but rather to understand and test theories and policies on the system. It helps us explain the endogenous generation of macro behaviour from the myopic behavior of individuals (Sterman, 1989).

The sales and operations planning process that was the focus of this study is extremely complex, spans the entire supply chain including internal and external parties as well as having casual and feedback loops that spans across varying time frames. System dynamics uses stock-flow diagrams to show causal loops, which includes those causes that create the behavior of interest (Forrester, 1994). The applicability of utilizing the system dynamics methodology and thinking to this study is well supported by the literature.

The System dynamics methodology seeks to model social systems and problems across the short, medium and long term, using inputs from the mental database as the primary input (Forrester, 1986). System dynamics modeling hence seeks to convert qualitative data into quantitative data to build the model using the relevant software. In this instance, I used software called *iThink.* This software is specifically developed and used in System dynamics applications. It is therefore essential that the data is collected and converted ready for use in a robust manner to ensure that the model accurately depicts the problem and hence system.

A common pitfall of modeling using System dynamics is that practitioners sometimes over use causal diagrams beyond the limits of mental simulation. The use of computer hardware and software technology overcomes this particular obstacle (Richardson, 1999)

The methodology I followed is Sterman's five step process. The five steps can be seen in the Figure below.

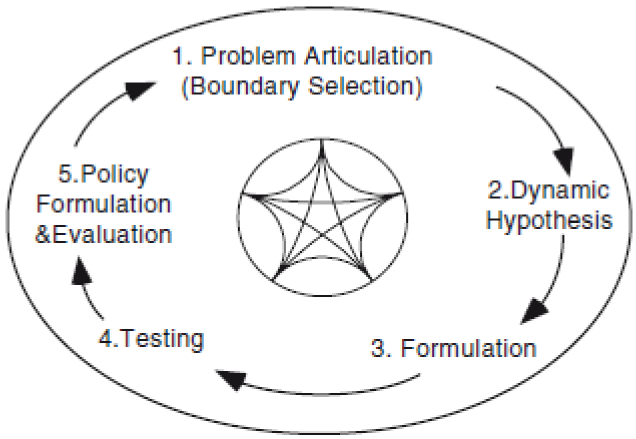


Figure 3.1: System Dynamics modeling process

(Sterman JD, 2000). Business Dynamics: Systems thinking and modeling for a complex world, Boston, Irwin McGraw Hill, Pg 87.

It is important to note that as can be seen in the centre of Figure 3.1, there is a network of lines joining each step to the other. This is indicative that the system dynamics methodology is an iterative one. The intention of this is purposeful, as during the modeling process the modeler is continuously improving his/her understanding of the situation and hence the model is improved. Forrester (1986) states that the holistic understanding and building of the model is typically achieved by completing diagrams, understanding concepts, stock-flow diagrams and doing simulations which can be compared to the real world as a test. Hence as the modeler or team member one should not expect the five steps to follow in series but rather a number of iterations of the model and to move between steps until the problem is accurately modeled and adequately depicts reality. This must translate into the model being fit-for-purpose.

Problem articulation or boundary selection seeks to identify the issue or problem within a particular environment as well as the scope of factors involved. Boundary selection is a critical step as having to narrow boundaries or scope will result in certain insights being omitted whilst having too broad boundaries results in unnecessary noise and data collection. Both of which could result in a model that does not accurately depict the problem and hence cannot be used for the intended purpose.

Dynamic hypothesis is the step in which the modeler would list or sketch the interactions and feedback loops of the problem which would enable a comprehensive understanding of the problem and its drivers. This aids the modeler in understanding the problem and feedback loops. I would like to once again emphasis that this is an iterative process hence the understanding of the problem and complexities involved would not occur at the first attempt.

Formulation is the process in which the modeler transforms the hypothesis into detailed diagrams showing feedback loops and corresponding equations (Forrester, 1961). Stock-flow diagrams form a part of this step as well.

Testing simply put is the validation and verification process applied to the model built. Validation is the process followed to authenticate that the model was constructed in accordance to the prescribed methodology. Verification on the other hand is the process of comparing the models behaviour over time with evidence from the real world problem and environment. This is done with the intent of establishing the accuracy of the model and ensuring that the model depicts reality, is plausible and fit for its intended purpose. Depending on the results, the modeler may need to revisit steps 1, 2 or 3 or a combination thereof.

Policy formulation and evaluation is the final step and will only occur once the system dynamics practitioner is confident that the model accurately depicts the problem and is able to simulate the real world problem and behaviours. The system dynamics model is then used as an improvement and learning tool to evaluate policy improvement interventions.

Information collection during this process was acquired from three sources viz mental, written and numerical databases. However, the key source of information is from the mental database with the content of information decreasing as one goes from the mental, to written to numerical databases as illustrated in Figure 3.2 below. Qualitative data collected was transformed into a format relevant for use in the software specified.

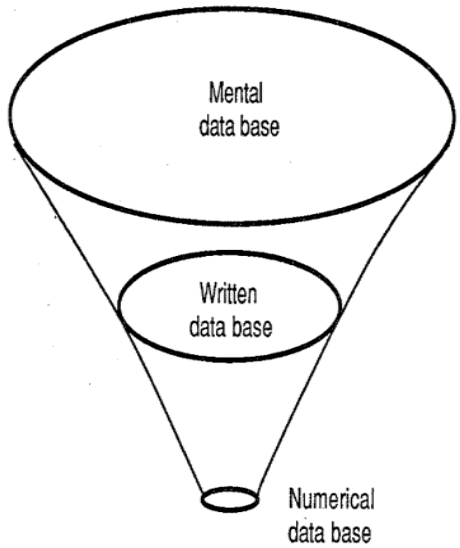


Figure 3.2: Sources of information and relative quantity of information acquired per source.

Forrester, J.W. (1986). Lessons from system dynamics modeling. The 1986 International Conference of the System Dynamics Society. Sevilla, October, 1986.

It is clear from the above diagram that a high reliance is placed on the mental database for inputs in the model building process. Lune-Reyes & Andersen (2003) stated that qualitative analysis when done properly brings a high level of rigour and robustness to the model built.

3.3 CASE STUDY

A case study approach was used, with the case being found within a multinational FMCG (Fast Moving Consumer Goods) organization. However, the organization in question has a large number of product categories and SKU's (Stock Keeping Units) which would make building the model onerous. It was therefore more practical to apply System dynamics modeling to the problem within a specific product category and thereby ensured that the boundaries could be more readily identified. Identifying these boundaries and hence ensuring that the model developed was inclusive of all causal relationships that influenced the problem resulted in all endogenous factors being considered and thus ensured that the model was reflective of reality (Kanung & Jain, 2008).

Restricting the study to a specific product category also ensured that qualitative data collection from various individuals could be carried out with a smaller cross functional group versus individuals across multiple categories.

This approach was in keeping with ensuring that the problem was modelled within closed and well defined boundaries, which is a key requirement in system dynamics given that feedback loops are one of the basic requirements for developing a system dynamics model (Richardson 2011). Chen, Drezner, Ryan & Simchi-Levi (2000) stated that system dynamics can be suitably applied to capturing relevant causal and feedback loops.

The system dynamics methodology uses a qualitative approach, which starts with assumptions, the use of a theoretical view and the understanding of the meaning that individuals or groups assign to a particular societal problem (McMillan & Schumacher, 2010). In this study, I used a phenomenological study approach. A phenomenological study seeks to gain insights from individuals on their understanding of a particular problem based on their experiences, perceptions and perspectives (Leedy & Ormrod, 2010).

3.4 SYSTEM DYNAMICS METHODOLOGY

As discussed briefly above the Sterman 5 step methodology was used. Building a simulation model is not just about understanding the software but also about involving the right people and pin pointing the right information as inputs (Wylan, Buxton & Fuqua, 2000). The research design employed gathered data from three databases (Mental, Written and Numerical) with the primary source of data being gathered via harnessing the mental database of individuals. Given the need to extract data from mental databases, a qualitative approach was adopted with the data being converted to quantitative inputs as required by the *iThink* software. However, through this study and the literature reviewed I adapted the approach to a certain extent and made use of data from the numerical database to substantiate and support the data obtained from individual mental databases. To ensure a successful study it was critical that I identify those individuals that were deemed to play a role within the system and problem being studied and who would be able to yield the best insights into the problem being studied (Marshall, 1996). A qualitative study is appropriate as the study seeks to delve into the behavioural aspects of individuals and groups as well as causal relationships (Botes, 2009). These are largely driven by the environment in which they find themselves and hence the study is also focused on understanding the impact of these behaviours and relationships on S&OP within the organisation.

3.4.1 Step 1: Problem articulation or boundary selection

The problem and its symptoms as discussed in previous chapters were used to first gain business buy-in and support. This was further supported by extracting company and product category related data from the numerical databases. The key measure of profitability within the chosen product category is COM (Cores Operating Margin) which is post costs, A&P (Advertising & Promotions) and indirect costs. Other Key Performance Indicators (KPI's) that are indicators of some of the symptomatic problems experienced within the category are customer service levels, Forecast Accuracy (FA), Forecast Bias (FB), Working capital and turnover. When choosing the category to be studied the above were reviewed and with input from key stakeholders one of the more crucial categories was selected.

3.4.2 Step 2: Dynamic hypothesis

The output of this particular step was to ensure a proper understanding of the problem by ensuring that I was able to list and sketch all causal relationships that were relevant to the problem within the context of the environment and boundaries that the problem existed. This also included having a robust understanding of all feedback loops. It is worth mentioning that understanding the boundaries was an iterative process and was done in consultation with relevant individuals within the organisation as well as an analysis of the S&OP policies and procedures that were obtained from the numerical database. This meant taking a helicopter or 10 000 metre view of the problem to ensure boundary adequacy and that the correct variables were treated as endogenous.

3.4.2.1 Data Collection

To ensure that the data collected is comprehensive I utilized multiple data gathering methods. Given that the case used was on a specific product category within the organization, individuals across multiple business functions were identified. This ensured that relevant information from the mental database of individuals was gathered. Note that points 3.4.2.1.1 and 3.4.2.1.2 are methods that were used to extract information from the mental database, with 3.4.2.1.3 looking at the written database and lastly 3.4.2.1.4 utilising information within the numerical database. The methods of data collection that I used are listed below:

3.4.2.1.1 Interviews

This technique is a one on one discussion between two individuals and gives the opportunity to have a more personal and detailed conversation with individuals and also gives the interviewer the opportunity to ask more probing questions. This was done with key individuals within the product category. Interviews can be designed in various formats to solicit rich data using and investigational approach (Turner, 2010). I used a dual approach to selecting interview candidates. Firstly, I selected interview candidates using concept or theory based selection, which was done in conjunction with key stakeholders. This is based on selecting individuals who are deemed to have the knowledge and firsthand experience of the study focus area (McMillan & Schumacher, 2010). During the original engagement with the selected individuals one of the techniques used was the snowball sampling technique. This is when the successive person to be interviewed was nominated by his predecessor who thought that the person he was nominating had sufficient knowledge within the context of the study to add value (McMillan & Schumacher, 2010). Between pre-selecting individuals based on their knowledge as well as the snow balling technique I was able to ensure that the number of individuals interviewed was sufficient. This confirmed that I was able to gain insights from different aspects.

3.4.2.1.2 Questionnaires

A questionnaire is a pre-determined set of questions that are sent to individuals with the aim of extracting information questions (See appendix 2 for questionnaire template). This approach was used in conjunction with the interview approach to gain maximum benefit. This was conducted with the view that the interview process provided for interactions that are more personal and hence enabled me to better tap into the mental database of individuals. It did however provide a means to gather insights, which could be cross referenced, to data gathered via the interviews as well as led to further discussion within the interview. The questionnaire once received from the interviewee was analysed by myself and partially used to prepare further discussion points during the interview process. Due consideration was given towards ethical considerations during this study to ensure that the academic guidelines were followed as well as adhering to the organisations requirements around anonymity.

3.4.2.1.3 Analysis of written documents/policies & procedures (Written database)

This technique entailed going through organization policies, procedures, reports and minutes of meetings to gather information. These were also used in discussions with individuals to understand similarities and differences between what the documented policies and procedures intended versus the real life experiences of individuals. Quantitative data that was required for the variables that were identified as inputs into the model were gleaned from the written database available. The information gathered was used as inputs into the *iThink* software.

One of the approaches that I adopted was to walk the process to understand what physically occurs at each stage of the S&OP process. This was beneficial when conducting interviews, as I was familiar with the process and jargon. It also enabled me to fully interrogate answers during the interview sessions, which added to the richness of the data, gathered and provided insights that I may have otherwise missed given I would not have probed further.

3.4.2.1.4 *Analysis of numerical data (Numerical database)*

This analysis provided data that was extremely useful in corroborating what was captured from the mental database by comparing what was said to what the performance metrics within the organization reflected. Any differences resulted in further discussions with individuals. Note however, this was not done to change individual's viewpoints but rather to understand the differences, which naturally added to the richness of the data gathered. Morecroft (2011) states that time series data is useful in showing the dynamics of interest. I have used the numerical database in this manner to ensure congruence and differences between the story told by the KPI's and that told by individuals and groups.

3.4.2.2 Process followed during field work

As mentioned above the two primary techniques followed during the field work undertaken were the questionnaire and interview techniques. The process followed in implementing these techniques were:

- Stage 1:
  Once the individuals were selected, their relevant line managers were engaged for alignment and signoff together with the alignment and signoff from my line manager. It was made clear that all discussions are done in confidentially and all participants would remain anonymous.

- Stage 2:
  An initial discussion was held with identified individuals to explain the purpose of the project as well as explain that sign off had been acquired from senior leadership within the business. Explanations were also given on the system dynamics methodology, the model building intent, and purpose of tapping into their mental databases as well as the use of the questionnaire to do this.

- Stage 3:

  Once agreement concerning their involvement and contributions was achieved, the questionnaire was e-mailed to them for completion. When the completed questionnaire was return to me, I read through and highlighted further questions and queries for discussions during the interviews.

- Stage 4:

  An interview was then scheduled with the queries and questions highlighted being further discussed and the answers or examples captured in the questionnaire document. The interviewee was also asked to draw behaviour over time graphs of their key KPI, which again prompted further discussion on the logic and the profile that they drew. A common discussion point was the reasons behind the behaviour over time graphs that they had drawn. All interviews were captured on the questionnaire that was originally completed by the interviewee with the interviews also being electronically recorded if permitted to ensure there was no loss of data as well as to ensure that the interview flowed smoothly without candidates having to pause to allow a scribe to catch-up. All recording was done with the agreement of the individuals being interviewed.

  Interviews were conducted using a structured approach but also one that gave both the interviewee and myself the latitude to have discussions on all points and enabled the interviewee to freely express themselves. The technique that I used to accomplish this was by making use of the cause and effect or Ishikawa Diagram. The technique uses a diagram resembling a fishbone and is used during brainstorming sessions in which individuals discuss the possible factors or causes that have an effect on the problem (Rao, et al, 1996). The possible factors can be broken down into broad categories such as human factors, Machines, Process related, Materials, Environment and Measurement (Russel & Taylor, 2006) and adds structure to the discussion. Note however that in the interests of ensuring a free flowing discussion I did not want to make the session too mechanistic and did not physically draw this diagram and then go through with the interviewee. I rather had it as a supporting document that I used to ensure all areas were being discussed. Categories can be added or changed to suite the particular problem and team provided it makes logical sense and supports the outcome.

- Stage 5:

  Post this process the interview transcript was given a final check and the updated version sent back to the interviewee for a final opportunity to ensure that what was captured was correct and to add further thoughts if necessary. All questionnaires and interview notes were triangulated to ensure that the key themes were extracted. The data was analysed with the aim of identifying themes and placed into rational categories to summarise and give meaning to the data gathered.

Some of the key outputs of this step in the methodology were a detailed understanding of the problem, possible causes of the problems and a sound understanding of the causal relationships impacting the problem. These outputs were played back to individuals to ensure accuracy and alignment in what the output was compared to what was said during the interview.

3.4.3 Step 3: Formulation

Step 3 focused on converting the list of causal relationships into causal loop diagrams, stock-flow diagrams and acquiring data that could be used as inputs into the *iThink* software. A causal loop diagram is a qualitative model and is good at showing feedback loops that contribute to dynamics and dynamic complexity. Stock-flow diagrams are a visual tool that is used to describe the problem and environment within which the problem resides. It further illustrates the cause and effect relationships and feedback loops within the system which when modeled shows the impact of these loops on the key KPI over the long term (Morecroft, 2011).

This was done by first agreeing the stock accumulations and feedback loops which I then converted to stock-flow diagrams to explain the problem in its current environment.

Morecroft (2011, Pg 56) listed the five tips that Sterman had previously mentioned for visual layout which I used to guide me in completing the causal and stock-flow diagrams. These five tips are:

Tip 1: *"Use curved lines to help the reader visualise the feedback loops"*

Tip 2: *"Make important loops follow Circular or oval paths"*

Tip 3: *"Organise diagrams to minimise crossed lines"*

Tip 4: *"Don't put circles, hexagons or other symbols around the variables in causal diagrams. Symbols without meaning are "chart junk" and serve only to clutter a nd distract"*

Tip 5: *"Iterate. Since you often won't know what all the variables and loops will be when you start, you will have to redraw your diagrams to find the best layout"*

Diagrams are extremely proficient at showing feedback loops which contribute to system dynamics and complexity. It is also critical to understand how the links in the diagram work as this is necessary when building the model on the computer software. Whilst doing this it is important to continuously compare to the real world scenario, which is why system dynamics is so reliant on the mental models of individuals (Morecroft, 2011).

Morecroft (2011) states that people often say that a connection is evident in all things but as human beings it is normally difficult to see these connections and even more difficult to explain to others. Words can be used but the saying that a picture is worth a 1000 words hold true when dealing with complex scenarios. Stock-flow diagrams are concise and visual and can be used to explain the interconnectedness, both obvious and hidden, between various variables. They can be used to expand people's thinking and understanding. Hence, the diagrams were played back to the individuals who took part in the study to confirm that the diagrams indeed reflected the real world as well as to aid in the change management process by getting individuals to see the whole picture and going through a learning process themselves (Ledet & Paich, 1994)

With the diagrams checked and revised to ensure they accurately represented reality the diagrams were modeled within the software.

3.4.4 Step 4: Testing

Step 4 in the methodology was the process whereby I completed the validation and verification of the model. This was done using the guidelines highlighted by Morecroft (2011) which is aimed at building confidence into the model. This is to ensure that the modeler and related team have confidence in the quality of the methodology followed to build the model as well as the model itself. Morecroft (2011) discusses three categories of tests that can be used to determine confidence in a System dynamics model. Figure 3.3 shows a summary of the tests that can be done.

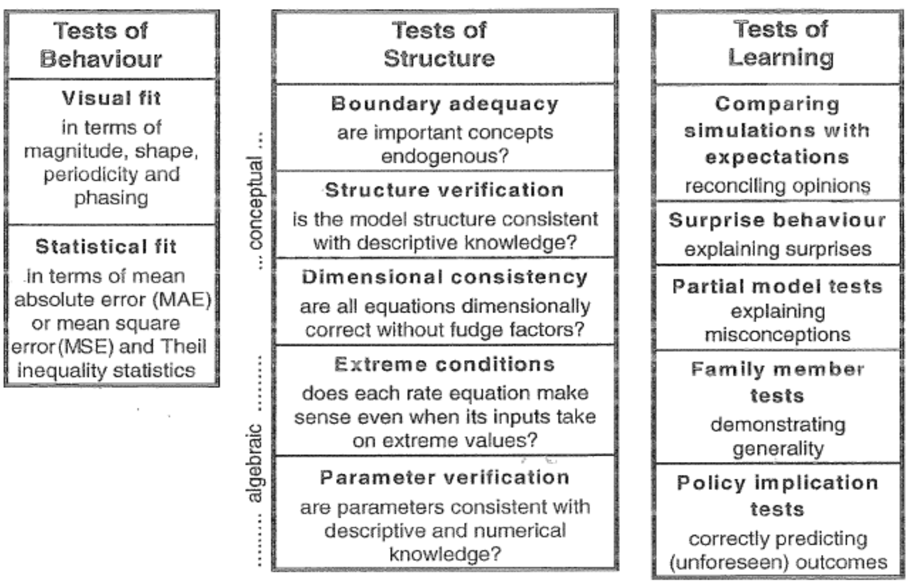


Figure 3.3: Opportunities for building confidence in models

Morecroft, J. (2011). Strategic Modelling and Business Dynamics, A feedback systems approach. John Wiley & Sons, Pg 411.

As reflected in Figure 3.3 the three categories of tests are:

- Tests of Behaviour
  The intent with these tests is to assess the fit of simulations done using the model to the behavior seen in the real world. The model was tested by doing both a visual check of the model outputs as well as checking statistical fit using time series data and comparing model outputs to actual outputs.

- Tests of Structure

  These tests are done on both the conceptual and algebraic model and are aimed at assessing if the feedback loops and equations used are aligned to the available facts and views of reality. As illustrated in Figure 3.2 the largest source of information used when building a model to reflect a social system sits in the mental database of individuals. This series of tests ensures that the information received from the mental models of individuals where captured accurately within the model.

- Tests of Learning

  This category of tests is utilized to determine if individuals have gained further insights on system structure and system behavior due to using the model. These tests are aimed at determining the impact the model has had on influencing and challenging users on how they perceive systems and problems as well as how they then change their behavior accordingly.

This was done in conjunction with the team and by using data obtained from the written database to substantiate the narratives from the interviews done. I want to also reiterate that some of these tests were applied throughout the model building process, as model testing is not a task that is done only when the model is completed but rather during the model building process as well.

3.4.5 Step 5: Policy formulation and evaluation

The final step in the methodology was the use of the model to evaluate the impact of current policies on behavior and decisions and hence on the overall organization. Further policy interventions were identified, formulated and tested on the model to determine the long term impact on the key business metrics identified. These will be discussed in far greater detail in Chapter Four and Chapter Five.

3.4 CONCLUDING REMARKS

The model and results obtained from following this methodology were found to be robust and reflective of current reality, making the model plausible and therefore fit-for-purpose. System dynamics was therefore found to be appropriate to this study given that it enabled me to use system thinking, management insight (mental models) and computer simulation to model endogenous factors to understand the changes and leverage points of system change. The model was then used to problem solve by guiding decisions and policy making (Richardson, 2011). The following chapters will elaborate on the use of the model and output of the overall study.

CHAPTER FOUR: BUILDING A WORKING MODEL

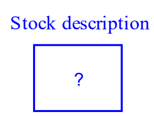
4.1 INTRODUCTION

This Chapter will explain the process followed in building and validating the system dynamics model that was developed in the context of the problem and environment described in earlier chapters. It starts off by giving a brief explanation of the common symbols used in system dynamics modelling which will enable the reader to follow the flow and logic of the models. This is followed by an overview of the S&OP process within the business context. The balance of the Chapter will describe in a systematic manner the approach how various portions of the model were developed to culminate into the final system dynamics model, which is representative of the current problem being experienced. A description of the testing process to ensure that the final model reflected reality, was fit-for-purpose and hence is suitable to be applied to the problem at hand is also included in this Chapter.

4.2 NOMENCLATURE AND SYMBOLS USED IN THE PROCESS OF BUILDING SD MODELS.

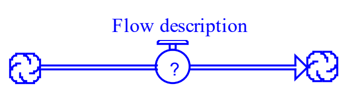
The following symbols are commonly found and used when completing a stock-flow diagram within system dynamics. A stock-flow diagram is a representation of a problem within a particular environment and set of boundaries, which captures the relationships and feedback loops through causal links (Morecroft, 2011). Below are the symbols that are used with a brief description of each of them.

4.2.1 Stocks



A stock is a representation of a tangible or intangible resource that the modeler wants to track and understand. They are accumulations of whatever flows into them. An example of a tangible resource is inventory levels whilst an example of an intangible resource could be employee morale.

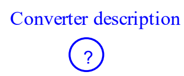
4.2.2 Flows



Every stock will have an inflow, outflow or both. The inflow contributes to increasing the stock whilst the opposite holds true for the outflow.

Morecroft (2011) often uses the bathtub as a means of explaining the stock and flow concepts. If the actual bath tub represents the stock (water level) then the inflow is the tap, which increases the stock of water, and the drain pipe represents the outflow, which reduces the stock of water in the tub.

4.2.3 Convertors



A convertor does exactly what the name suggests. It converts inputs into an output to capture a specific process or dynamic that exists in reality. This calculation is based on the physical rules, processes, procedures and policies that govern the particular environment within which the problem resides. A converter receives input via a connector, which is either a causal or an information link.

In the above symbols, one would notice that there is a question mark present. This indicates that an algebraic equation or number is required as an input.

4.2.4 Connectors

- **Causal link**

- **Information link**

The information and causal links are responsible for connecting the stocks, flows and convertors and depicts the influence of the different aspects of the diagram on each other. They represent the feedback loops that are evident in the model, which is inherently found in reality.

4.2.5 Ghosting of stocks and convertors

When a stock or convertor is seen in a model in the above format (broken vs solid lines and description in italics) this is referred to as a ghost. Ghosting is purely a replication of the original and used to de-clutter the visual model by ensuring there is no inter-weaving of connectors. This further aids in explaining the model and facilitates effective learning via the use of the model.

4.3 S&OP WITHIN THE BUSINESS CONTEXT

In most organisations that service a customer need, there exists a clear and common relationship at both the operational and strategic level. Figure 4.1, is an illustration of such a relationship. As with most, if not all large organisations, there exists a board of directors who map out the strategic direction of the organisation. A strategy however needs to be operationalised and supported by a management information system, which includes key performance metrics that informs relevant stakeholders if the targets and milestones are being achieved. This enables decision makers to understand the current performance and direction the organisation is taking versus the original strategic intent.

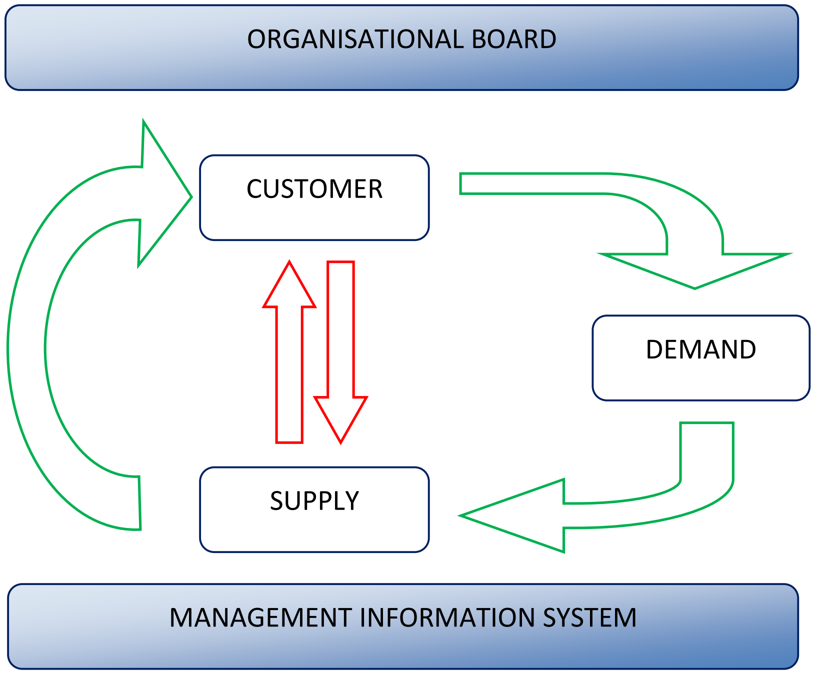


Figure 4.1: Strategic and operational customer, demand and supply relationships

As can be observed in Figure 4.1, the green arrows depict the S&OP flow of information from the CUSTOMER to the DEMAND side of the business, which results in a forecast. It is important to note that the forecast is not determined solely by the CUSTOMER but is also a function of inputs received from within the organisation via the sales and marketing teams. This forecast is fed into the SUPPLY function that in turn needs to gear the supply chain to be able to deliver against customer needs. This typically occurs over the medium to long term (0 to 24 months). The red arrows depict the more operational relationship between the CUSTOMER and SUPPLY (organisation) which occurs on a daily basis. This interaction centres on the customer placing orders and the organisation responding accordingly.

To gain further understanding and based on information extracted from the mental and written databases, Figure 4.1 was observed from a higher level resulting in Figure 4.2 below, showing further granularity *(Original hand drawn diagram contained in appendix 3).*

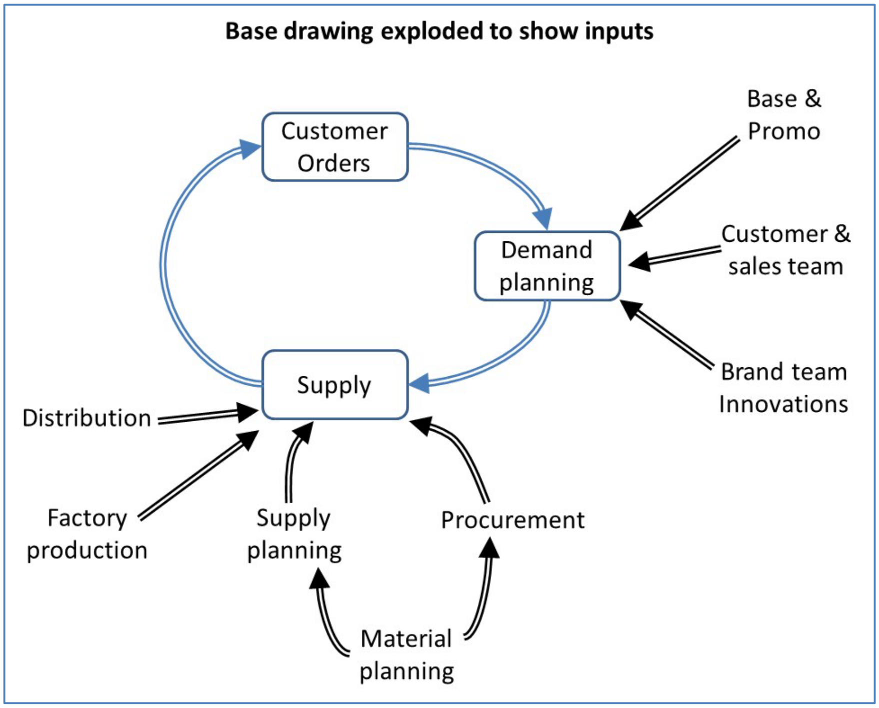


Figure 4.2: Helicopter view (5000 metre) showing further inputs

When observing the environment from a higher level, the inputs to the supply, customer and demand areas of the business can be clearly understood at a glance. The diagram clearly shows that demand is not solely driven by the customer but is a function of inputs from within the organisation in the form of base generation, promotions and innovations, which is acquired from the sales, marketing and brand teams. This is done in most cases in collaboration with the customer.

The supply element of the diagram highlights the key activities or functions that are required to manufacture and deliver a product to the customer. These elements will be discussed further in this Chapter.

In seeking to understand the boundaries of the model it is important to gain what is often referred to as the 10 000 metre view of the problem (Richardson, 2011). This approach ensures that all endogenous factors are included within the model, thereby capturing relevant feedback loops (Sterman, 2000). This approach contributed to understanding the sectors that would need to be included in the model building process. Figure 4.3 shows the output of the 10 000 metre view *(Original hand drawn diagram contained in appendix 4).*

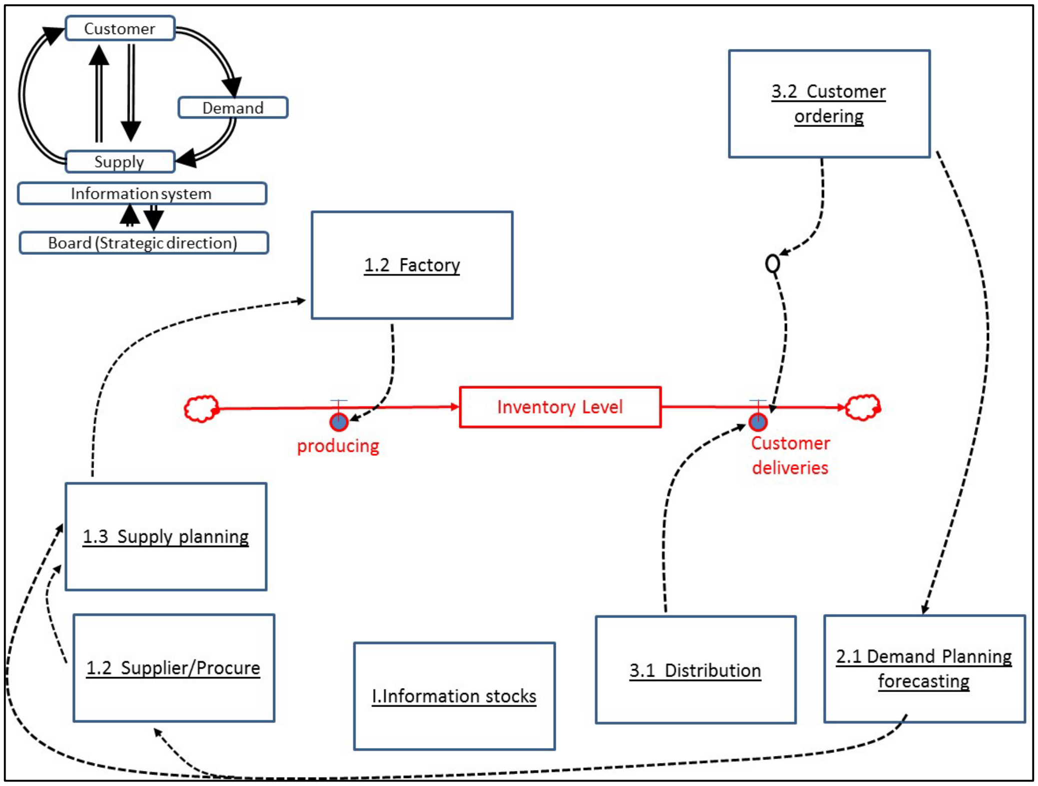


Figure 4.3: Helicopter view (10 000 metre) showing core sectors

The above Figure can be sub-divided in the following parts:

- The centre of the diagram in red highlights that the organisation produces to stock inventory, which is then delivered to the customer.
- The customer portion comprises of the customer ordering and distribution elements, which looks at the order to delivery process.
- The demand element uses inputs from the customer to determine a forecast, which feeds into the supply planning element.
- The supply element comprises of sub-elements found within the supply chain of the organisation, which are planning, factory operations and material procurement or supply.

With this understanding of S&OP within the business context the system dynamics model was developed. The balance of this Chapter will give a step by step explanation of the model, the sectors that make up the model and the validation of the model. Figure 4.4 reiterates the modelling process that was used in this study, with this Chapter covering steps 3 and 4.

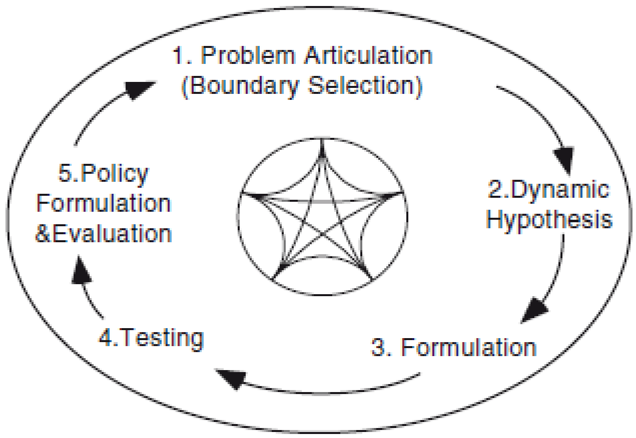


Figure 4.4: System Dynamics modeling process

(Sterman JD, 2000). Business Dynamics: Systems thinking and modeling for a complex world, Boston, Irwin McGraw Hill, Pg 87.

These steps are model formulation, including the development of stock-flow diagrams and the testing of the model with the intent of showing that the process followed and the end result (ie: the final system dynamics model) is robust, plausible and fit-for-purpose.

4.4 FORMULATING THE SYSTEM DYNAMICS MODEL

Before initiating any form of modelling exercise it is imperative that one understands what the core of the model would be, around which other elements are built. Given that the focus of this study is to understand the impact of S&OP on organisational profitability, the question that was asked is “What is the basic activity that the organisation must perform to generate income?” Note that I purposefully used the word “income” versus “profitability” as income is not synonymous with profitability. To explain, the organisation can sell thousands of products and generate income in the millions but if the cost of producing and selling the product is higher than the selling price, no profit is made. Figure 4.5 captures the answer to this question.

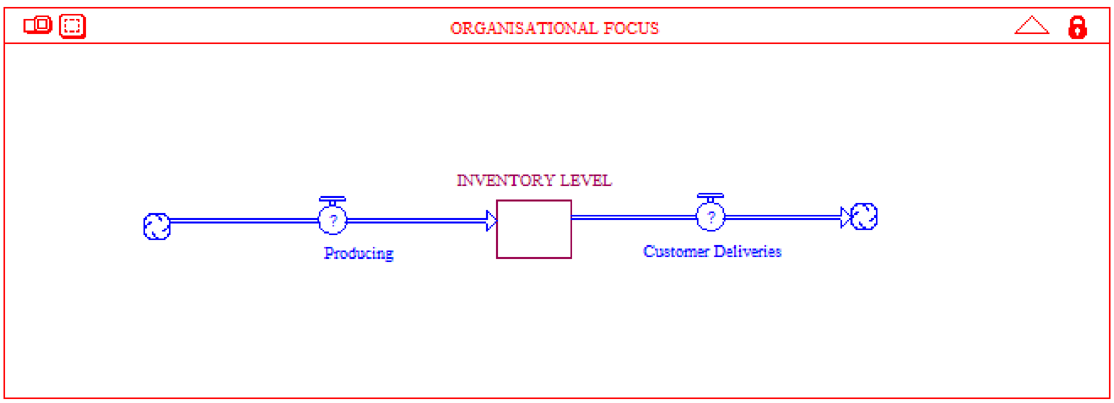


Figure 4.5: Organisational focus and core business activity

The customer is at the core of the business as ultimately the consumer goes to a customer (large retailer) who in turn purchases products from the organisation. Reading Figure 4.5 from left to right, the organisation is involved in activities that result in the producing of the products, which are first stored in a warehouse as inventory followed by customer deliveries as per the customer orders.

As illustrated in Figure 4.1, I have chosen to sub-divide the environment within which the identified problem resides into five areas, each with a different number of sectors:

- Area 1: Organisational focus or "the Core" of the business 1 sector
- Area 2: Demand 1 sector
- Area 3: Supply 3 sectors
- Area 4: Customer 2 sectors
- Area 5: Management information system 1 sector

Now that the core of the business and surrounding areas are understood, we will delve into the sectors that make up the five areas within the model. The above areas revolve around the core, which has been described in Figure 4.5 above. There are eight sectors that can be found in the model, which adequately captures the input factors, relationships and feedback loops and can be used to explain the impact of S&OP on profitability within the organisation. The model was developed using inputs obtained primarily from the mental and numerical databases but underpinned by the operational policies of the organisation.

Before we get to the detail behind each sector, it is worthwhile mentioning how each sector will be explained. Each sector will be illustrated by a Figure with a corresponding explanation. Post this explanation will be the equations with an explanation of the key equations as well as dimensional analysis of some of the equations to prove consistency in the equations and hence model. Each sector has been sub-divided into smaller fragments and will be explained individually and how they feed into other fragments will be explained. The combination of these fragments will culminate in a sector. The unit of time used consistently throughout this study is weeks.

4.4.1 Area 1: Organisational focus

As discussed previously this area and sector is what I refer to as the core of the business, which is to ensure customer deliveries are carried out in an efficient and effective manner.

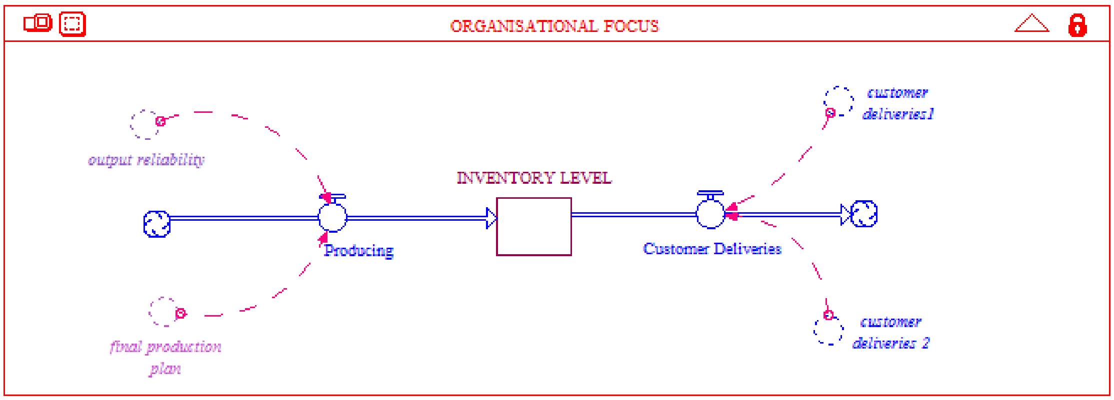
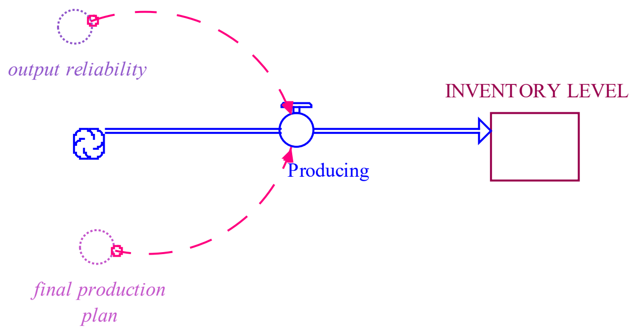


Figure 4.6: Organisation focus overview with inputs

As you would have noticed, Figure 4.5 and Figure 4.6 are similar to each other with a few minor but important differences. The additional convertors seen in this sector reflects the inputs into the inflow and outflow in the form of ghosts which stem from some of the other sectors that will be discussed later in this Chapter. They are relevant inputs into the producing inflow as well as the customer deliveries outflow as they capture the dynamics and feedback loops that are in existence in the real world environment. The inventory level stock will be further seen and used in other sectors within the model such as supply planning, customer ordering and management information system.



INFLOW:

*Producing = DELAY (final production plan * output reliability, 3)*

Dimensional analysis:
Left hand side: [units/week]
Right hand side: [units/week] * [percentage], 3 weeks delay = [units/week)

Figure 4.7: Producing to stock inflow

The formulation for producing to stock inventory can be broken down into two elements, namely the "final production plan" and "output reliability" convertors as shown in Figure 4.7. This feeds into the "inventory level" stock, which will be explained further down.

Producing inflow:

It can be seen from the diagram that the inputs feeding into the producing inflow are the "final production plan" and "output reliability". The "final production plan" is an output of the supply planning sector and is measured in units/week that the factory should be producing. How this value is derived is explained in further detail in the supply planning sector.

The "output reliability" is a constant derived from the historical numerical database and is the current reality with regards to the factory output. The "producing" inflow is therefore a multiplicative formula and is expressed as the product of the "output reliability" and "final production plan", with a built in delay. The "DELAY" at the start of the equation denotes that the inflow value, which will feed into the stock, will be delayed by the last value in the equation, which in this case is 3 weeks. The delay value used is indicative of what is occurring operationally and the total time taken from publication of the plan to the factory, to production and distribution of stock to the warehouses ready for customer orders.

It is worth pausing to explain how the dimensional analysis process aided in ensuring that the Unit of measure (UoM) used in the model is consistent and hence contributes towards the testing of the model.

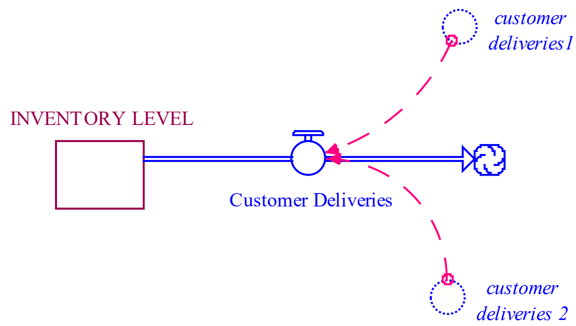
Dimensional analysis:
Left hand side: [units/week]
Right hand side: [units/week] * [units], 3 weeks delay = [units/week)

The above dimensional analysis box reflects the original UoM used in this equation. If one looks at the right hand side portion of the dimensional analysis box, it is noticed that units/week multiplied by units (highlighted in red) would return a $units^2$/week, which renders the equation meaningless. This was the original view, which the use of dimensional analysis identified as a simple but easily overlooked flaw in the model.

Dimensional analysis:
Left hand side: [units/week]
Right hand side: [units/week] * [percentage], 3 weeks delay = [units/week)

On closer examination of the operational thinking information that was obtained from individuals as well as further discussions with factory and planning personnel, a simple conclusion was reached. Output reliability is actually a percentage that is reflective of the factory performance; hence, the UoM used should be percentage and not units. However, instead of being shown as 97% in the model, I chose to reflect it as 0.97. So in essence, the equation stands up to scrutiny and is acceptable.

Note that the unit of measure (UoM) is consistently applied in all equations. The size of the producing inflow will be driven by the “final production plan” with the boundaries of this convertor being explained in the supply sector further in this Chapter.



INVENTORY LEVEL STOCK:

*INVENTORY LEVEL (t) = INVENTORY LEVEL (t - dt) + (Producing – Customer Deliveries) * dtINIT INVENTORY LEVEL = 87266*

Dimensional analysis:
Left hand side: [units/week]
Right hand side: [unit/week] + [units/week] – [units/week] = [units/week]
with an initial inventory level of 87266 in week 1.

OUTFLOWS:

Customer Deliveries = customer deliveries 1 + customer deliveries 2

Dimensional analysis:
Left hand side: [units/week]
Right hand side: [units/week] + [units/week] = [units/week]

Figure 4.8: Inventory levels and customer deliveries

The formulation for "inventory level" and "customer deliveries" is shown in Figure 4.8. The "inventory level" stock reflects the quantity of products that is available for "customer deliveries" per week.

Inventory level stock:

As with most manufacturing organisations, in order to supply customer needs the organisation has to produce what the customer requires. In this particular FMCG organisation, inventory is carried to satisfy customer requests as orders are placed and delivery expected within a minimum lead time. This stock is merely a subtraction of the inflow ("producing") and outflow ("customer deliveries 1" and "customer deliveries 2") whilst taking into consideration the opening inventory balance. Typically, within the *iThink* software the stock used would need to have an initial value specified. The value of 87266 units is the opening balance at the start of a financial year and is based on a stock holding policy, which stipulates that the inventory level must be equivalent to 3 weeks sales demand.

The dimensional analysis for the "inventory level" stock reflects the units of measure (UoM) that was used in the equation. As can be observed the UoM on the left hand side is equal to the UoM on the right hand side of the equation and is reflective of the units produced, held the warehouse and delivered to customers in a given week. To simplify this means the equation is using common variables and hence will return a plausible result.

In this study, two types or variations of customer deliveries are done, hence the equation above is a straight forward summation of "customer deliveries 1" and "customer deliveries 2". The detail behind "customer deliveries 1 and 2" resides within the distribution sector and will be explained later in the Chapter. As much as we would want instantaneous customer deliveries within this industry it is not possible, hence the delay for the outflow is reflected in the distribution sector. It is worth mentioning at this stage that the actual customer ordering process is explained within the customer ordering sector and feeds into the distribution sector. Given the straight forward nature of these formulae you would notice that the left hand side and right hand side UoM is the same.

This sector captures another dynamic that is evident in reality. This reality is simply that instantaneous replenishment (inflow) and stock depletion (outflow) is not possible and there is a delay in both. Subsequent sectors which will be explained revolve around the organisational focus sector and captures both the 10 000 metre and operational thinking views.

4.4.2 Area 2: Demand

The S&OP process as explained in previous chapters focuses on ensuring the supply and demand elements are synchronized. In principle, those involved in the demand side of the business are focused on forecasting expected customer sales. Figure 4.9 below shows the variables that contribute to this.

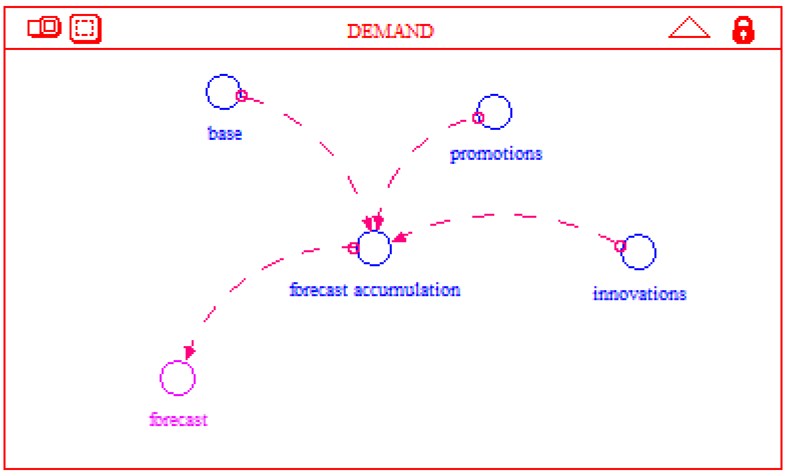
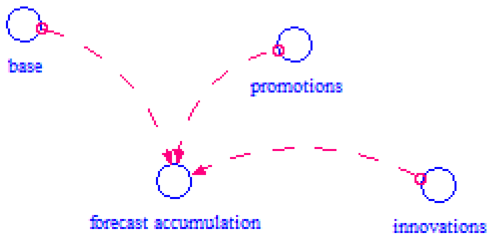


Figure 4.9: Demand sector

If we take a close look at the demand sector, we see that it culminates into a forecast, which in turn feeds into other sectors within the model. In the organisation, the forecast is the trigger for the supply side of the business to ensure it has sufficient resources to execute customer deliveries. The forecast convertor will feed into the supply planning, procurement and information systems sectors.



CONVERTORS:

base = POISSON (78540, 12)

innovations = POISSON (4363, 12)

promotions = POISSON (4363, 12)

Dimensional analysis for base, innovations and promotions:
Left hand side: [units/week]
Right hand side: [units/week]

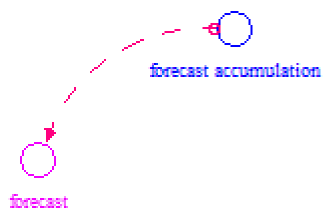
forecast accumulation = base + innovations + promotions

Dimensional analysis:
Left hand side: [units/week]
Right hand side: [units/week] + [units/week] + [units/week] = [units/week]

Figure 4.10: Inputs into the forecast accumulation

The feature that can be immediately identified for the “base, promotions and innovations” convertors is that the formulae in each utilizes a poisson distribution given that customer orders or call rates follows a poisson arrival pattern (Shen & Huang, 2008). McGarvey & Hannon (2004) further state that customer behaviour follows a poisson distribution. Each of the convertors reflects the average value, with a seed value of 12. All data used has been obtained from current numerical databases. All three convertors meet the dimensional analysis requirement in that the left hand and right hand sides have the same units of measure.

A forecast is a function of the various inputs that contribute towards determining a demand signal and is hence a summation of the “base, innovations and promotions”. These three input variables make up the total forecast and is a reflection of what is done operationally by those functions that contribute towards the demand side of the S&OP process. The demand signal is determined in weekly time buckets and is the number of units that the organisation expects the customer to order. Given that the units/week is consistent throughout the equation the required dimensional balance is achieved.



$$forecast = forecast\ \ accumulation$$

Dimensional analysis:
Left hand side: [units/week]
Right hand side: [units/week]

Figure 4.11: Simple formulation for forecast accumulation and forecast

A convertor was added within the demand sector and is equivalent to the forecast accumulation. This was added merely to aid in making the modelling process more glass box then black box and to support in the explanation process when engaging with stakeholders within the business. Given the simplicity of the equation dimensional balance was achieved.

4.4.3 Area 3: Supply

I now introduce area three in which the three sectors that contribute towards supply will be discussed. These sectors feed into the producing inflow found in Figure 4.6, area 1. Figure 4.12 below starts with the factory sector.

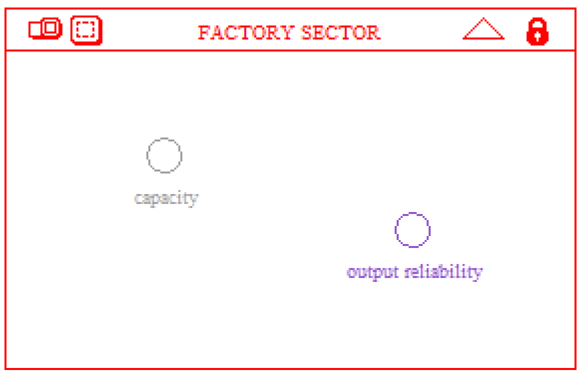


Figure 4.12: Factory sector

If one mentions a factory, images of various input resources such as people, processes, machinery and material with finished goods as an output springs to mind. This naturally makes one think that this is a complex environment, yet I show it as two convertors in the above sector. I have purposefully simplified because the reality that sits in the minds of those interviewed share two common basic requirements of the factory "Does the factory have the capacity to produce what is needed?" and "Does the factory produce what is asked of it?".

capacity = 140000

Dimensional analysis:
Left hand side: [units/week]
Right hand side: [units/week]

Figure 4.13: Capacity calculation explained

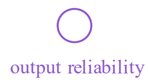
The capacity convertor is a constant based on what the factory is capable of producing. To aid in the understanding the two equations below reflect the calculation used to determine the factory capacity as per the original design and demonstrated capacity.

Equation 1: Capacity at design speed = design speed (units/hour) * actual available working hours

Equation 2: Demonstrated capacity = design speed (units/hour) * equipment efficiency (%) * actual available working hours

Equation 1, above reflects the capacity if the factory and the equipment which runs at the machine speed as per the designers intent with no stoppages. This multiplied by the available working hours reflects the best case scenario with regards to the output that can be expected. Equation 2 reflects the demonstrated capacity with the primary difference being the inclusion of the equipment efficiency, which is reflected as a percentage. The equipment efficiency is a measure of how effectively and efficiently the assets are running.

The constant value used in the capacity convertor is a value of 140000 units/week, which is the demonstrated capacity of the factory. This is a product of the design speed, equipment efficiency and actual available working hours per week. The actual available hours is the total available hours (24 hours x 7 days = 168 hours) less time that cannot be used due to external requirements such as labour law restrictions as well as internal requirements such as line trials and preventative maintenance. It is the actual number of units that the factory is capable of producing within the allowed factory production time. This piece of information was obtained via the current master data and further validated during interviews with the planning community.



Output reliability = 0.97

Figure 4.14: Factory output reliability

The output reliability convertor shown in Figure 4.14 is similar to the capacity convertor in that it is reflected as a constant number. Output reliability is a measure of how well the factory is able to meet the production plan and is measured at a SKU level. The measure penalizes both over and under production with the unit of measure being a percentage value. It is hence an accurate representation of the factory's ability to satisfy production plans. As reflected in Figure 4.14 a constant of 0.97 or 97% was used in the model. This is based on 52 weeks of historical data, which is representative of the seasonality's that exist.

Interestingly, the factory is able to consistently complete 97% of all plans allocated to it, yet there is still a view from certain functions that the factory performance is poor. This study and the associated field work resulted in a few misconceptions being explained and understood. This approach aided in the learning and understanding gained by individuals that contributed towards this project.

In this organisation supply planning is considered one of the key functions as they cover finite production planning in the short term as well as the total aggregate supply plans across the S&OP spectrum of 24 months. I have chosen to reflect the supply planning sector in Figure 4.15 in a rather simplistic manner versus what is seen operationally. However, the sector and model still capture the interactions and feedback loops that are found within the organisation.

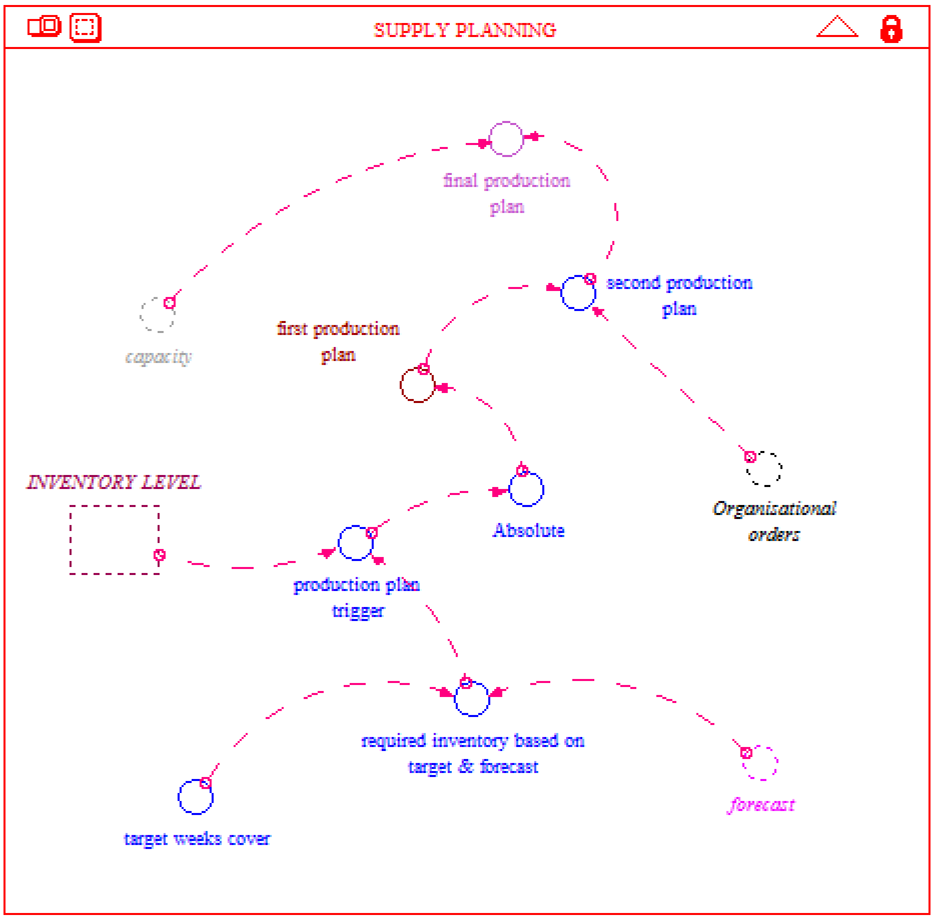
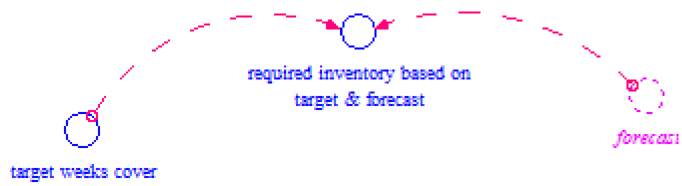


Figure 4.15: Supply Planning made simple

Figure 4.15 will be explained in fragments with the key trigger for the supply planning sector being the forecast. The fundamental basis for supply planning within the organisation can be found in Figure 4.16, which reflects two of the key inputs into the supply planning process. They are the forecast and target weeks cover.



target weeks cover = 3

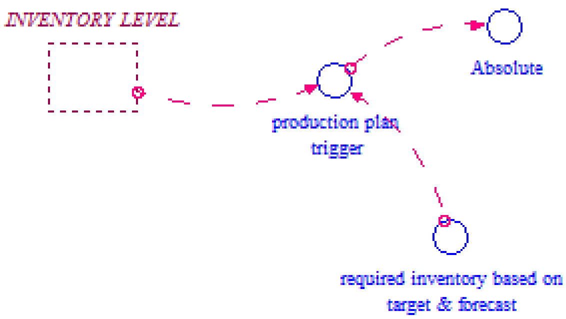
*required inventory based on target & forecast = target weeks cover * forecast*

Dimensional analysis:
Left hand side: [units]
Right hand side: [week] * [units/week] = [units]

Figure 4.16: Basis of supply planning – target weeks cover and forecast

The "target weeks cover" is reflective of the current stock holding policy, which stipulates that 3 weeks equivalent stock based on the forecast must be held at any given point in time. The forecast, as stated earlier, stems from the demand sector and is an input into the supply planning sector. The planning team will combine these two pieces of information to determine what the required inventory levels should be across the S&OP horizon in weekly buckets. Figure 4.16 highlights the equation for "required inventory based on target & forecast" which is a multiplication of the stock holding policy of 3 weeks and the stipulated weekly forecast.

The conclusion that can be reached from looking at the dimensional analysis is that the equation is acceptable given the right hand side and left had side units of measure are the same. From the right hand side of the equation the weeks UoM cancel each other out leaving just the units, which is equal to the left hand side of the equation, demonstrating dimensional consistency.



Production plan trigger=INVENTORY LEVEL - required inventory based on target & forecast

Dimensional analysis:
Left hand side: [units/week]
Right hand side: [units/week] - [units/week] = [units/week]

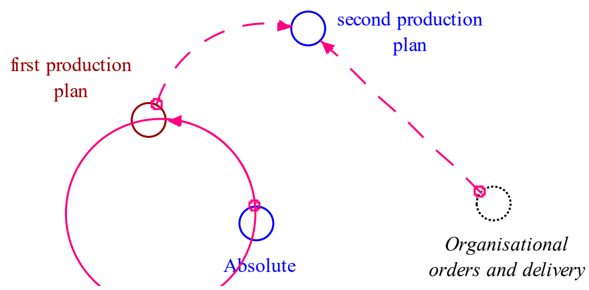
Absolute = IF (production plan trigger < 0) THEN (ABS (production plan trigger)) ELSE 0

Dimensional analysis:
Left hand side: [units/week]
Right hand side: IF [units/week < 0] THEN [units/week] ELSE 0 = [units/week]

Figure 4.17: When is a production plan triggered?

Once the required inventory level is known the current inventory level as described in sector 1, Figure 4.8 is introduced. Figure 4.17 reflects how the “inventory level” and required inventory feed into the production plan trigger. When inventory levels are sufficient and in line with the inventory holding policy, no action is triggered (ie. No production plan is triggered). If however the “required inventory based on target & forecast” is not at the appropriate level, a production plan is triggered. The “absolute” convertor is to ensure that the model only reacts if the production plan trigger is less then zero. As you would imagine we do not want to trigger production when inventory levels are in line with the inventory holding policy as this has working capital implications. The dimensional analysis of both formulae shows that they are dimensionally correct. The UoM on the right hand side and left hand sides of both formulae are equal, which means that they are credible.

The absolute value stemming from the trigger leads into the first and second iteration of the production plan, which takes into consideration an input from the procurement sector as reflected in Figure 4.18.



first production plan = IF (Absolute>0) THEN (Absolute) ELSE 0

Dimensional analysis:
Left hand side: [units/week]
Right hand side: IF[units/week > 0] THEN [units/week] ELSE 0 = [units/week]

second production plan = IF (first production plan <= Organisational orders and delivery) THEN (first production plan) ELSE (Organisational orders and delivery)

Dimensional analysis:
Left hand side: [units/week]
Right hand side: IF[units/week <= units/week] THEN [units/week] ELSE (units/week) = [units/week]

Figure 4.18: Evolution of the production plan

The above two equations deals with the production plan that needs to be issued to the factory to produce. The "first production plan" is an output from Figure 4.17, which considered the current inventory holding, and expected inventory holding with the equation being balanced given the UoM is consistent. One of the possible constraints that is found within the supply chain is the ability of the supplier to delivery material to the factory. The "second production plan" considers the material delivery from the supplier and is represented by the “organisational orders and delivery” convertor as shown in Figure 4:18. The “first production plan” is a view of what is actually required with the “second production plan” being constrained according to what the supplier is able to deliver.

final production plan= IF (second production plan < capacity) THEN (second production plan) ELSE (capacity)

Dimensional analysis:
Left hand side: [units/week]
Right hand side: IF[units/week < capacity] THEN [units/week] ELSE 0 = [units/week]

Figure 4.19: The final production plan

Depending on factory capacity, a final production plan is submitted to the factory for execution. The “final production plan” is hence the “second production plan” constrained based on the “capacity” convertor as depicted in Figure 4:19. The capacity input is reflective of the actual factory outputs as discussed in the factory sector earlier in the Chapter. From a dimensional analysis perspective all variables in the equation is in units with the left hand and right hand sides balancing. This brings to a conclusion what occurs within the supply planning sector.

It is worthwhile mentioning at this stage that a strong theme that came out during the interviews were the tendency of departmental key performance indicators (KPI) to drive certain behaviours. An example of this would be the factory preferring to do long production runs with minimum changeovers whilst what is actually required is a more agile and responsive supply chain. These requirements are largely driven by the poor forecast accuracy that is evident, customer buying patterns that oscillate and poor individual behaviours.

The last sector within the supply area is the procurement or supplier sector, which is illustrated in Figure 4.20 below. This sector reflects the relationships and agreements that the organisation has with suppliers.

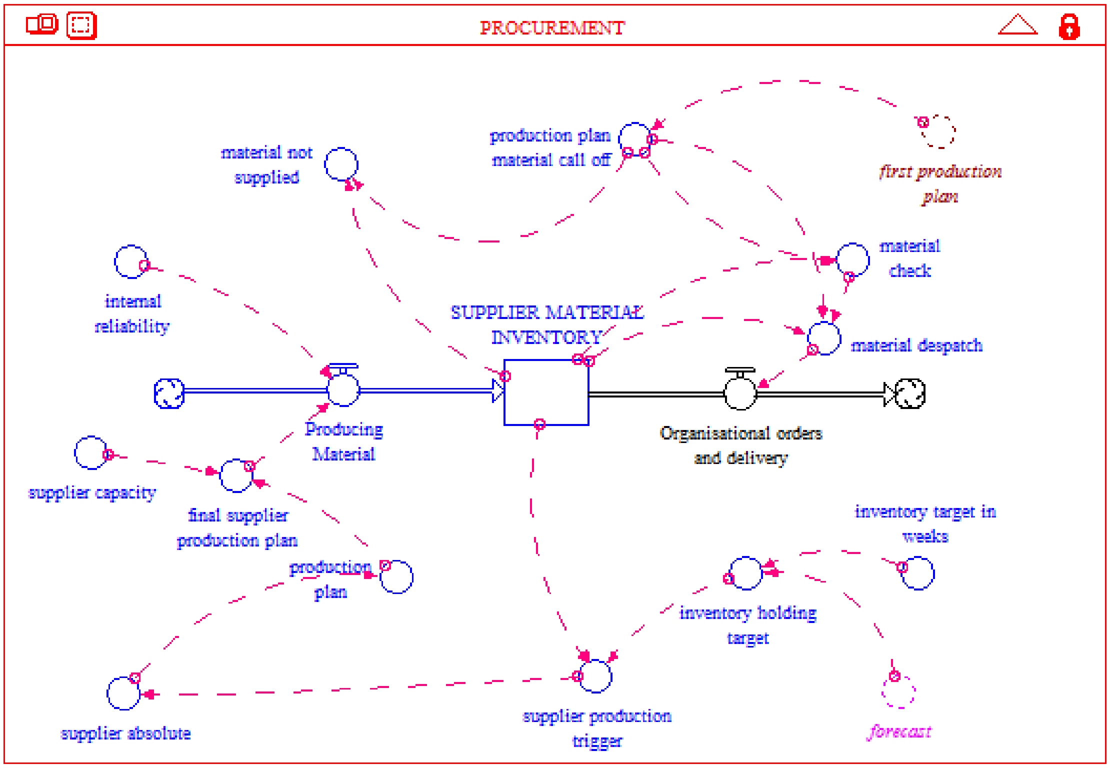
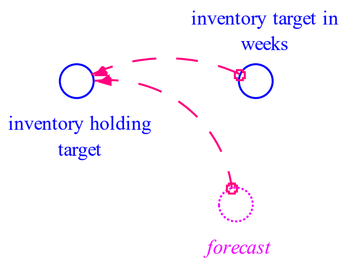


Figure 4.20: Procurement sector

I will endeavor to breakdown this sector into smaller fragments below, starting with Figure 4.21.

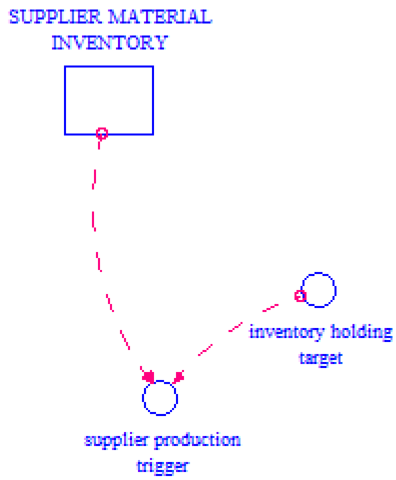


inventory holding target = forecast * inventory target in weeks

Dimensional analysis:
Left hand side: [units]
Right hand side: [units/week] * week = [units]
with an initial inventory level of 349067 in week 1.

Figure 4.21: Supplier inventory holding target

Commercially a contract is signed by both parties with one of the stipulations being a stock holding policy that the supplier would follow in terms of the material stock that should be held within the supplier warehouse at any point in time. This is reflected by the inventory target in weeks within the sector, which together with the forecast drives the expected inventory holding target. You would notice that this is similar to that found in the supply planning sector with the same equation and UoM. They are essentially stock holding policies that are in place both within the organisation as well as for the supplier. Like the equation in the supply planning sector there is dimensional balance.



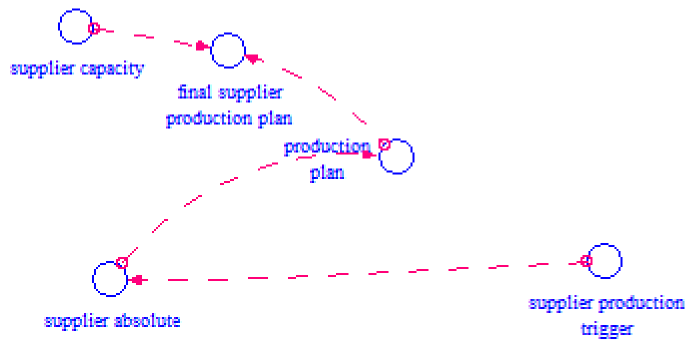
supplier production trigger = SUPPLIER MATERIAL INVENTORY - inventory holding target

Initial SUPPLIER MATERIAL INVENTORY = 349067

Dimensional analysis:
Left hand side: [units/week]
Right hand side: [unit/week] - [units/week] = [units/week]

Figure 4.22: Supplier production plan trigger

The equation for this stock is similar to that in Figure 4.6 with the exceptions of the initial stock being different due to it being aligned to the stock holding policy agreed between the supplier and organisation. Both the left hand side and right hand sides of the equation are equivalent.



supplier absolute =

IF (supplier production trigger < 0) THEN ABS (supplier production trigger)) ELSE 0

Dimensional analysis:
Left hand side: [units/week]
Right hand side: IF [units/week] < 0] THEN (ABS [units/week]) ELSE 0 = [units/week]

supplier capacity = 100000

production plan = IF (supplier absolute > 0) THEN (supplier absolute) ELSE 0

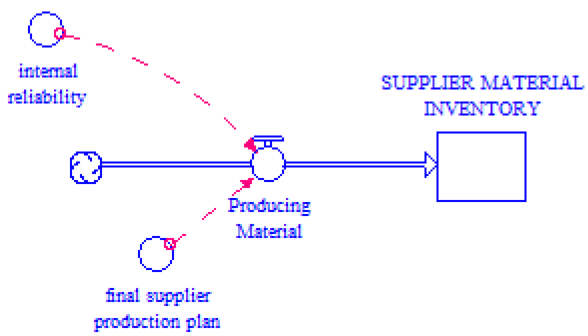
final supplier production plan = IF (production plan > supplier capacity) THEN (production plan) ELSE (supplier capacity)

Dimensional analysis:
Left hand side: [units/week]
Right hand side: IF [units/week] > [units/week] THEN [units/week] ELSE [units/week] = [units/week]

Figure 4.23: Reaching the final production plan

Figure 4.23 highlights the inputs into reaching the point at which the final supplier production plan is issued to the supplier factory teams. The inventory check and subsequent production trigger results in the production plan, which is constrained based on all factors except the supplier internal capacity. The "final supplier production plan" takes into consideration what is required versus the capacity available. Essentially the supplier will produce either what is required or produce to capacity if what is required is greater then the capacity. “Supplier capacity” is a constant and is based on historical data.

This sector captures another dynamic that is evident in reality. This reality is simply that instantaneous replenishment (inflow) and instantaneous stock depletion (outflow) is not possible, and there is a delay in both. You will see in the inflow (Figure 4.24) and outflow explanation below that there is a delay of 3 weeks to produce and a further 3 weeks to deliver. Given that the process found in the supplier leg is similar to that, found within the organisation, I will explain the exceptions only.



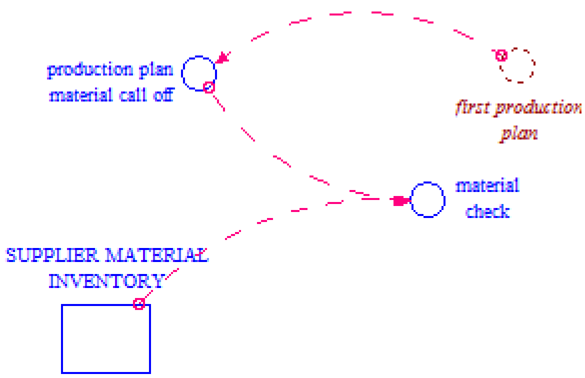
internal reliability = 0.55

*Producing Material = DELAY (final supplier production plan * internal reliability, 3)*

Dimensional analysis:
Left hand side: [units/week]
Right hand side: IF [units/week] > [units/week] THEN[units/week] ELSE [units/week] = [units/week]

Figure 4.24: Understanding the producing inflow

The key exception is the internal reliability of 55% that was utilised. This is low due to low internal efficiencies being experienced as well as the inability of the supplier to react to high volatility. When tapping into the mental database of individuals the view was that the erratic and fluctuating nature of our material call-offs results in out of stocks and delays, which are captured in the supplier internal reliability metric.



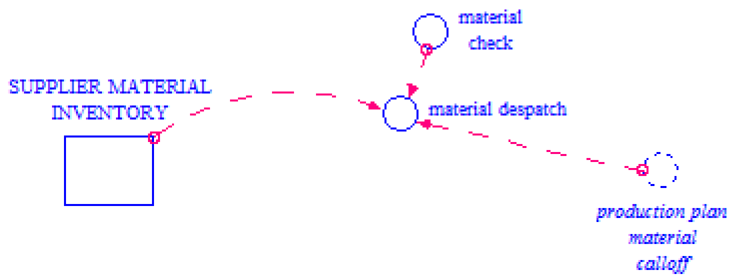
production plan material call off = first production plan

material check = SUPPLIER MATERIAL INVENTORY - production plan material call off

Dimensional analysis:
Left hand side: [units/week]
Right hand side: [units/week] - [units/week] = [units/week]

Figure 4.25: Material check before dispatch

The "production plan material call off" is as per the organisation's production plan or material call off and is what is expected from the supplier. The supplier needs to first check if this can be supplied out of current inventory and feedback appropriately. As seen in Figure 4.25 the "material check" equation is hence a subtraction between stocks on hand and what is required. All values within the equation are in units per week ensuring dimensional balance.

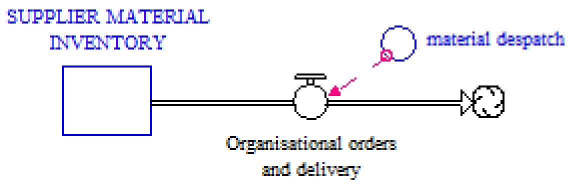


material dispatch = IF (material check > 0) THEN production plan material call off ELSE SUPPLIER MATERIAL INVENTORY

Dimensional analysis:
Left hand side: [units/week]
Right hand side: IF [units/week > 0] THEN[units/week] ELSE [units/week] = [units/week]

Figure 4.26: Material dispatch

Once the check on available material is done, the next step is to determine what quantity is to be dispatched. The supplier will always seek to satisfy the full requirement ("production plan material call off") but if this is not possible the inventory on hand (" supplier material inventory") will be dispatched. Figure 4.26 captures this dynamic with an equation that does a check on order versus stock on hand. Like the previous equation, all variables have a common UoM and is balanced.



Organisational orders and delivery = DELAY (material dispatch, 3)

Dimensional analysis:
Left hand side: [units/week]
Right hand side: DELAY [units/week] = [units/week]

Figure 4.27: Organisational orders and delivery outflow

Once the decision on the quantity of raw and packaging material that is available to satisfy the order is reached, it can be dispatched. Figure 4.27 captures this dynamic in which the equation reflects a delay of 3 weeks for the supplier to produce and send stock to the business. Whilst there is typically a 3 week lead time from order confirmation to delivery one of the consequences that was evident as a result of the erratic forecast and customer ordering patterns was that the supplier was approached to expedite the delivery of materials which caused further inefficiencies within the suppliers business. It also resulted in the supplier's buffer stock being depleted in a shorter space of time. Whilst this dynamic is included in the model variables and is reflected in the service levels, the cost of the inefficiency is not.

4.4.4 Area 4: Customer

We now get to the primary reason the business is in existence, which is to sell products to the customer in a profitable manner. This is explained in area 4, which revolves around the customer. There are two sectors that contribute towards this area and will be discussed below. They are customer ordering and distribution.

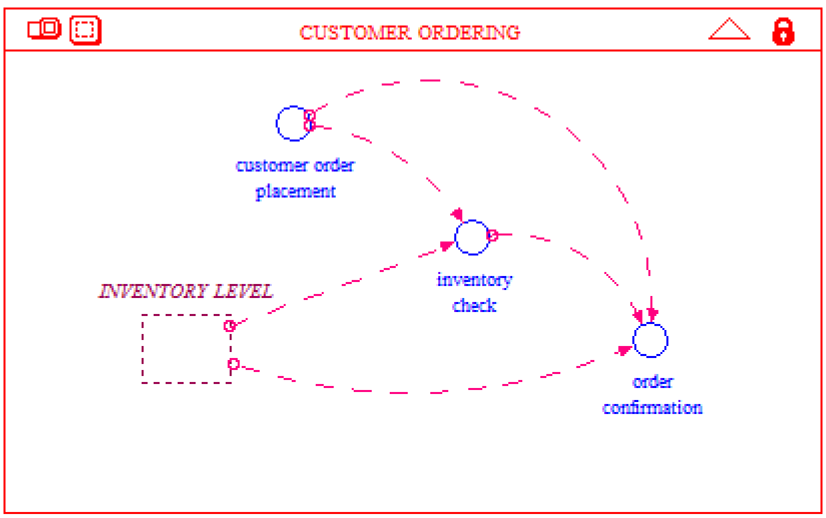
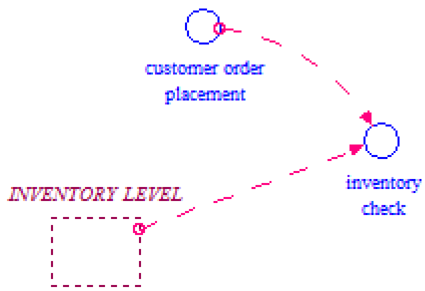


Figure 4.28: Customer ordering

The process and relationships shown in Figure 4.28 is initiated when a customer places an order with the organisation. This can be done telephonically or via an electronic exchange of data. Figure 4.29 below reflects the initial stage of the customer ordering process.



Convertors:

customer order placement = INT (RANDOM (697, 229894, 12))

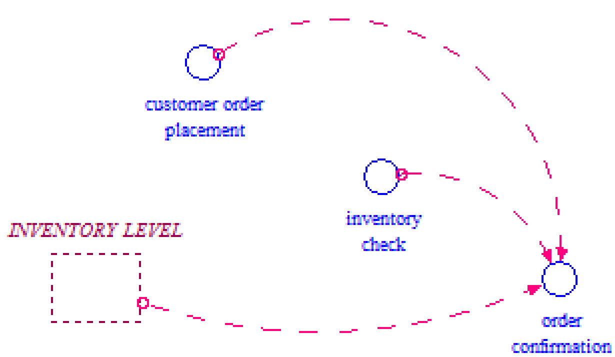
inventory check = INVENTORY LEVEL - customer order placement

Dimensional analysis:
Left hand side: [units/week]
Right hand side: [units/week – units/week] = [units/week]

Figure 4.29: Initial Customer orders and inventory checks

On analysis of the customer ordering data, it was found that there was a lot of variability with a standard deviation of 36799 units. As you would have noticed this variance is extremely high and caused some concern initially. The values however were obtained from historical data and validated against the mental database of individuals closely involved in the customer order taking process. Whilst it is recognized that there are behaviours which drives sales higher in certain parts of the month, quarter or year there exists randomness in the ordering process which is supported by the business experiencing a forecast accuracy lower then 50%. It was therefore decided that the equation used would be a random number generator with the minimum order size being 697 units and the maximum order size being 229894 units with a seed value of 12 as reflected within the equation found in Figure 4.29. The minimum and maximum values selected were derived from the numerical database that was used which covered data points spanning a 52 week period. This was further assessed against the mental database of individuals interviewed who validated that this type of extreme values reflects reality. Given we are dealing with consumer units, no customer would order less then a full unit, hence the INT at the front end of the equation signifies that only integer values must be generated.

An inventory check is done to determine what portion of the order can be fulfilled from existing stock that is available. This is a straightforward subtraction of what stock is available in inventory versus what the customer required. This leads into the next portion of the sector, which looks at order confirmation. The units of measure used in the equations are consistent and hence dimensionally balanced.



order confirmation = IF (inventory check > 0) THEN customer order placement ELSE INVENTORY LEVEL

Dimensional analysis:
Left hand side: [units/week]
Right hand side: IF[units/week > 0] THEN[units/week] ELSE [units/week] = units/week

Figure 4.30: Order confirmation

Order confirmation by definition describes the action taken by the organisation to verify to the customer the amount of stock that they would be receiving. As described by the equation in Figure 4:31 this can only be done once the inventory check is complete and is available in inventory is understood. Based on this either the full, partial or none of the order is confirmed.

In discussions with individuals during the data collection process, one of the strong themes that was communicated was that the variability seen in customer ordering is also a function of the behaviour seen from the sales team and customers. This behaviour is mostly driven by the organisations attempt to fulfill short term sales and turnover targets. This is more often then not achieved by selecting certain products across a multi-category organisation as these products typically have a higher turnover. Later in this Chapter, I speak about working capital implications and forecast accuracy, which sits in the region of 50% to 60%. This type of behaviour will have a direct impact on these two leading organisational KPI's. Whilst as a business it is understood that this is not per S&OP processes the attraction to meet short term goals is high. This short term focus then detracts from the core of S&OP, which is to focus on the 2 year period.

Once a customer order is confirmed, the distribution teams which includes both warehousing and transport logistics are required to execute the order. This leg of the process is illustrated in Figure 4.31.

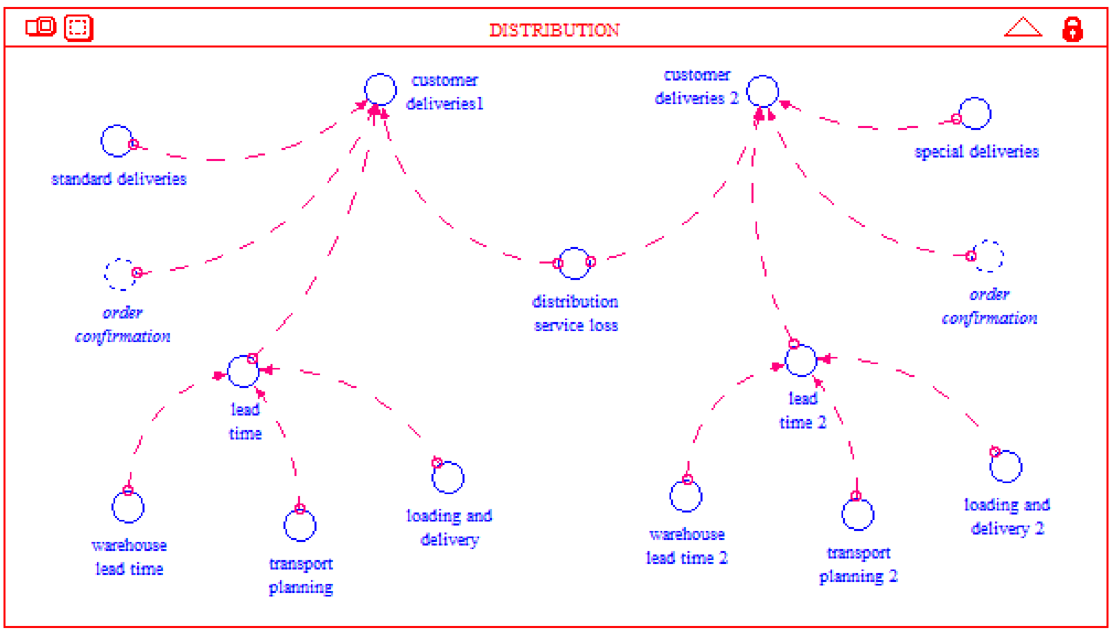
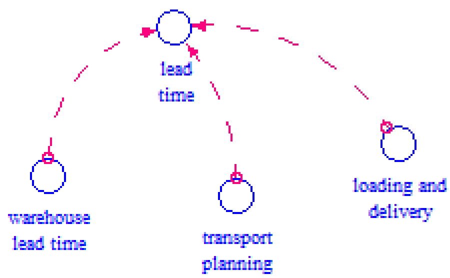


Figure 4.31: Inside the distribution sector

At first glance, this sector seems to have two identical halves, which on closer examination can be seen to be different in that the left side has a convertor called standard deliveries and the right hand side has a convertor called special deliveries. The driver for this is a particular behavior that surfaces within the business. In most instances when a customer places an order a standard lead time to delivery is followed but in certain instances, normally when there is a sales drive, special deliveries are required in a shorter time frame and normally results in higher costs being incurred. Both "customer deliveries1" and "customer deliveries2" feed into the outflow found in Figure 4.6.

I will start by explaining the "customer deliveries1" portion found on the left hand side. Distribution of any product will have a lead time from the customer placing the order to the delivery of that order. Figure 4:32 highlights the inputs into the "lead time" convertor.



loading and delivery = 0.07

transport planning = 0.14

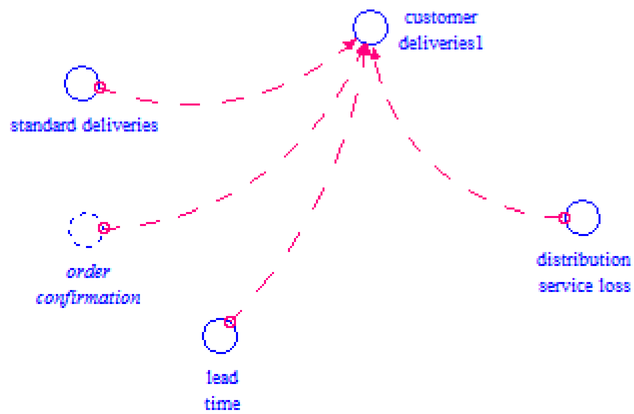
warehouse lead time = 0.14

lead time = loading and delivery + transport planning + warehouse lead time

Dimensional analysis: Left hand side: [weeks] Right hand side: [weeks] + [weeks] + [weeks] = [weeks]

Figure 4.32: Understanding the lead time in a standard situation

The three main activities that make up the operation is the time taken within the warehouse to get the stock ready for dispatch, time taken to do transport planning and get a vehicle at the warehouse and the time taken to load the vehicle and deliver the products to the customer. Determining the lead time is therefore a summation of these three factors. The Figures used for the above are all constants, acquired from the numerical database of the organisation and validated against the mental database of the individuals interviewed. All Figures used have been converted to weeks as the uniform measure of time that ensures that the lead time equation is dimensionally balanced.



distribution service loss = 0.989

standard deliveries = 0.95

*customer deliveries1= DELAY (order confirmation * distribution service loss * standard deliveries, lead time)*

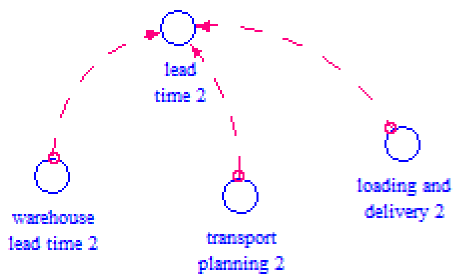
Dimensional analysis:
Left hand side: [units/week]
Right hand side: [units/week] * [factor] * [factor] = [units/week]

Figure 4.33: Customer deliveries under standard conditions

In order for the customer to get their delivery there are other factors besides the lead time, which needs to be taken into consideration. Given that no operation is perfect, losses are experienced during the process. The "distribution service loss" is a constant of 98.9% or 0.989, which essentially means that 98.9% of the customer order confirmed is actually delivered. The balance of 1.1% are losses experienced due to damages, stock not being found within the warehouse, theft, stock being delivered to the incorrect customer or stock not found in the vehicle on delivery. As explained previously most deliveries follows the standard process but there are occurrences when a special delivery is required. Based on the mental databases of individuals it was found that approximately 95% of the time a standard delivery was done, with the balance of 5% resulting in a special delivery. Figures used for the "distribution service loss" and "standard deliveries" are constants obtained from the numerical and mental databases. "customer deliveries1" is hence a multiplication of the order, service loss factor and standard delivery factor. The equation reflects a delay equivalent to the lead time as well.

The dimensional analysis check reflect that equation is balanced given the UoM in both the right hand and left hand side of the equation are equivalent making it credible.

We now get to the right hand side of the sector in which we find the "customer deliveries2" convertor. Figure 4.34 below reflects the lead time make up in special situations and structurally looks identical to Figure 4.32.



$$loading\ and\ \ delivery\ \ 2 = 0.07$$

$$transport\ planning\ \ 2 = 0.07$$

$$warehouse\ lead\ \ time\ \ 2 = 0.07$$

$$lead\ time\ 2 = loading\ and\ delivery\ 2 + transport\ planning\ 2 + warehouse\ lead\ time\ 2$$

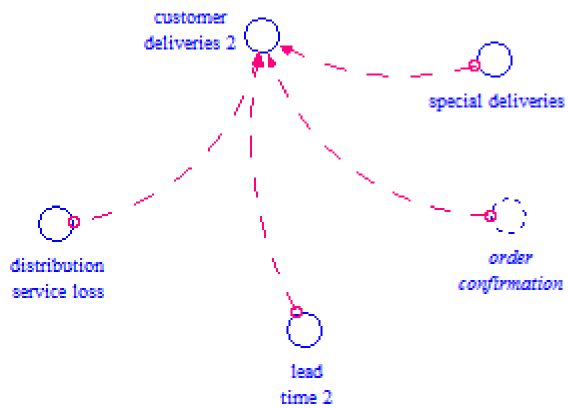
Dimensional analysis:

Left hand side: [weeks]

Right hand side: [weeks] + [weeks] + [weeks] = [weeks]

Figure 4.34: Understanding the lead time in a special situation

A key difference in a special situation is that the lead times for transport planning and the warehouse are reduced by half. The overall lead is hence still a summation of the three elements shown in Figure 4.32 and is dimensionally balance.



distribution service loss = 0.989

special deliveries = 0.05

*customer deliveries 2= DELAY (order confirmation * distribution service loss * special deliveries, lead time 2)*

Dimensional analysis:
Left hand side: [units]
Right hand side: [units]*[factor]*[factor] = [units]

Figure 4.35: Customer deliveries under special conditions

As mentioned above it can be seen that 5% of the time special deliveries occur hence the shortened lead times in the warehouse and transport elements. These special deliveries are largely a factor of the organisation just coming into a positive stock balance and have to expedite orders or are attempting to reach a sales target in a given period of time. "customer deliveries2" is again a multiplication of the order, service loss factor and special delivery factor. The equation reflects a delay equivalent to the lead time as well. This equation follows the same format as that of "customer deliveries1" and is dimensionally balanced.

The efficiency with which the customer ordering and distribution process is carried out to ensure delivery of the order on time and in full, is a measure of the service level achieved which will be discussed further in the management information system area.

4.4.5 Area 5: Management information system

The last area contains only one sector and is dedicated to the management information system that underpins the organisation. It is responsible for providing data to key stakeholders who use this to determine if the organisation is on track both operationally and strategically and to take corrective action if there are deviations. Figure 4.36 highlights some of the key indicators that were deemed pertinent to this study. As one would appreciate, a management information system covers the breadth and width of an organisation. This in itself highlights the conflicting KPI's that drives the various functions and individuals.

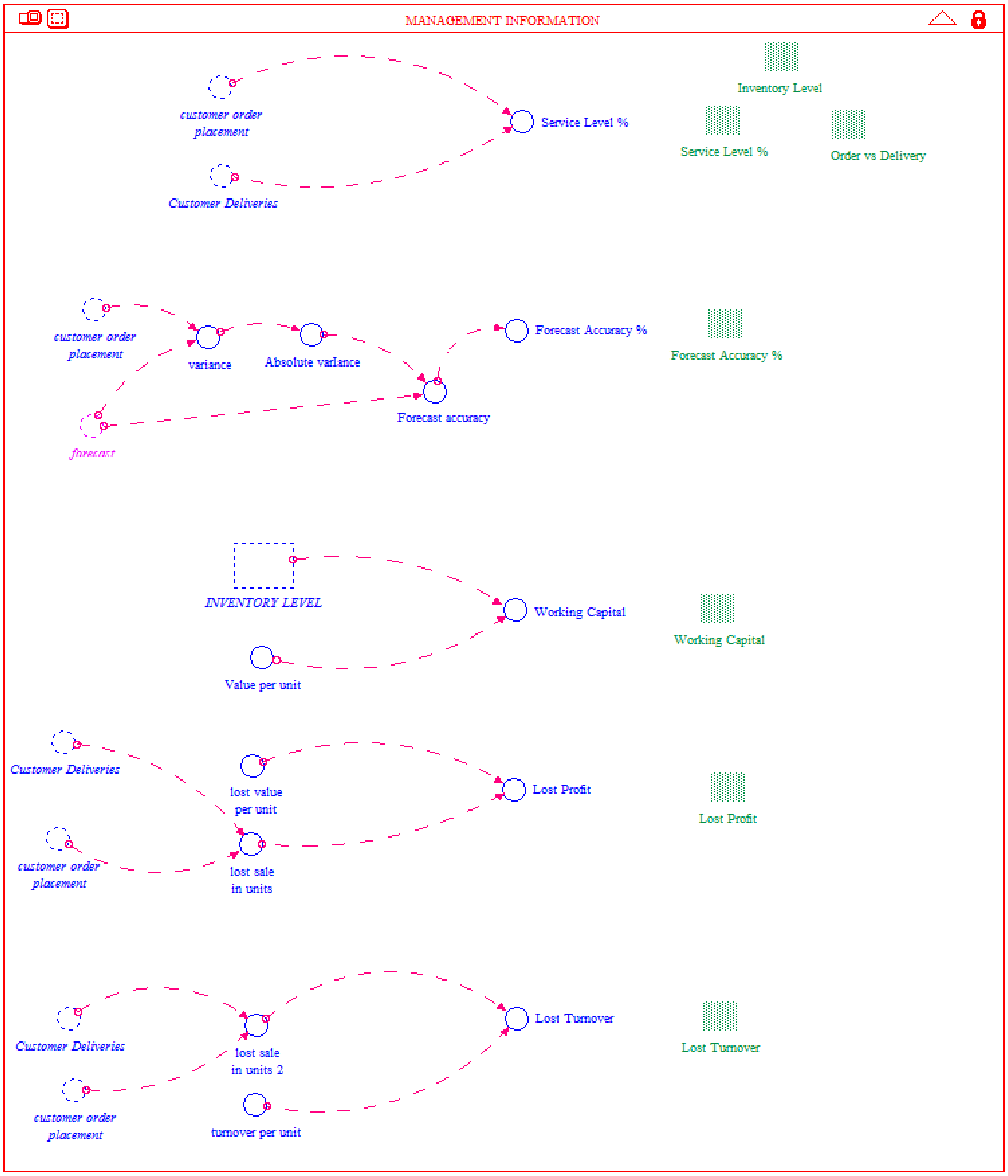
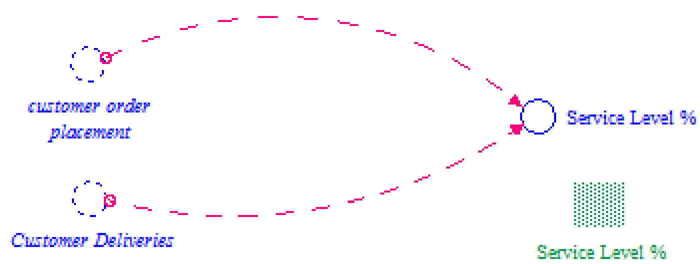


Figure 4.36: Organisational management information system

Figure 4.36 highlights the key KPI's selected that are considered leading indicators of how effective and efficient the S&OP process is and will be explained in detail below.

4.4.5.1 Supply and Customer:



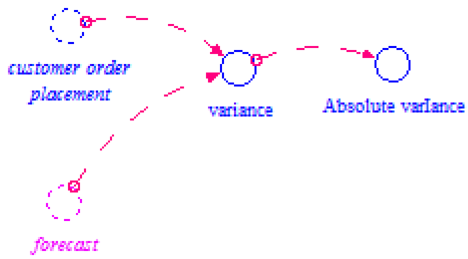
*Service Level % = (Customer Deliveries / customer order placement) * 100*

Dimensional analysis:
Left hand side: [%]
Right hand side: [units/week] / [units/week]*100% = [units/week] * [week/units] * [%] = [%]

Figure 4.37: Customer service levels

Customer service in its simplest form is a measure to determine how successful the organisation was in delivering what the customer initially ordered. As reflected by the equation in Figure 4.37 service level is reflected as a percentage and is the customer order divided by the actual delivery. Shortfalls as a result of no stock or not sufficient stock levels results in a poor service level and leads to lost profitability driven by the negative impact on working capital, lost profit, lost turnover and the cost incurred to recover the sale. As can be seen in the dimensional analysis box, the equation is balanced.

4.4.5.2 Demand:

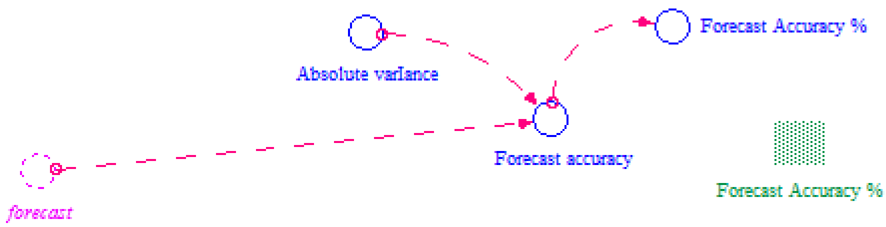


variance = forecast - customer order placement

Absolute variance = ABS (variance)

Figure 4.38: Forecast variance

Forecast Accuracy is a measure of how well the organisation is able to predict customer requirements. The forecast represents one of the outputs of the S&OP process and is the organisation's best guess as to what the customer will want in the future. The "customer order placement" is the actual demand placed on the organisation by the customer. Figure 4.38 reflects the initial variance calculations, which are a subtraction of the forecast and customer order placed with all inputs being in units, ensuring dimensional balance.



Forecast accuracy = (forecast - Absolute variance) / forecast

*Forecast Accuracy % = ABS (forecast accuracy * 100)*

Dimensional analysis: *Forecast accuracy* Left hand side: [factor] Right hand side: [units] - [units] / [units] = [factor] could be a positive or negative value
Dimensional analysis: *Forecast Accuracy %* Left hand side: [%] Right hand side: ABS[factor] * [100] = [%]

Figure 4.39: Understanding the forecast accuracy metric

"Forecast accuracy" is measured as a factor and is the forecast less the variance divided by the forecast, which are all in units. The "Forecast accuracy %" is a transformation of the "forecast accuracy" output into a percentage value and is hence a multiplication of the absolute forecast accuracy multiplied by 100. Due to the forecast accuracy having the potential to be either a positive or negative value, the "forecast accuracy %" equation contains and absolute (ABS) function. Both equations have the left and right hand side units of measure being equivalent indicating that they are dimensionally balanced.

To further simplify the forecast accuracy calculation can be echoed by the equation below.

$$Forecast\ accuracy = Absolute\ \left(\frac{Forecast - \ Customer\ order}{Forecast}\right) \times 100$$

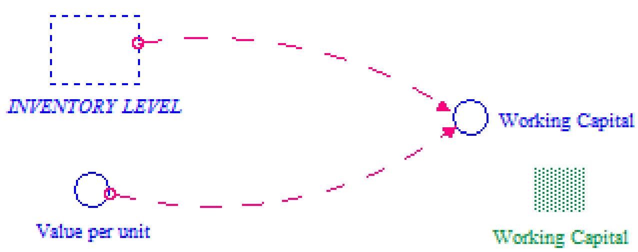
The equation calculates forecast accuracy as a percentage, which is an indication of how well the organisation was able to forecast demand. It is hence a measure of the variance, which is calculated by subtracting the customer order from the forecast, and this number is then divided by the forecast and converted to a non-negative percentage.

4.4.5.3 Profitability:

The profitability measures selected for this study are working capital, lost profits and lost turnover. Please note that the unit of measure or currency utilised could not be disclosed to protect the confidentiality and identity of the organisation within which this study was conducted and was stipulated by the organisation in question. The unit of measure used was therefore selected as *"Currency Unit (CU)"*.

Working capital

Working capital is a measure of the stock value that is held in inventory at a given point in time. Holding stock ties up business cash, which could be used elsewhere to drive growth or held in a bank earning interest. The target weeks cover mentioned earlier is driven by the policy and is a focus area for improvement. Reductions to working capital are constantly being investigated and implemented. We also know that inventory is a buffer against inefficiencies making the reduction a double-edged sword. This conflicting KPI results in the factory and planning team having to balance holding sufficient stock to ensure high service levels versus reducing stock holding but have service level failures.



Value per unit = 39

*Working Capital = Value per unit * INVENTORY LEVEL*

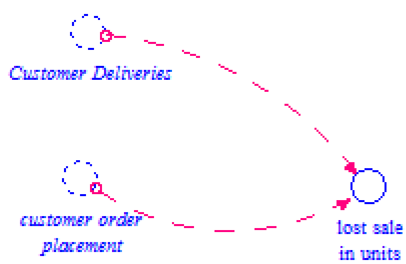
Dimensional analysis:
Left hand side: [Currency unit value]
Right hand side: [Currency unit/unit] * [units] = [Currency unit value]

Figure 4.40: Working capital explained

Figure 4.40 reflects the working capital calculation and dimensional analysis. Given the explanation above, working capital is a multiplication of the inventory level at a point in time and the value per unit held. It is reflective of the monetary value of the stock that is in the warehouse on any given week. The "value per unit" is a constant which would typically be obtained from the finance team (Values used are for illustrative purposes). Dimensional analysis is achieved given the left hand and right hand sides are currency unit values.

Profit

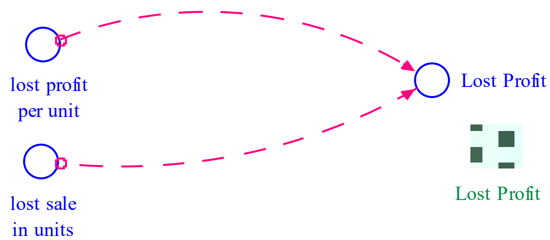
Very simplistically, any product not sold will result in the opportunity to make a profit being lost.



lost sale in units = customer order placement - Customer Deliveries

Figure 4.41: Lost sales calculation

A lost sale is defined as the loss incurred due to the organisation not being able to deliver what the customer ordered. The equation to calculate lost sales as reflected in Figure 4.41 is hence the original customer order placed less the actual stock delivered to the customer with the inputs and output being in units.



lost profit per unit = 33

*Lost Profit = lost sale in units * lost value per unit*

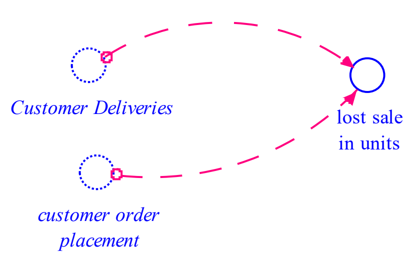
Dimensional analysis:
Left hand side: [Currency unit value/week]
Right hand side: [Currency unit/unit] * [units/week] = [Currency unit value per week]

Figure 4.42: Lost profit calculation

The lost value metric is in effect the amount of cash that would have contributed to gross profit if the sale had been made. A "lost value per unit" of R33 was used in this instance to calculate the overall lost profit and is a multiplication of the standard value per unit and lost sales in units per week. As shown in Figure 4:42 the equation is balanced.

Turnover

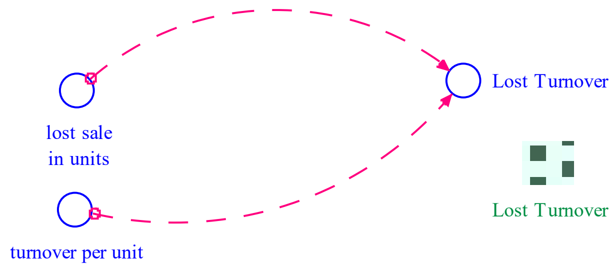
The lost turnover metric is in essence the amount of cash that would have contributed to overall business turnover if the sale had been made.



lost sale in units = customer order placement - Customer Deliveries

Figure 4.43: Lost sales

Figure 4:43 repeats the lost sales calculation explained and shown in Figure 4:41. This was done intentionally to show how it feeds into the lost turnover calculation.



turnover per unit = 78

*Lost Turnover = lost sale in units * turnover per unit*

Dimensional analysis:
Left hand side: [Currency unit value per week]
Right hand side: [Currency unit/unit] * [units/week] = [Currency unit value per week]

Figure 4.44: Lost turnover calculation

A turnover per unit of R78 was used to calculate the overall lost turnover being experienced. The lost turnover is a multiplication of the turnover per unit and lost sales in units per week reflected in Figure 4.44.

Application of the dimensional consistency test was done throughout the explanations of the various sectors and shows that the model has met the required test criteria. Further testing of the model to ensure that it was fit-for-purpose model was done and will be discussed below.

4.5 TESTING

There are numerous testing techniques that are available within the system dynamics framework to further validate that the model is plausible and fit for its intended use. Whilst a number of them are inherently built into the model building process, I will nevertheless still explain them in more detail, including their application and results achieved.

Morecroft (2011) categorise these tests into three areas, viz:

- Test of behaviour are typically visual checks done to compare the behaviour over time outputs generated by the model to that obtained from the numerical database as well as the behaviour over time graphs obtained from the mental database of individuals within the organisation.

- Tests of structure are essentially used to determine if the model structure and equations used are consistent with what is observed in the real world environment. This is applicable to both the stock-flow diagrams and the mathematical equations and logic used.

- Tests of learning seek to determine if model users and those involved in the model building process have extracted new insights into the problem as well as the impact that individual behaviour has on S&OP and profitability.

The tests that have been applied in this research project are:

- **Tests of behaviour:**
    - **Visual fit**

I have purposefully chosen to focus this particular test on the forecast accuracy and service level KPI's within the management information system sector. The rationale behind this decision is primarily that the demand KPI is reflective of the demand side of the S&OP process and the service level KPI is a leading indicator of the supply side of the process.

Forecast Accuracy %

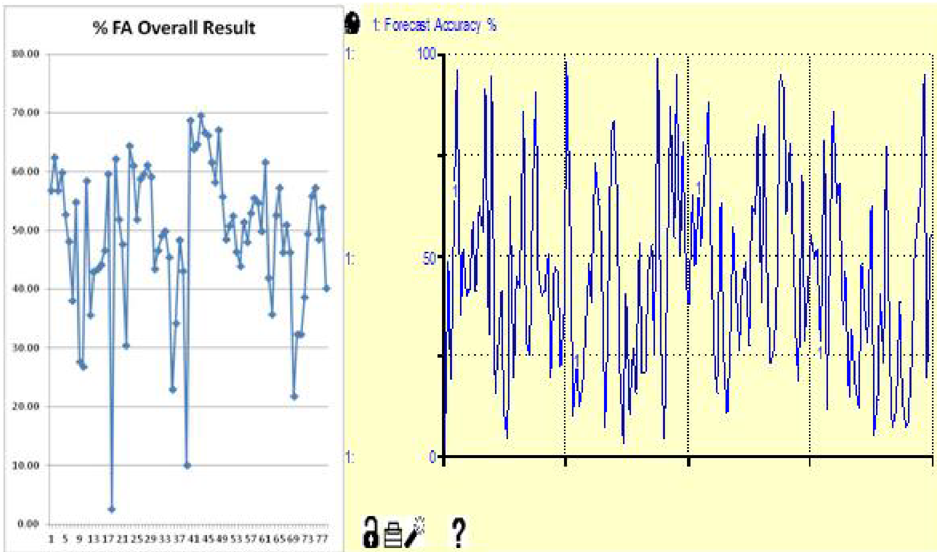


Figure 4.45: Forecast accuracy comparison: Historical data vs model data

Whilst it is accepted that no qualitative or quantitative model will perfectly replicate historical data, it is nevertheless useful to compare the two. The graph on the left hand side in Figure 4.45 represents forecast accuracy obtained from the numerical databases and contains 52 data points whilst the graph on the right is an output from the system dynamics model and contains 156 weeks of data, which is the duration the simulation was run. It is evident from visual inspection that both the graphs seem to average out at the 50% levels with there being a high level of volatility across both. Given the above as well as the magnitude and shape of the graphs being similar, the conclusion that can be drawn is that the model adequately represents reality. A further check that was completed was to engage with the demand planning individual to verify that what is seen in the above Figure is aligned to what resides in their mental database. Whilst there were questions around the model showing results closer to 100% then the numerical database, it was still concluded that the model passes this particular test.

Service Level %

Graph A Graph B

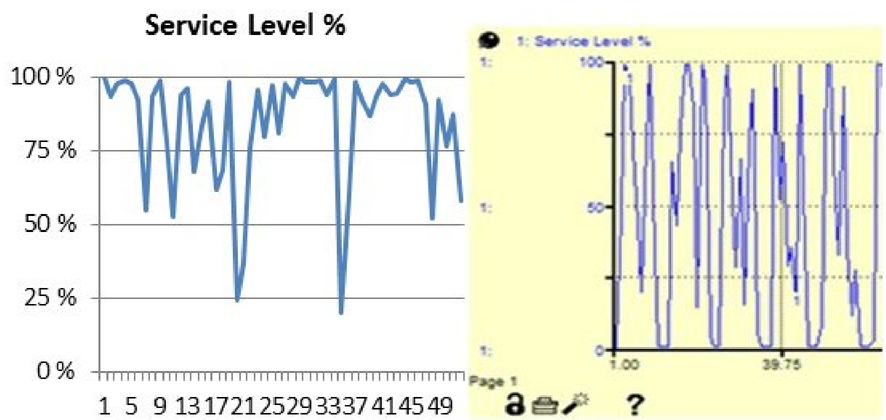


Figure 4.46: Historical service level % versus model generated service level %

Figure 4.46 reveals two behaviour over time graphs, marked A and B which reflects service level obtained from two sources for a period of 52 weeks. Table 4.1 below reflects the source of the graphs.

Graph	Source obtained
A	Numerical database of the organisation
B	System dynamics model

Table 4.1: Source of behaviour over time graphs

When comparing graph A and B what is evident is that both show variability across the period being examined. The visual fit is therefore acceptable given the model captures the oscillation experienced in reality.

Graph C **Graph D**

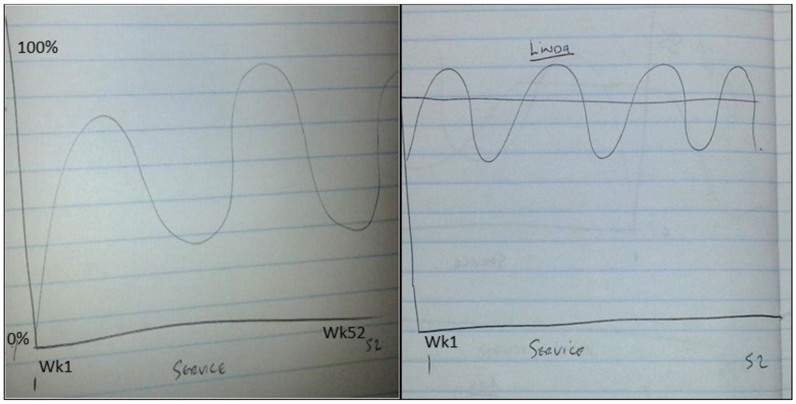


Figure 4.47: Mental model generated service level profile

Figure 4.47 reveals a further two behaviour over time graphs, marked C and D which reflects service level profiles obtained from the interviews conducted. Table 4.2 below reflects the source of the graphs.

Graph	Source obtained
C	Mental model of individual 1
D	Mental model of individual 2

Table 4.2: Source of behaviour over time graphs

The primary purpose of showing these graphs is to complete a visual comparison of behaviour over time graphs of service levels between the mental models of individuals, historical data and the system dynamics model. All four graphs show the same pattern, which is consistent oscillation over a minimum period of a year. Individuals interviewed were unanimous in stating that this pattern repeated itself over the years. When compared to the two behaviour over time graphs (C and D) that was sketched by the individuals interviewed, one would notice that variability is experienced, which is in line with both the model output (B) and historical data (A). This leads to the conclusion that the fit is acceptable.

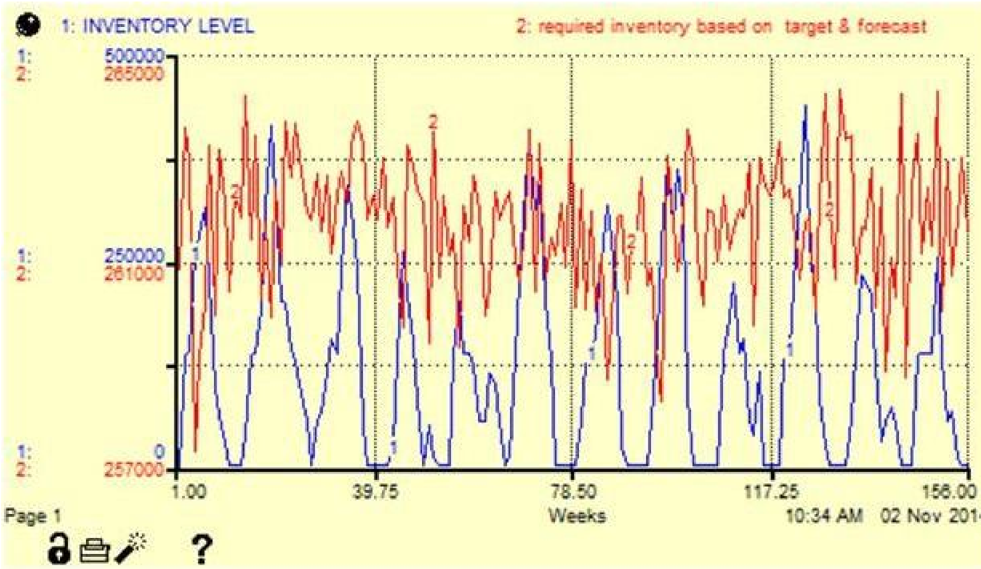


Figure 4.48: Comparison of actual Inventory levels to required inventory levels

Whilst obtaining data on required inventory levels in the required time buckets was not possible, it was worth comparing the model generated picture to that held within the mental databases of individuals. Whilst individuals could not comment on the values, they could relate to the behaviour over time graph seen in Figure 4.48 and confirmed that this type of volatility is being experienced. A common comment made was that we sometimes have too little of what the customer does need and excessive of what they do not need. Some of the learning that came out of this area was the realization that to a large extent this situation is being created by stakeholders within the organisation and is not a function of exogenous forces. I will explain further by way of an example. The demand signal reflects that SKU A will sell at a weekly average of 2000 units and SKU B at a weekly average of 500 units over the next 13 weeks. Based on this appropriate production plans are triggered and the supply chain ensures that the stock held is as per the stock holding and working capital policies. Numerous factors or events can change this reality. One example that occurs is the sales team decides to do a promotion of SKU B instead of SKU A. This results in different customer and consumer buying patterns resulting in the business selling at a far higher rate on SKU B and a lower rate on SKU A. The nett impact is the business is seen as having excessive of what we do not need (SKU A) and too little of what is needed (SKU B).

- **Tests of structure:**
  - **Boundary adequacy**

This test seeks to determine if important concepts are endogenous and have hence been included in the model. To answer this question first lets repeat what has been mentioned in previous chapters. S&OP seeks to integrate the supply and demand aspects of the business to ensure that the supply side of the organisation has the capacity and capability to satisfy demand. Figure 4.1 further highlighted not just the demand and supply aspects but specifically mentioned the customer elements though in certain instances the customer is assumed to be under the demand banner as ultimately the customer drives demand.

The model developed achieves the above as the S&OP framework was used to define the various areas and sectors as described above. Each sector then captured the operational thinking of individuals combined with real world data.

Key points highlighted by individuals and included in the various sectors are:

- The delays experienced in both the producing inflow and customer delivery outflow within the organisational focus sector.
- Demand was broken down in sub sections, which included base, promotions and innovations demand numbers with each following a poisson distribution.
- Factory capacity and reliability were fixed based on numerical data.
- In the supply planning sector the stocking holding policy was included.
- The procurement sector included the stock holding policy that has been agreed with the supplier
- The random nature of orders being placed on the organisation due to various target closing actions was captured used the appropriate equation.
- Within the distribution sector, the lead times used depending on it being a standard or special delivery was included together with the loss factor that was brought to the fore.

The pertinent points from the mental databases have been verified and included, which is a key requirement of boundary adequacy tests.

- **Structure verification**

Structure verification follows from boundary adequacy, as you cannot have one without the other. The model structure developed attempts to capture the operational realities as well as the descriptions given by the various stakeholders. The model structure further compared to the structure, processes and flows seen in the business and they are alike. It is therefore possible to state that the structure can be verified as being similar to the real world.

- **Parameter verification**

Parameter verification is the third aspect under tests for structure with boundary adequacy, structure verification and parameter verification combining to give an holistic view of the model and whether its structure represents reality or not. All parameters contained in the model are consistent with what was obtained from the descriptions acquired via the mental models of individuals and cross referenced against factual parameter values obtained from the organisations historical database. It is worth mentioning that in certain instances descriptive knowledge was further verified against the written database. An example of this would be the stock holding policy used is aligned to organisational policy as well as descriptive information.

- **Dimensional consistency**

This test has been explained within each of the fragments and sectors and hence will not be repeated here. What is worth repeating is that the model equations pass this test and they are all dimensionally balanced.

- **Tests of learning:**

One of the key indicators of a model's success is its ability to stimulate learning by providing new insights to the problem for either the modeler or stakeholders. When this is achieved, then the model has passed the test of learning (Morecroft, 2011). This was achieved largely by sharing information gathered and insights gained. The model building process and how the model and theory fitted together was explained. The model structure and outputs were shared with individuals who served a twofold purpose. The individuals firstly served as a testing mechanism as well as could see how their decisions impact the model and business. From a personal perspective, the learning has been immense. It has encouraged me to think along different lines and to challenge my original way of thinking as well as understand the causal relationships and feedback loops that exist. This was acquired through reading the literature which gave me a theoretical grounding as well as an understanding of the typical applications of system dynamics, following the methodology stipulated in the literature and finally by actually building and using the model.

  - **Surprise behaviour**

This test aims to assess if under certain test conditions the model reflects results, which are unexpected, or a surprise. This could be attributed to the model structure and inputs containing a flaw, which needs to be understood and corrected, or the real system does show this behaviour, which potentially went previously unnoticed or was misunderstood (Ranganath & Rodrigues, 2008). Typically if the model is run for an extended period of time this type of behaviour can be identified by studying the behaviour over time graphs. This test strives to achieve the following (Ranganath & Rodrigues, 2008):

- The better and more comprehensive a system dynamics model, the more likely it is to exhibit behavior that is present in the real system but which has gone unrecognized.
- When unexpected behavior appears, the model builder must first understand causes of the unexpected behavior within the model, and then compare the behavior and its causes to those of the real system.
- When this procedure leads to identification of previously unrecognized behavior in the real system, the surprise-behavior test contributes to confidence in a model's usefulness.

In this scenario, the base case was run for a 10 year period with no changes being made. Therefore, it was assumed that for the next ten years the business would be run in the same manner as today. The forecast accuracy KPI was chosen to illustrate this test of surprise behaviour as forecast accuracy is a measure of forecast versus actual demand, with the forecast being a trigger to how the business reacts. Figure 4.49 reflects the forecast accuracy that one could expect across this period.

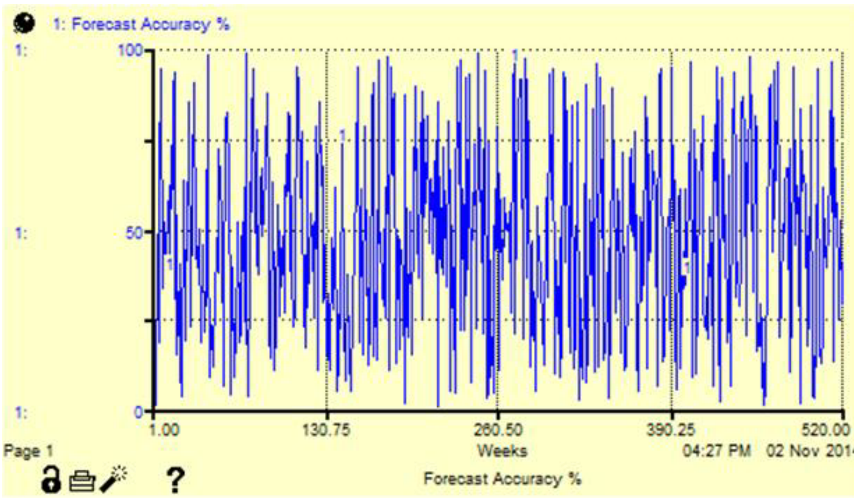


Figure 4.49: Forecast accuracy – 10 year view

So in essence what this means is that if no changes in policy or in the manner in which business is conducted are made, the forecast accuracy would follow the same profile. Two inferences can be reached:

1. Given that the organisation is continuously attempting to improve forecast accuracy this result is surprising to the organisation as improvements are expected. This implies that following the current improvement plans would not realize significant improvements. It is important to note that the organisation has historically worked on optimizing forecast accuracy without seeing a fundamental improvement.
2. Based on the full study conducted, including the analysis discussed in Chapter Five around what policy interventions could lead to improvements, the proposal is to implement policies to control demand and customer orders within a narrower value range. This leads to improvements in forecast accuracy that are more significant. Whilst there has been attempts to optimize these areas they have been done in isolation with the system

dynamics model suggesting an approach that focusses on both the demand and customer ordering elements.

The explanation for the behaviour observed when running the simulation for the 10 year period is that the improvement programs are not addressing root cause, fundamentally changing behaviour or changing metrics that drive behaviour, which is detrimental to profitability. In fact, the reality and discussion that this sparks is that the accuracy would probably decline or oscillate further given that the economic and business landscape would be more competitive and potentially more volatile due to customer demands. Note however that any individual is not able to fully understand the cause and effects of actions taken. Hence, the purpose of this type of test is to stimulate such discussions in the hope of the business gaining new insights. The strength of this test lies not only in individuals being able to predict behaviour over the long term but rather to have an internal view which can be compared to the model outputs, thereby giving rise to further discussions, analysis, what-if & policy intervention scenarios and better overall understanding.

4.6 OVERVIEW OF THE S&OP MODEL – BASE MODEL

Given that individual sectors have been discussed at length, it is an appropriate time to show an overview of the S&OP model that was developed as the base case *(A3 diagram repeated in appendix 14)*.

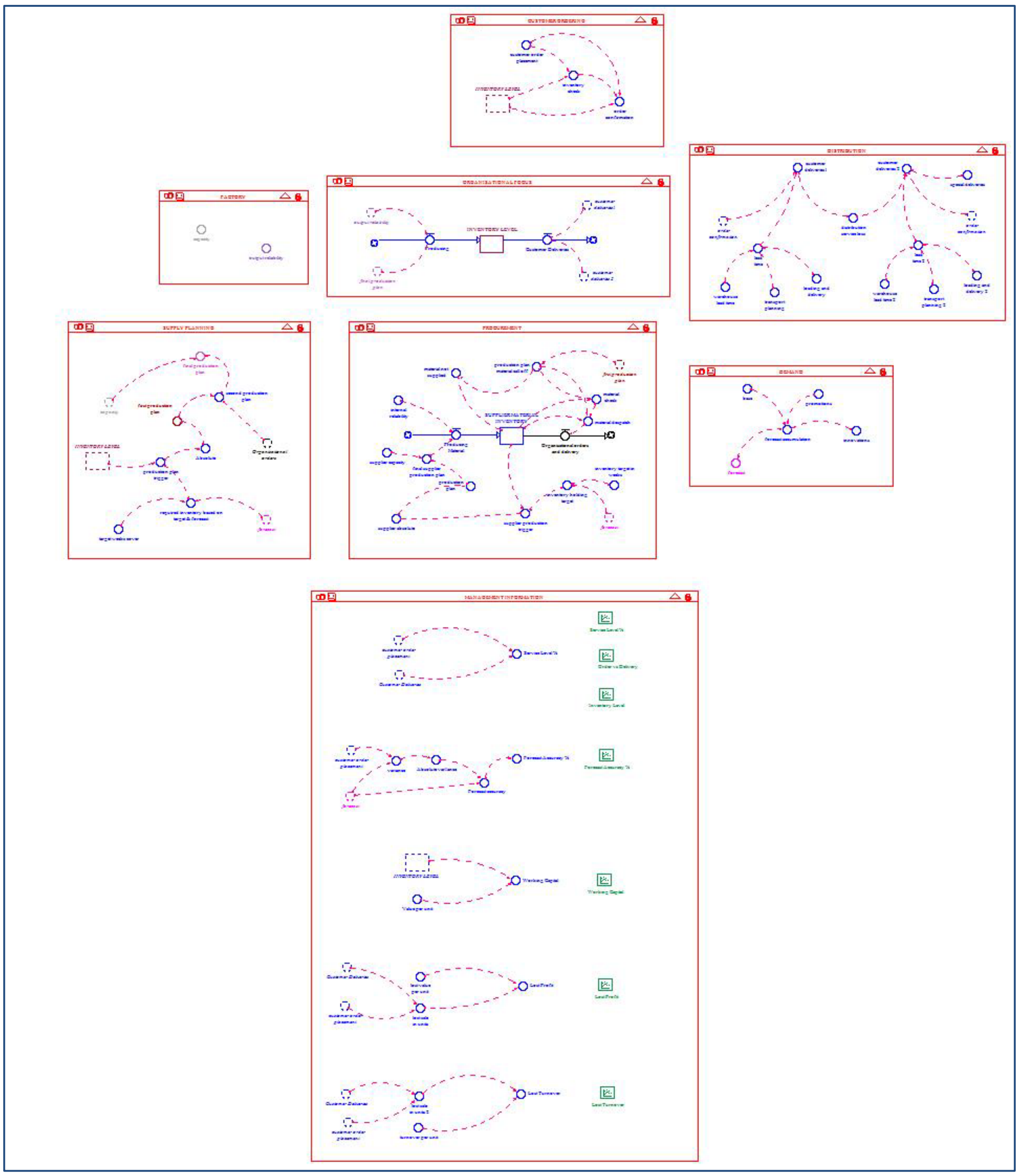


Figure 4.50: Overview of the S&OP model showing sectors, causal relationships and feedback loops

Looking at the overall model in Figure 4.50, one can see that the sectors covers all functions and aspects that play a part in the S&OP process as well as the feedback loops that impact the business. The model also includes the various dynamics as per the inputs obtained from stakeholders.

4.7 CONCLUDING REMARKS

Chapter Four has described in detail the model together with its sectors, the logic behind the variables and the testing of the model using a variety of testing techniques as stipulated in the literature. The questions that model testing seeks to answer is not “Is the model valid?” but rather “Is the model suitable for its purpose and does it reflect reality and the problem?” (Martis, 2006). The tests used in this study is hence what was deemed relevant to answer these questions and is not exhaustive. Through the formulation and testing process followed, the model has been deemed to be fit-for-purpose and is consistent with the problem it endeavors to capture. Due to the model being fit for its intended use, the following Chapter will delve into the use of the model to evaluate an array of alternative scenarios.

CHAPTER FIVE: RESULTS AND FINDINGS

5.1 INTRODUCTION

Chapter Four described in a high degree of detail the model building and testing process with the conclusion being reached that the model developed is plausible and fit for its planned use. The intended use is to apply the model to understanding the impact of various policy change scenarios on the overall business by evaluating the behaviour of the specific business metrics discussed in Chapter Four. The following Chapter will give details on how the system dynamics model described in Chapter Four was utilised and the results and findings that emanated from the study.

Prior to explaining the systematic process followed in the use of the model, I will give a brief overview of the sectors and the linkages that can be found within the model. This will be followed by an explanation of the process used in applying the model, the scenarios being evaluated including the base model, an analysis of the outputs and findings per scenario as well as a holistic summary of scenarios evaluated. Note that the context in which the word scenario is used centers around either a policy change or decision being evaluated.

5.2 MODEL SECTOR OVERVIEW

The system dynamics model developed and explained in Chapter Four is based on the current dynamics that is found within the S&OP framework of the organisation. Figure 5.1 highlights the five areas that can be found within this framework and is the basis for the eight sectors that make up the overall composition of the model.

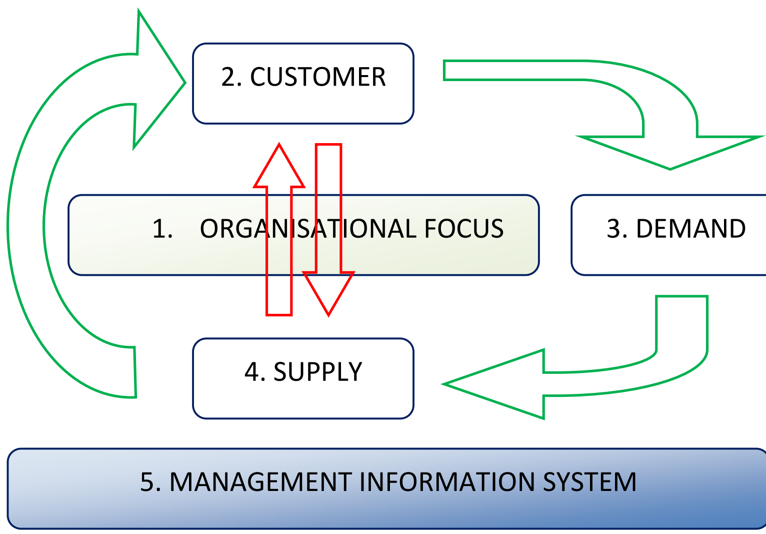


Figure 5.1: S&OP framework within the organisation

Working our way through Figure 5.1 it can be observed that the core area of the model and organisation has been defined as "organisational focus". This captures the underlying reason for the organisations existence, which is to produce stock to inventory that, will be delivered to the customer based on a customer order. This leads to the customer area, which comprises two sectors "customer ordering", and "distribution" which captures the dynamics that play a role in the outflow of inventory. This includes factors such as order receipt, order confirmation and the physical distribution of the inventory to the customer. In order for the organisation to ensure it has the correct stock in anticipation of customer orders the business needs to be able to predict demand. This is reflected in the "demand" sector of the model. Once the demand is known, the supply chain within the organisation will need to ensure the supply of products. This area encapsulates three sectors which covers the "supply planning" aspects, "procurement" of raw and packaging materials to produce and to then physically produce the stock within the "factory" which then is stored as inventory awaiting customer orders. A virtuous cycle which if done in an efficient and effective manner leads to business sustainability. The last but underpinning sector is the "management information system" which tracks key metrics and provides a feedback loop to stakeholders on business performance.

5.3 PROCESS FOLLOWED IN THE USE OF THE MODEL TO EVALUATE SCENARIOS

In building and using a model I found that a pitfall that could likely be encountered is one in which the modeler starts to play with the model and generates a large number of scenarios without necessarily following a methodological process. This results in the duration of the study being extended and combined with the large number of scenarios creates frustration and confusion. This would be counterproductive as one of the purposes of system dynamics is to serve as a learning laboratory, which contributes towards improving communication skills, ensuring cross functional alignment, making mental models explicit, and to serve as a change management tool (Senge & Sterman, 1990). System dynamics should further serve as a teaching tool within an organisation (Martinez-Olvera, 2008). With this in mind, a more systematic approach was adopted.

5.3.1 Seven step scenario generation and evaluation process

The process followed is explained by the following seven step process:

- Step 1: Scenario selection. Understanding and determining from which sector a variable would be selected.
- Step 2: Determining the magnitude of the change for the chosen variable/s and understanding the logic and rationale behind the change.
- Step 3: Inputting the selected values and running the model
- Step 4: Evaluating the behaviour over time graphs and numerical data outputs per scenario
- Step 5: Based on step 4 determining if further scenarios should be evaluated. This included combining scenarios as the analysis and intuition pointed

to there being a potential for greater benefits.

- Step 6: Evaluating outputs of further scenarios run
- Step 7: Ranking and analysis of scenarios based on outputs

5.4 BASE MODEL AND SCENARIO SELECTION

It is important to note that the scenarios selected are not exhaustive but were rather chosen across the various sectors as well as combining of scenarios. This was based on the outputs of preceding scenarios as well as stakeholder input. It is essential to remember that one action may not yield tangible benefits but when two or more actions/decisions are combined better results are evident. Lyneis, Cooper & Els (2001) states that system dynamics is utilised to understand and evaluate the impact of not only individual decisions or policies but a combination of one or more decisions and policies. The logic behind the selection will be explained below and emanated primarily from the interview process (mental database of individuals). Each scenario will be simulated on the system dynamics model with the outputs evaluated. The five output metrics that will be evaluated and discussed in this study are service level, forecast accuracy, working capital, lost profit and lost turnover. The model, which reflects the current reality found in the organisation, captures the relevant interactions and feedback loops which leads to these metrics.

5.4.1 Base model

Table 5.1 summarises six of the sectors within the base model together with the original input values. These six sectors feed into the "organisational focus" and "management information" sectors, which combined makes up the total of eight sectors.

SECTOR	VARIABLE (CONNECTOR) DESCRIPTION	INPUT VALUE	UNIT OF MEASURE
Demand inputs	Base	POISSON 78540	units / week
	Promotion	POISSON 4363	units / week
	Innovations	POISSON 4363	units / week
	Forecast	Base + Promotion + Innovation	units / week
Factory inputs	Capacity	140000	units / week
	Output reliability	0.97 or 97%	%
Supply planning	Target weeks cover	3	weeks
Procurement	Inventory target in weeks	4	weeks
	Internal reliability	0.55 or 55%	%
	Supplier capacity	100000	units / week
Customer ordering	Customer order placement	RANDOM (min of 697 & max of 229894)	units / week
Distribution	Warehouse lead time (1)	0.14	Weeks
	Transport lead time (1)	0.14	Weeks
	Loading & delivery (1)	0.07	Weeks
	Standard deliveries (1)	0.95	Weeks
	Distribution service loss	0.989 or 98.9%	%
	Warehouse lead time (2)	0.07	Weeks
	Transport lead time (2)	0.07	Weeks
	Loading & delivery (2)	0.07	Weeks
	Standard deliveries (2)	0.05	Weeks

Table 5.1: Inputs into base system dynamics model

Given the above inputs, the model was utilised to simulate a 156-week period. The table below and behaviour over time graphs contained in Appendix 5, reflects the outputs per metric generated by the base model.

	Service Level %	Forecast Accuracy %	Working Capital	Lost Profit	Lost Turnover
Average	75.8	43.5	CU 5 357 725	CU 1 877 527	CU 4 437 791
StDev	34.4	25.0	CU 4 372 712	CU 2 334 028	CU 5 516 793
Min	0.0	3.0	CU 47	CU 959	CU 2 266
Max	98.9	98.8	CU 17 125 361	CU 7 529 038	CU 17 795 909

Table 5.2: Outputs of the base model

Table 5.2 summarises the average output and standard deviation of all data points for the duration of the simulation run. The analysis was completed for each of the five metrics discussed previously. The average or mean is calculated by summing up the values in the data range and dividing by the number of items in the range to give a central or average number. The standard deviation is a measure of the spread of the data from the average and gives an indication of the variability that exists within the data range. The larger the standard deviation the greater the variability (Leedy & Ormrod, 2010). The minimum and maximum values contained in Table 5.2 for each of the metrics shows that the data points are spread across a broad range. The values are reflective of reality as they describe the variability experienced. Note that the financial average calculations are based on assumptions given the sensitive nature of sharing this type of information. The spread of data and behaviour over time graphs observed though is insightful of current data profiles.

Appendix 5 reflects the behaviour over time graphs per metric and supports the view seen in Table 5.2 as the graphs visually reflect the variability and spread of data of each of the metrics.

5.4.2 Scenario evaluation process

A total of seven scenarios or policy interventions were simulated using the system dynamics model developed with the outputs being discussed below. Each scenario will be compared to the base model established using the categories highlighted in Table 5.3. This will be used for the mean improvement observed per metric. The standard deviation, minimum and maximum values that will be present per scenario will be used to further explain the success of the scenarios but are not categorised.

Metric	**Marginal improvement (%)**	**Tangible improvement (%)**	**Metric regressed (%)**
Service level %	0 - 5	>5	< base model
Forecast accuracy %	0 - 20	>20	< base model
Metric	**Marginal improvement (CU'000)**	**Tangible improvement (CU'000)**	**Metric regressed (CU'000)**
Working capital	0 - 300	>300	> base model
Lost profit	0 - 500	>500	> base model
Lost turnover	0 - 1 000	>1 000	> base model

Table 5.3: Metric categorisation

The categories have been classified into three groupings, namely marginal improvement, tangible improvement and metric regression. Marginal and tangible improvements have been determined based on what is deemed realistic by the business. The last category of metric regressed is when the scenario being evaluated shows that the metric is worse than the base model outputs.

The schematic in Figure 5.2 illustrates the logic and flow used. Principally the average value per metric of the base model and the scenario are compared to each other with the metric categorisation contained in Table 5.3 being applied.

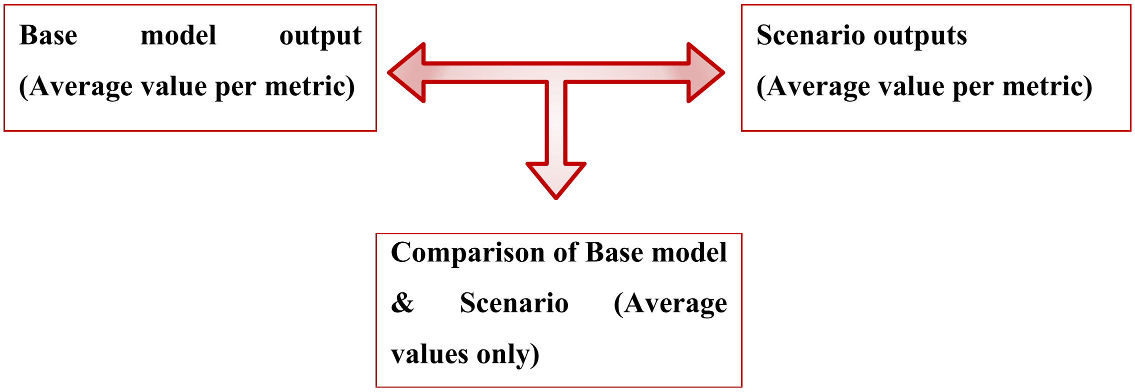


Figure 5.2: Illustration of base model vs scenario comparison

5.4.3 Scenario 1: The crystal ball

In this intervention, the model was used to determine the impact of implementing policies and actions that could result in the organisation being able to predict demand in a more accurate manner. Many would think that this would require a crystal ball to enable any individual to see the future and hence be accurate. What this scenario is suggesting is that the actions taken is not aimed at ensuring a 100% accuracy but to rather reduce the bandwidth or standard deviation of the *forecast* and hence gain a higher degree of control. A random function was also used within the model, as it would be naïve to assume that total control would be achieved. The equation used in the model for the *forecast* variable was "RANDOM (Min, Max, seed value)" with the values being "RANDOM (60580, 140743, 12)". The minimum and maximum values in the base model data set was 33894 units/week and 194220 units/week respectively, with the average being 87267 units/week. The values of 60580 and 140743 were determined by assuming that a 50% reduction in the difference between the average and minimum or maximum values is achievable. This is reflected in Equation 5.1 and 5.2 below.

- **Base model values:**

  Minimum: 33894 units/week

  Maximum: 194220 units/week

  Average: 87267 units/week

- **Scenario 1 values:**

  Minimum: 60580 units/week

  Maximum: 140743 units/week

  Average: 87267 units/week

Equation 5.1: Minimum = $(Average - ((Average - Minimum) \times 50\%)$

Minimum (60580) = $(87267 - ((87267 - 33894) \times 50\%)$

Equation 5.2: Maximum = $(Average + \ ((Maximum - Average) \times 50\%)$

Maximum (140743) = $(87267 + ((194220 - 87267) \times 50\%)$

Table 5.4, Table 5.5 and the figures in Appendix 6 reflect the outputs post the simulation of this scenario.

	Service Level %	Forecast Accuracy %	Working Capital	Lost Profit	Lost Turnover
Average	78.7	58.6	CU 4 902 234	CU 1 775 035	CU 4 195 538
StDev	30.5	21.6	CU 3 887 315	CU 2 259 335	CU 5 340 247
Min	0.1	4.3	CU 60	CU 959	CU 2 266
Max	98.9	99.2	CU 16 987 772	CU 7 536 541	CU 17 813 643

Table 5.4: Outputs of scenario 1: The crystal ball

When comparing the average service level result in Table 5.4 to that obtained in the base model the following is observed:

Metric	**Comparison of metrics to base model**
Service Level %	Marginal improvement achieved
Forecast Accuracy %	Marginal improvement achieved
Working Capital	Tangible improvement achieved
Lost Profit	Marginal improvement achieved
Lost Turnover	Marginal improvement achieved

Table 5.5: Comparison of outputs – base model versus scenario 1

As observed in Table 5.5 improvements are seen in all metrics. A further comparison of the standard deviations between this scenario and the base model also shows a marginal improvement. There exists a large degree of variability as revealed by the standard deviation and range between the minimum and maximum values. Appendix 6 reflects the behaviour over time graphs of each metric with variability being observed in all metrics.

5.4.4 Scenario 2: Extra cash for investment

Let us assume that there are no economic pressures and the business has extra cash to invest. This scenario uses this assumption to investigate the option of investing in additional factory *capacity*. The base model uses 140 000 units per week as the input, with this scenario being modelled on 210 000 units per week. The decision to change this variable to 210 000 is based on the acquisition of a new line which would give an incremental capacity increase of 70 000 units per week. The model was run with this change and the outputs reflected in Table 5.6 and 5.7.

	Service Level %	**Forecast Accuracy %**	**Working Capital**	**Lost Profit**	**Lost Turnover**
Average	86.1	43.5	CU 9 111 531	CU 1 799 120	CU 4 252 466
StDev	28.5	25.0	CU 7 164 772	CU 2 490 935	CU 5 887 664
Min	1.0	3.0	CU 83	CU 959	CU 2 266
Max	98.9	98.8	CU 28 117 628	CU 7 537 262	CU 17 815 345

Table 5.6: Outputs of scenario 2: extra cash for investment

Metric	**Comparison of metrics to base model**
Service Level %	Tangible improvement achieved
Forecast Accuracy %	No improvement
Working Capital	Metric regressed
Lost Profit	Marginal improvement achieved
Lost Turnover	Marginal improvement achieved

Table 5.7: Comparison of outputs – base model versus scenario 2

Increasing capacity results in there being a tangible improvement in service level but a regression in the working capital is noted. What this implies is that the organisation is able to maintain higher stock covers to satisfy customer orders, hence the service level improvement. However, given the demand volatility, which can be seen by the forecast accuracy not changing, when the weekly orders are smaller then the demand forecast the impact is working capital or stock on hand being higher. Both lost profit and turnover show marginal improvements. The standard deviation on the working capital metric gets worse due to the volatility observed, with improvements seen in the standard deviation of the service metric. The deviation for both lost profit and turnover get marginally worse as well. Even though improvements are noted, Appendix 7 highlights that the pattern or profile of the metrics are similar to those seen in the base model in that there is variability. An observation that is further supported by the range seen between the minimum and maximum values as well as the standard deviation across all variables.

5.4.5 Scenario 3: If ever there is no working capital pressure

With the organisation focusing heavily on reducing working capital and thus releasing more cash to be invested elsewhere, this scenario analysed the option of increasing stock holding levels. Whilst many would argue that increasing stock levels is not the answer and generally hides problems it is also understood that managing an organisation is about attempting to find the correct balance between the various metrics that drives as business. This scenario hence investigated the impact of changing the stock holding policy to hold more stock on the key metrics discussed previously. The decision was taken to increase the *stock holding target* from 3 to 10 weeks' worth of stock. Typically, imported products have a stock holding policy of 10 weeks, which is the logic, used to change from the current target of 3 weeks.

	Service Level %	**Forecast Accuracy %**	**Working Capital**	**Lost Profit**	**Lost Turnover**
Average	76.3	43.5	CU 4 665 642	CU 1 968 866	CU 4 653 684
StDev	31.4	25.0	CU 3 850 154	CU 2 289 550	CU 5 411 663
Min	1.4	3.0	CU 169	CU 3 247	CU 7 676
Max	98.9	98.8	CU 14 802 986	CU 7 517 370	CU 17 768 328

Table 5.8: Outputs of scenario 3: if ever there is no working capital pressure

Metric	Comparison of metrics to base model
Service Level %	Marginal improvement achieved
Forecast Accuracy %	No improvement
Working Capital	Tangible improvement achieved
Lost Profit	Metric regressed
Lost Turnover	Metric regressed

Table 5.9: Comparison of outputs – base model versus scenario 3

Intuitively, one would have expected to see a tangible improvement in service level given the fact that if more stock is carried, surely we could better service customer orders. On the opposite end, one would have expected to see working capital increasing. What was observed however is only a marginal improvement in service and a tangible improvement or decrease in working capital. This can be explained by the inventory levels still being lower than expected customer orders as reflected in Figure 5.3 below. This translates into the additional stock being produced, stored and depleted by the customer orders, which contains a high level of variability.

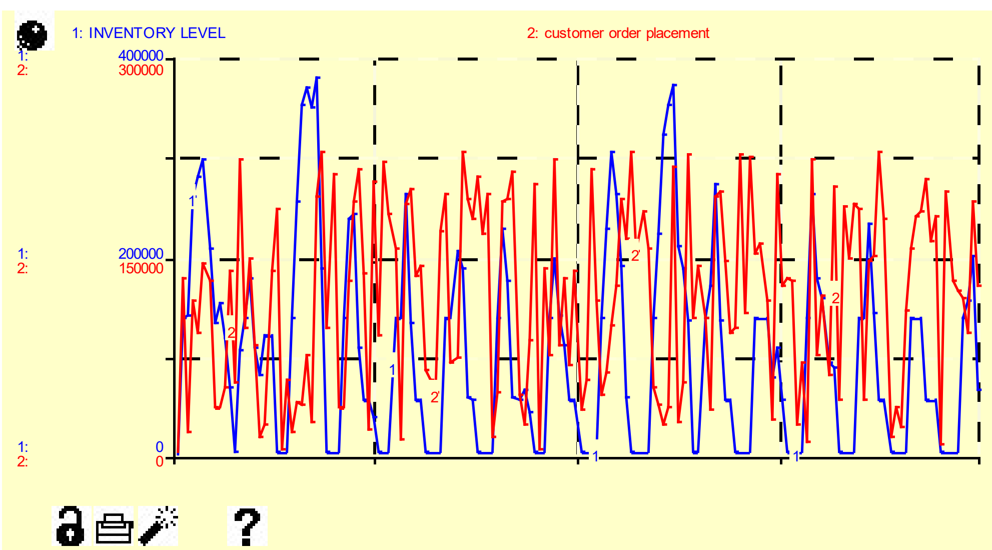


Figure 5.3: Inventory level versus customer orders received

The change in the stock holding policy resulted in no change to the forecast accuracy, which was expected as well as the lost profit and turnover metrics worsening. Even though the stock holding policy was increased, it is still not sufficient to cater for the variable demand. Hence, when stock is refilled it is depleted immediately with the time to replenish being a long lead time process.

During this when orders are placed and the organisation is not able to react a loss of turnover and profit is experienced. If a large order was placed and not delivered against, it contributes greatly towards a loss in turnover and profit. The standard deviation of all metrics except forecast accuracy show marginal improvement though the data range is still high. Appendix 8 highlights that the behaviour of the metrics are similar to those seen in the base model.

5.4.6 Scenario 4: Burden the supplier

With markets getting tougher and suppliers needing to be unique in their service offering one of the elements looked at was to get the supplier to hold more stock to cater for the variability seen. To this end, the stock holding policy for the supplier was changed from 4 weeks cover to 6 weeks cover for the *inventory target in week's* variable and the model run. The alternate reason for running this scenario is due to there being a perception that the supplier is sometimes the reason for out of stock situations and hence poor customer service. The view is that if the supplier carried more stock then the reaction time to requests by the organisation would be faster. Tables 5.10 and 5.11 contains some of the tabular outputs.

	Service Level %	**Forecast Accuracy %**	**Working Capital**	**Lost Profit**	**Lost Turnover**
Average	77.8	43.5	CU 5 287 216	CU 1 563 726	CU 3 696 080
StDev	31.1	25.0	CU 4 026 561	CU 2 097 962	CU 4 958 819
Min	1.3	3.0	CU 83	CU 959	CU 2 266
Max	98.9	98.8	CU 18 677 814	CU 7 507 111	CU 17 744 081

Table 5.10: Outputs of scenario 4: Burden the supplier

Metric	**Comparison of metrics to base model**
Service Level %	Marginal improvement achieved
Forecast Accuracy %	No improvement
Working Capital	Marginal improvement achieved
Lost Profit	Marginal improvement achieved
Lost Turnover	Marginal improvement achieved

Table 5.11: Comparison of outputs – base model versus scenario 4

As reflected in the above tables, marginal improvement is seen across four of the metrics with forecast accuracy seeing no change. One could argue that increasing the stock holding policy from 4 to 6 weeks is not sufficient and increasing it by a larger number should be considered. This approach however will not necessarily result in tangible benefits because the reason for increasing stock covers is not due to the supplier being the root cause of all problems but rather the volatile behaviour seen in both the demand and customer ordering behaviour over time graphs. Furthermore, a larger stock holding by the supplier will not result in additional inventory of finished goods as downstream policies such as factory capacity or supply planning stock holding policies would not have changed. Hence, an improvement in business metrics will not be seen. This is evident in Appendix 9, which reflects the behaviour over time graph for forecast accuracy. The standard deviation, minimum and maximum values further reflects the variability experienced and showed a small improvement when compared to the base model.

5.4.7 Scenario 5: Customers and sales teams that listen

This particular scenario aims to understand what the impact of reducing the variability in customer ordering would be on the key metrics. Whenever this topic is raised, most avoid it and cite numerous reasons why it is out of the organisations control and is hence an exogenous variable. The fast moving consumer goods (FMCG) organisation, even though a global player is generally of the opinion that they are at the mercy of the retailer in within the country in question. Internal sales targets further drive certain behaviours, which result in variability in customer ordering.

The same random function used in the base model for *customer order placement* was used in this particular scenario, though the minimum and maximum values were changed to within a narrower bandwidth. The minimum and maximum values in the base case data set was 697 units/week and 229894 units/week respectively, with the average being 83549 units/week. The values of 41775 and 125324 were determined by assuming that a bandwidth equal to 50% of the average value is realistic. This is reflected in Equation 5.3 and 5.4 below.

- **Base model values:**
  Minimum: 697 units/week
  Maximum: 229894 units/week
  Average: 83549 units/week

- **Scenario 5 value calculations:**
  Minimum: 41775 units/week
  Maximum: 125324 units/week
  Average: 83549 units/week

Equation 5.3: Minimum = $(Average - (Average \times 50\%)$

Minimum (41775) = $(83549 - (83549\ \times 50\%)$

Equation 5.4: Maximum = $Average + (Average \times 50\%)$

Maximum (125324) = $(83549 + (83549 \times 50\%)$

Table 5.12 and Table 5.13 reflect the outputs post the simulation of this scenario.

	Service Level %	**Forecast Accuracy %**	**Working Capital**	**Lost Profit**	**Lost Turnover**
Average	87.4	74.6	CU 6 701 186	CU 1 001 479	CU 2 367 133
StDev	25.8	14.5	CU 4 750 936	CU 1 409 679	CU 3 331 968
Min	1.2	48.1	CU 143	CU 15 462	CU 36 547
Max	98.9	99.4	CU 15 863 127	CU 4 117 739	CU 9 732 837

Table 5.12: Outputs of scenario 5: Customers and sales teams that listen

Metric	**Comparison of metrics to base model**
Service Level %	Tangible improvement achieved
Forecast Accuracy %	Tangible improvement achieved
Working Capital	Metric regressed
Lost Profit	Tangible improvement achieved
Lost Turnover	Tangible improvement achieved

Table 5.13: Comparison of outputs – base model versus scenario 5

Tables 5.12 and 5.13 show that 4 of the 5 metrics displayed that tangible improvements can be achieved if customer ordering was more tightly controlled. One would notice that working capital however increased. If one recalls, the forecast accuracy calculation utilised both the demand and customer ordering values. Merely changing and controlling the customer order process results in tangible improvements in forecast accuracy. Whilst the minimum and maximum values across four of the five metrics shows a wide range, forecast accuracy reflects an improvement. The standard deviation in four of the metrics has showed improvements with working capital showing a slight increase. This is again due to the volatility seen in the demand forecast. Appendix 10 reflect the behaviour over time graphs for the metrics and supports the tables and explanations above.

The above five scenarios were originally selected and evaluated. However, you will recall that mention was made of system dynamics being utilised to understand the effect that multiple changes or causes will have on the system given the various feedback loops. With this in mind, two further scenarios were selected and will be discussed below.

5.4.8 Scenario 6: Gaining ultimate control

This scenario explores the impact of implementing policies and taking subsequent actions that would reduce the variability in both the *forecast* and *customer order placement* inputs. The logic behind looking at this combination originated from a key theme that originated from the stakeholder interviews conducted, which is that if forecast accuracy were improved it would resolve many of the current operational issues being experienced. Further logic used was that the two key input variables into the forecast accuracy calculation is demand and customer orders.

Scenario 1 (the crystal ball) and scenario 2 (Customers and sales teams that listen) were incorporated and the model run. The equation used in the *forecast* connector were “RANDOM (60580, 140743, 12)” and in the *customer order placement* connector were “RANDOM (41775, 125324, 12)”. The model was run with the outputs contained in Tables 5.14 and 5.15.

	Service Level %	Forecast Accuracy %	Working Capital	Lost Profit	Lost Turnover
Average	84.8	81.9	CU 6 305 184	CU 933 569	CU 2 206 617
StDev	30.5	5.8	CU 4 545 488	CU 1 393 466	CU 3 293 646
Min	1.1	69.0	CU 128	CU 15 421	CU 36 450
Max	98.9	89.0	CU 15 984 094	CU 4 117 517	CU 9 732 314

Table 5.14: Outputs of scenario 6: gaining ultimate control

Metric	**Comparison of metrics to base model**
Service Level %	Tangible improvement achieved
Forecast Accuracy %	Tangible improvement achieved
Working Capital	Metric regressed
Lost Profit	Tangible improvement achieved
Lost Turnover	Tangible improvement achieved

Table 5.15: Comparison of outputs – base model versus scenario 6

Tangible improvements were seen in four of the five metrics with the only metric showing a regression being working capital. Note however that the working capital metric is a comparison between the outputs of this scenario versus the base model. In comparison to the base model, the working capital or inventory stock levels have increased. The primary reason for the working capital being lower in the base model relates to the lower service levels experienced. Given customer orders placed were to a large extent exceeding inventory levels one would anticipate that the smaller quantity of inventory would be used to satisfy the order, hence reducing the stock levels and working capital. In retrospect, the poor service level in the base model due to being out of stock would lead to the working capital not being a true reflection given that the inventory stock was not at the correct levels. The conclusion is therefore not that the working capital value achieved is negative but rather highlights to the business that should these policy changes be made then whilst other metrics improve an increase in working capital must be expected.

The standard deviations for forecast accuracy, lost profit and lost turnover shows a decline when compared to the base model suggesting that the variability in these metrics have declined whilst the service level and working capital metrics did not drastically change suggesting that variability is still evident. Of particular interest is the increase in forecast accuracy to 81.9% and the associated drop in the standard deviation from 25% in the base model to 5.8% in this scenario. Appendix 11 reflects the behaviour over time graphs of all five metrics. What can be observed is that the variability in the forecast accuracy metric is drastically reduced whilst some reduction in variability is still witnessed in the other metrics. The minimum and maximum values for service levels shows not movement and hence there still exists a broad range. The other metrics however all show a smaller gap between the minimum and maximum values with forecast accuracy showing a bugger improvement,

5.4.9 Scenario 7: Increasing capacity and inventory

In this scenario, the objective was to assess the impact of carrying more inventory and the factory having additional capacity. This entails additional capital investment within the factory and increasing the working capital target. The model that was developed is a combination of scenario 2 and scenario 3 with the factory *capacity* being increased from 140000 units/week to 210000 units per week and the *stock holding target* being increased from 3 weeks to 6 weeks. The outputs of the model is contained in the below Tables and Appendix 12.

	Service Level %	**Forecast Accuracy %**	**Working Capital**	**Lost Profit**	**Lost Turnover**
Average	88.5	43.5	CU 8 336 200	CU 1 357 306	CU 3 208 178
StDev	25.1	25.0	CU 6 220 096	CU 2 197 057	CU 5 193 044
Min	1.0	3.0	CU 162	CU 1 071	CU 2 531
Max	98.9	98.8	CU 22 192 837	CU 7 448 178	CU 17 604 783

Table 5.16: Outputs of scenario 7: increasing capacity and inventory

Metric	**Comparison of metrics to base model**
Service Level %	Tangible improvement achieved
Forecast Accuracy %	No improvement
Working Capital	Metric regressed
Lost Profit	Tangible improvement achieved
Lost Turnover	Tangible improvement achieved

Table 5.17: Comparison of outputs – base model versus scenario 7

The service, profit and turnover metrics all showed tangible improvements, with there being no improvement in forecast accuracy and working capital regressing in comparison to the base model. Similar to scenario 6 it is observed that the working capital value has increased and is expected given the higher stock holding policy. There is no movement of the forecast accuracy metric which is expected given the there was no impact to the demand or customer ordering metric.

The standard deviation for service does show a reduction though as observed in Figure 5.38 there is still a fair amount of variability. Variation in working capital increases with there being minimal to no movement to the forecast accuracy, lost profit and lost turnover metrics. The data range as illustrated by the minimum and maximum values is still broad.

Appendix 12 reflect the behaviour over time graphs of four metrics with all of the graphs showing that variability still exists.

5.5 HOLISTIC SUMMARY OF OUTPUTS

In total seven policy or decision interventions have been described and compared to the base system dynamics model. What will follow is a more holistic summary and comparison of the outputs from the various interventions. Table 5.18 contains the output per intervention reflected as an average value.

Intervention description		Service Level % (SL)	Forecast Accuracy % (FA)	Working Capital (WC)	Lost Profit (LP)	Lost Turnover (LT)
	Base model	75.80	43.55	5 318 038	1 877 527	4 437 791
Scenario 1	Demand	78.67	58.64	4 703 496	1 775 035	4 195 538
Scenario 2	Capacity	86.10	43.55	8 575 559	1 799 120	4 252 466
Scenario 3	Supply weeks cover	76.29	43.55	4 250 209	1 968 866	4 653 684
Scenario 4	Procurement weeks cover	77.84	43.55	5 181 472	1 563 726	3 696 080
Scenario 5	Customer ordering	87.44	74.61	6 248 403	1 001 479	2 367 133
Scenario 6	Demand & customer ordering	84.81	81.89	6 056 295	933 569	2 206 617
Scenario 7	Capacity & weeks cover increased	88.49	43.55	7 776 724	1 357 306	3 208 178

Table 5.18: Summary of Outputs

Table 5.19 gives an overview of the colour coding used per category with each intervention being compared to the outputs of the base model.

Category description	Colour coding
No improvement	
Marginal improvement achieved	
Tangible improvement achieved	
Metric regressed	

Table 5.19: Explanation of colour coding used in Table 5.18

The conclusion reached from examining Table 5.18 will vary depending on the view point of the reader. If one assumes a conservative approach then scenario 1 and 4 may be more appealing given there is marginal improvement with no metric regressing. If a more optimistic view point is taken then potentially scenarios 5, 6 and 7 will be considered. The questions that spring to mind on scenario 7 would be "what is the cost of investing in capacity?" and "what is the cost of working capital if the weeks cover policy was increased?" versus the benefit achieved. Scenario 2 and 3 as stand-alone options would probably not even be considered given the limited perceived benefit vs the cost of investing in both capacity and additional inventory.

Naturally, a decision will not be made solely on the above table, as there are counter balance metrics to each of the metrics shown in the table. What it does do though is trigger discussion that could lead to further assessments. Given organisation resource constraints it is important to direct ones efforts versus attempting to evaluate all alternatives.

Table 5.20 contains an attempt by the author to rank the various options. The ranking mechanism selected is relatively simple with equal weighting being given to all metrics as they are deemed business critical. As an example if the service level metric is taken, then the scenario with the highest service level output of 88.49% was ranked number 1 with number 2 being scenario 5 with a service level of 87.44. If no improvement of the metric was seen when compared to the base model then no ranking was given as displayed by scenario 7 in which the forecast accuracy value did not move. This was done for all metrics, a total calculated and all scenarios arranged in descending order based on the total values to illustrate the better interventions.

Intervention description		SL	FA	WC	LP	LT	TOTAL
Scenario 6	Demand & customer ordering	4	1	4	1	1	11
Scenario 5	Customer ordering	2	2	5	2	2	13
Scenario 7	Capacity & weeks cover increased	1	7	6	3	3	20
Scenario 1	Demand	5	3	2	5	5	20
Scenario 4	Procurement weeks cover	6	7	3	4	4	24
Scenario 2	Capacity	3	7	7	6	6	29
Scenario 3	Supply weeks cover	7	7	1	7	7	29

Table 5.20: Ranking of interventions

As observed in Table 5.20 scenario 6 is on the top of the list with an overall rating of 11 followed by scenario 5 with a rating of 13. All scenarios with a score greater then 15 were marked as red and will not be discussed further.

In scenario 6, combining the demand & customer orders scenarios gives a greater level of control leading to a reduction in the bullwhip effect and hence better performance with regards to service levels and forecast accuracy. This results in further financial benefits with regards to working capital, lost profit and lost turnover reductions. To achieve this a high level of collaboration between internal functional teams as well as between the customers and business is required to ensure alignment towards a common cause.

Note that the mean value per metric was used to categorise each intervention and ranked below accordingly. However analysing the mean value on its own is not the best approach and could lead to incorrect conclusions. It is for this reason that the minimum, maximum and standard deviations were also considered, when analysing each intervention, as they all contribute towards a holistic understanding of the intervention outputs. This approach assisted in ensuring that the best options were selected in context of what the business deems important. To illustrate, if all metrics showed significant improvement but the working capital increased from a weekly average value of R6 000 000 to R106 000 000 this could lead to excess cash being tied up in inventory levels, which in turn hamstrings the organisation, leading to overall negative business benefits in the short, medium and long term. It is therefore important to understand the minimum and maximum values as they give an understanding of the range that the data spans. The standard deviation on the other hand shows the spread or variation that is evident in the data points. To illustrate further let us consider a few possible permutations *(Note the numbers used are randomly selected and not mathematically calculated).*

Permutation 1:

Description: In permutation 1 let us assume that the working capital average value increased to CU106 000 000 with a minimum of CU99 000 000 and maximum of CU115 000 000, together with a standard deviation of CU5 000 000.

Outcome: If I compared the working capital outcome to those of the base model outcomes, which are contained in Table 5.1, one would probably consider the following. The positive points to note is that the standard deviation is low indicating low variability, which is further supported by the minimum and maximum values being close to the average value. Statistically the mean, minimum, maximum and standard deviation values reflects a process in control and hence a good picture. However, from a practical significance perspective the business in which this study resides would not want to implement, as it would lead to cash being invested in inventory with a major negative impact to the business.

Permutation 2:

Description: In permutation 2 let us assume that the working capital average value increased to CU35 000 000 with a minimum of CU27 000 000 and maximum of CU43 000 000, together with a standard deviation of CU5 000 000.

Outcome: On comparing the working capital outcomes of permutation 2 to those of the base model outcomes, which are contained in Table 5.1 the following, can be concluded. In this permutation, it can be seen that the standard deviation is low indicating low variability and is supported by the minimum and maximum values being close to the average value. Statistically the mean, minimum, maximum and standard deviation values reflects a process in control and hence a good picture. From a practical significance perspective, the business will seriously consider implementing this solution provided the other metrics showed significant improvement and there are overall business benefits.

Permutation 3:

Description: In permutation 3 let us assume that the working capital average value increased to CU35 000 000 with a minimum of CU3 000 000 and maximum of CU85 000 000, together with a standard deviation of CU5 000 000.

Outcome: In this permutation, it can be seen that the standard deviation is low indicating low variability though the overall mean value does show and increase to the base model. However, the minimum and maximum values are far from the mean showing a wide range. A maximum of CU85 000 000 could be detrimental to the business and hence even a few outliers could make the particular option non-viable.

In the business environment and in the context of this research study this type of logic would be applied to all metrics to ensure that the statistical and practical views are considered when evaluating an intervention.

5.6 SCENARIO 8: INFINITE EVERYTHING

I have described the first five interventions (scenario 1 to 5) which was an assessment of the outputs one would expect if a single variable within a particular sector were changed. Based on the outputs and stakeholder inputs received during the data collection process a further two interventions (scenario 6 and 7) were identified and resulted in at least two variables being changed and simulated. Based on this approach the interventions were ranked according to benefits expected. This intervention (scenario 8) was chosen for no reason other then to evaluate the impact of a world with minimum restrictions (infinite everything). Table 5.21 describes the values that was used as inputs into the model and as can be noted a number of sectors were impacted.

SECTOR	VARIABLE (CONNECTOR) DESCRIPTION	INPUT VALUE	UNIT OF MEASURE
Demand inputs	Forecast	RANDOM (min of 60580 & max of 140743)	units / week
Factory inputs	Capacity	420000	units / week
Supply planning	Target weeks cover	20	weeks
Procurement	Inventory target in weeks	20	weeks
	Supplier capacity	450000	units / week
Customer ordering	Customer order placement	RANDOM (min of 41775 & max of 125324)	units / week

Table 5.21: Inputs into "infinite everything" model

The demand and customer ordering input values were as per those used in the previous scenarios, with the other four inputs being increased to values that in the current business context would probably not be approved. The outputs described in Tables 5.22 and 5.23 are however interesting.

	Service Level %	Forecast Accuracy %	Working Capital	Lost Profit	Lost Turnover
Average	98.9	81.9	CU 81 165 404	CU 39 535	CU 93 445
StDev	0.0	5.8	CU 19 056 583	CU 108 310	CU 256 005
Min	98.9	69.0	CU 13 205 205	CU 15 421	CU 36 450
Max	98.9	89.0	CU 126 074 324	CU 1 378 806	CU 3 258 996

Table 5.22: Outputs of scenario 8: infinite everything

Metric	Comparison of metrics to base model
Service Level %	Tangible improvement achieved
Forecast Accuracy %	Tangible improvement achieved
Working Capital	Metric regressed
Lost Profit	Tangible improvement achieved
Lost Turnover	Tangible improvement achieved

Table 5.23: Comparison of outputs – base model versus scenario 8

All metrics except working capital show tangible improvements in both the average output as well as the standard deviation. The variable across all metrics except working capital is drastically reduced as further illustrated by the narrow gap between the minimum and maximum values. The increase in working capital is expected given the stock holding policy was increased to 20 weeks.

The standard deviation for working capital reflects a substantial increase with the other metrics showing a tangible reduction in variability. Appendix 13 reflects the behaviour over time graphs of all metrics with all graphs showing a drastic decrease in variability.

5.7 CONCLUDING REMARKS

This Chapter has focused on how the model was used to evaluate various potential policy and decision making interventions. The results of each evaluation was discussed together with the supporting data and behaviour over time graphs followed by a holistic summary of the results and findings.

As observed within this Chapter system dynamics is a powerful tool that can be used to shape the manner in which individuals and organisations understand complex problems and the effects that various actions can have. It also provides a platform to understand dynamic business complexity, prevents costly mistakes and most importantly drives a holistic business culture that enables individuals to be united towards a common purpose.

Chapter Six will focus discussions on the linkages that exist between the cast study done and the literature review conducted.

CHAPTER SIX: DISCUSSION OF LITERATURE VERSUS THE CASE STUDY

6.1 INTRODUCTION

Chapter Six seeks to integrate the literature covered in Chapter Two and the case study that systems dynamics was applied too. It will cover the key points identified in the literature together with the impact that was evident during the study. The Chapter will then go on to discuss how system dynamics contributed towards S&OP in the context of the problem identified. It will cover how the study addressed the problem statement and research questions as well as the various phenomena experienced. This will explained by using the applicable headings and key statements found in the literature review Chapter.

6.2 PROBLEM STATEMENT AND RESEARCH QUESTIONS

Before we delve into understanding the linkages, it is worth mentioning the problem statement and research questions. This was the original intent, post a few revisions, of the study conducted.

Problem Statement:

The intention of this research is to construct a system dynamics model to ascertain the impact of S&OP processes within an FMCG organisation.

Research questions:

- What are the casual relationships between S&OP policies and profitability of an organization?
- What are the organizational variables that have an impact on the effectiveness of S&OP within an organization?
- How do current behavioural patterns affect the organisation when compared to an S&OP process that is implemented and followed rigorously?
- What are the key factors that if leveraged can be used to ensure alignment between current practices and organisational policies and strategies?
- Is system dynamics modelling a suitable tool that can be used to simulate this particular supply chain problem?

6.3 EXTRACTS FROM THE LITERATURE REVIEW WITH DISCUSSIONS BASED ON THE OUTPUTS AND LEARNINGS FROM THE RESEARCH STUDY

This section will be structured such that extracts from Chapter Two will be followed by my views and conclusions based on the study conducted within the context of the problem and environment in which it is found. Note that the extracts from Chapter Two form a part of the literature review that I had completed and is reflected in this chapter to facilitate the discussion and comparison between the literature covered and this research study. By following this approach, I was able to draw direct discussions to the extract and to highlight the linkages. All extracts will be in *italics*.

6.3.1 Global & Supply Chain challenges

There is a general feeling of uncertainty as to what will happen next amongst SC people with the current global economy and difficulties being a source of concern (Daugherty, Gawe & Caltagirone, 2010). These factors have led to organisations looking for quick fixes instead of really fixing the root cause.

Whilst there is merit in this observation, what I have encountered during this study is that the organisation within which this study resides does acknowledge that this occurs and actively seeks for ways to implement sustainable solutions. This is evident in the fact that the study was endorsed by the organisation. Intuitively leaders understand that various functions and individuals within the organisation must work in a seamless and aligned manner to ensure overall business success. The S&OP process is accepted as being the underlying framework that aids the organisation in ensuring the business is on track to achieve its short, medium and long term objectives. This study therefore focused on applying system dynamics towards understanding the impact of S&OP on profitability and contributed towards the organisation better understanding the current situation and identifying possible alternatives that could be considered for implementation. System dynamics seeks to understand cause and effect relationships across long time periods versus the conventional approach of trying to understand cause and effect in the short term only. System dynamics has proven to be an apt tool in this application.

> *A successful supply chain is one that is managed in a manner, which breaks down barriers between internal and external stakeholders (Shukla, Garg & Agarwal, 2011). Huang et al (2007) further stated that effective supply chains are those that are able to supply the right product, to the right customer, at the right price and at the right quality.*

If one considers that S&OP cuts across multiple functional departments then it is understood in the business that barriers and misalignment between internal departments creates confusion both internally and with external suppliers and customers. System dynamics as a tool was applied to this problem with the involvement of cross functional stakeholders being instrumental in developing and applying the model. Following the Sterman 5 step methodology ensured involvement and led to individuals gaining a better understanding of the impact of individual actions on the overall business. It also gave insights into the conflicting key performance indicators that drove individual actions.

The ultimate aim of the supply chain and hence the organisation is to improve competitiveness of the organisation as a whole. This is achieved by directing the company into a sustainable, strategic position compared to its competitors (Stadtler, 2005). This can only be done if the entire structure or system is understood properly.

System dynamics as a tool and methodology proved to be well suited towards ensuring the problem within the current environment was understood. The activities that are necessary to complete the model such as accessing the mental, written and numerical databases of individuals and the organisation play a crucial role in understanding feedback loops, completing stock-flow diagrams and gaining an overall understanding of the problem and system. Once the model was developed and validated it was found to be useful in evaluating the impact of various policy interventions on the business. The model could be further used to explain the various relationships and dynamics that impact the business but may not necessarily be evident.

The need for understanding of the system is further driven by decision making and policies contributing to instability and fluctuations (Rabeli, Sarmiento & Jones, 2011).

The literature correctly cites the need to understand the impact of policy changes to the organisation and go so far as to state that not fully understanding the impact could create further instability. The fluctuations and variability that is found within the business will cost the business financially and hence it makes sense to be able to assess options before implementation. System dynamics was able to bring clarity and purpose to a sometimes fuzzy picture.

6.3.2 Demand variability challenges

> *The smoother the forecast, the smaller the increase in variability will be. Uncertain and changing demands further leads to either lost sales or increasing inventory holding to buffer against uncertainty (Kim, et al 2005).*

Forecast accuracy is a measure of how well the business is able to predict customer requirements. The model developed demonstrates the current erratic forecast observed and the knock on affect that it has on the other business metrics. In particular, I observed the negative impact it had on lost sales, working capital and the overall morale and behaviours of individuals. The business has a stock holding policy in place with the intent that the buffer stock being held would be sufficient to cater for bottlenecks and problems experienced. It was however, observed that the stock levels were not sufficient to cater for the variability seen. The S&OP process also covers the demand forecasting processes, which should lead to the organisation being able to calculate what the correct inventory level should be with the supply side of the business ensuring that these inventory levels are achieved. In theory, this would cater for variability experienced. What was observed, however, is that a large degree of variability still existed resulting in service levels being below expectations, working capital being erratic and financial losses still being incurred. The study hence showed that relatively high inventory levels and buffering are still not necessarily the answer with regards to improving service levels, reducing working capital and preventing financial losses.

6.3.3 Relevance of S&OP

> *Daugherty (2011) points out that most research and many of the marketing strategies treat buyer-seller exchanges as discrete events, and not as ongoing relationships. Baumann & Andraski (2010) highlight that collaboration towards improving the total supply chain is a key element towards gaining business benefits.*

One of the gaps that was identified was that current thinking generally considered most processes and interactions as discrete relationships. These relationships in turn are heavily dependent on behaviours, which are driven by a myriad of factors. The literature goes on to highlight that collaboration is essential towards improving overall business performance. System dynamics has proven to be useful in modelling and understanding the various relationships across functions and variables within the organisation. It has also been able to provide a more in-depth understanding of the problem and factors that affect it.

> *Spen & Bask (2002) reiterated that in managing the supply chain researchers have emphasised integration, the flow of information to achieve efficiency improvement and managerial and structural issues as being important to improving the efficiency and effectiveness within the supply chain.*

The model developed ensured that the boundaries were understood and therefore all factors of the S&OP process were encompassed within the model. By doing this, I was able to demonstrate that the current S&OP process is not performed in an aligned and integrated manner. This was further observed in the behaviour over time graphs of the key metrics as well as from information gleaned from individuals completing the questionnaires. By simulating various scenarios, I was also able to show that certain policy interventions would result in increased business performance.

> *Wright & Yuan (2007) showed that an improvement in the areas of demand forecasting and ordering policies contributes towards alleviating the bullwhip effect.*

System dynamics in this application has shown that managing both demand and customer ordering profiles does contribute in a positive manner to business performance metrics. The model development and data gathering exercise is largely dependent on the mental database of individuals as a rich source of data. This contributed towards the understanding that conflicting KPI's were evident across the various functions resulting in misalignment and further drove individuals to inadvertently being counterproductive. This conflict and misalignment resulted in behaviour, which contributed towards the variability seen in both the demand forecast as well as the customer ordering behaviour over time graphs. This behaviour is hence caused by an endogenous variable and is therefore considered to be within the control of the organisation and can be optimised. The use of system dynamics in this instance clearly showed the impact of behaviours on business metrics in a quantifiable manner, which makes buy-in and support from key stakeholders easier.

6.3.4 S&OP shortcomings reviewed

> *Chakravorty (2012) stated that identifying the correct priorities for improvement programs is required because incorrect priorities increase the probability of failure. Instead of reducing strategy to a formula with detailed planning, it was noted that the human elements of leadership, morale and almost instinctive practical understanding characterize the best leaders (Chakravorty, 2012).*

During the period of this study and via the numerous interactions with individuals interviewed, a common theme that emanated was the misalignment amongst the leadership team, which resulted in there being further misalignment and incorrect priorities within downstream activities and across functions. The leadership team in the context of this study are the board members of the organisation. System dynamics showed the relationships and feedback loops amongst the various functions and activities, which gave a solid appreciation of the advantage points that could be explored and led to the policy interventions that were discussed in Chapter Five. One of the outcomes of this study is to compose and share a business paper with the leadership team to share the findings in more detail. The system dynamics approach which results in the development of easy to understand stock-flow diagrams will assist in explaining the findings and rationale to individuals.

> *The attributes that drives the planning process are identified as information, procedural and alignment quality (Oliva & Watson, 2011). In addition, social elements were also identified though substantial work in this area has not been done. The quality of decision making and the resulting plans is impacted by inconsistent decision making procedures or procedures subject to the cognitive and social limitations, influences and idiosyncrasies of individuals and groups (Oliva & Watson, 2011). Godsell, et al (2010) states that there has long been tension between marketing and supply chain functions and it is this conflict and misalignment that is reflected in the difficulty of reconciling market segments and product characteristics when developing supply chain strategy. This leads to a sub-optimum situation in which the demand profile is inaccurate leading to a myriad of symptomatic problems within the organisation.*

Whilst the literature alludes to social and behavioural influences contributing to the planning and S&OP process, it is also evident that work in this area is not at an advanced stage. This study via the application of system dynamics modelling techniques to the S&OP problems has considered behavioural elements within the organisation. As an example, it has highlighted that the sales team may be driven towards achieving a turnover target and hence in their quest to achieve this turnover they incentivize customers, which in turn drives sales upwards, which is not in line with the forecasted demand resulting in the creation of variability. On the other hand, the supply planner has a working capital target, which is driven by the stock holding policy. Hence, he/she will try to manage this with certain parameters. This could then result in the incorrect stock levels being maintained and a drop in customer service. Naturally, when in discussions with various individuals they were of the opinion that they were potentially making the correct decisions according to business priorities and that the problem was as a result of another function or individual. One can conclude that the double edged sword is therefore an endogenous variable.

There is a tendency for individuals to over react. There are many contributors towards the S&OP process not functioning as stakeholders would like with the bullwhip effect being cited as one of the major sources of inefficiency within the supply chain. They further state that both operational and behavioural factors have an impact on bullwhip effect (Lim and O' Connor, 1995).

The S&OP process is generally accepted within the business as being the tool that is used to align supply and demand. There is however complacency in that there is a belief that variability is due to external factors or driven by inefficiencies within the supply chain and factories. This in turn leads to stock availability issues. There is a mindset that if operational issues within the supply chain were resolved then stock levels and hence customer service would improve. When interviewing supply chain individuals there is an opposing view that this is not the root cause and that the cause lies elsewhere in the business. System dynamics has demonstrated that the problem being investigated is to a large extent due to internal operational and behavioural shortcomings. System dynamics has further shown that the solution does not lie in one particular area or function as it is complex problem within a dynamic environment. It has also shown that because individuals are driven to achieve short term goals as dictated by leadership or policy, there is a negative impact on the efficiency of the S&OP process, which in turn impacts the business negatively.

There are those that see S&OP as counter to the current world class manufacturing and lean initiatives, even though they go hand in hand. A lot more discussion and experience is required to change this mindset in which individuals see S&OP and world class manufacturing as supportive of each other. One can argue that S&OP is in itself a world class manufacturing initiative. Using system dynamics can go a long way to changing this mindset around S&OP not being an integral part of the manner an organization goes about its business, as it can be used to answer what if questions and evaluate the benefits of decisions and policies over the short, medium and long term (Ross, 2003).

System dynamics within the context of this study was effective in demonstrating that S&OP touches all aspects of the business and certainly has an impact on the business critical metrics that were included in the model. It also proved useful in displaying the inter-relationships between the various functions as well as in evaluating the impact of policy or improvement interventions. The system dynamics process further supported the point that S&OP underpins the strategic direction of the organisation and is key to ensuring alignment, which in turn leads to the correct actions being taken to ensure organisational goals are met. One of the insights I have gained and propose is that system dynamics can be used to identify and evaluate potential improvement alternatives and the more traditional world class manufacturing (WCM) techniques can be utilised to identify solutions on how to implement in a sustainable manner.

> *Alizadeh (2012) stated that with known solutions it still takes a long time for supply chains to improve. This is largely due to the bullwhip effect and S&OP being a three dimensional problem and is hence difficult for people to conceptualise. It involves replenishment, time and geographical considerations (McCullen & Towill, 2002). Due to the multidimensional and multitude of quantitative and qualitative variables that an individual must consider it is highly improbable that anyone or even a group of people have the ability to visualize the holistic picture.*

In this regard, system dynamics was able to frame the problem in a holistic manner by following the recommended system dynamics modelling process. The process led to the extraction of information, primarily from the mental database of individuals, the development of stock-flow diagrams and ultimately the construction and validation of the model. This process was therefore able to visually represent feedback loops and the interaction between variables, which may be easily explained and understood. It serves as an effective learning and teaching tool and makes S&OP more understandable. It enables individuals to assess what the impact of their actions and decisions would have on business metrics.

> *Niehhaus et al (2003) state that causes of the bullwhip effect can be divided into time lags and planning as well as behavioural aspects. System dynamics is well suited to this application as demand forecasting and ordering policies are two key methods of controlling the bullwhip effect.*

System dynamics once again displayed that policies and metrics drive behaviours and decisions. If there is misalignment then this leads to a negative impact on business performance. It was further able to capture the time lags that are evident within the supply chain. As discussed in previous chapters, system dynamics was able to display that the biggest opportunity for focused improvement opportunities resides in the area of customer ordering and customer demand forecasting. Reducing the variability in these areas would result in an optimum solution and would realize the biggest business benefits when compared to other options evaluated.

As stated by Chen, Drezner, Ryan & Simchi-Levi (2000) various attempts have been made to quantify the impact of the bullwhip effect but these models do not capture many of the real world complexities that are typically found in organisations.

Whilst this statement may hold true for many modelling approaches, system dynamics was able to demonstrate its ability to model the S&OP process and the current problems being experienced. The sources of information covered the mental, written and numerical databases ensuring that both quantitative and qualitative factors and inputs were considered. The approach in developing and validating the model ensured that current complexities and dynamics found within the organisation was represented by the model.

There is a tendency for individuals to be focused on driving local functional improvement as opposed to overall business improvements (Repenning & Sterman 2001). There therefore exists an opportunity for system dynamics to be suitably applied to such a problem to capture the causal relationships and feedback loops that would be evident in such a problem.

System dynamics in this instance has proven to be a suitable tool that can be applied to an S&OP related problem within an organisation or supply chain. It was able to suitably capture the real world dynamics and relationships that exist and to evaluate policy interventions for improvement. Via this study, I was able to demonstrate that misalignment between the various functional teams led to individuals focusing their efforts on achieving local optima to the detriment of the organisation.

Metters (1997) highlighted that the bullwhip effect is due to a lack of systems thinking by management. The bullwhip effect is generally accepted as stemming from rational, profit maximising managers who have the best intentions when making decisions. Given they do not necessarily have the big picture in mind they cause more harm then good.

One of the tenets of system dynamics thinking is being able to take a 10 000 metre view of the problem within its environment which when combined with operational thinking leads to an understanding of the causal relationships and interactions that exist. It also assists in understanding the impact of implementing various solutions. This study demonstrated that system dynamics when applied as per the methodology is able to provide a tool that aids in developing systems thinking amongst individuals.

> *Research into assessing product variety on the S&OP process was conducted by Wan, Evers & Dresner (2012). The work was focussed on modelling the physical system and did not consider the impact of social or behavioural aspects on performance or profitability. The article did however state that causal relationship plays a role. It further highlighted the need for practitioners to understand the impact of non-linear factors on profitability (Wan, Evers & Dresner, 2012).*

According to the literature, work has been done on modelling the S&OP process but the focus has been primarily on quantitative modelling. As described in previous chapters both the theory and application of system dynamics show that the key consideration is given to understanding causal relationships and behavioural factors driven by current business policies and dynamics.

> *A common view is that new research is required in finding ways to improve supply chain co-ordination with the current economic recession/climate being cited as an area of study with regards to the bullwhip effect and S&OP. The bullwhip effect is especially prevalent in developing markets in which demand amplification is common place (Bhattacharya & Bandyopadhyay, 2011).*

Given the above statement and the volatile and uncertain environment that the organisation operates within, there is a need to find more effective ways to optimize. Given the focus on current quantitative modelling and the application of WCM techniques in the more traditional manner, system dynamics provides a different approach. This approach seeks to understand the absolute root cause of the problems, together with the feedback loops of the various variables so as to identify and evaluate improvement interventions. In this study, I was able to apply system dynamics in a manner that showed the suitability of system dynamics to this type of application.

In the literature review numerous authors cite behavioural elements and cross functional integration and ways of working as being a lever that contributes to the success or failure of the S&OP process. From the literature, it is also evident that more focus has been on the quantitative aspects of S&OP instead of the behavioural contributors.

6.3.5 SYSTEM DYNAMICS

> *There is an opportunity and requirement within organisations for linking the strategic and operational level issues (Martinez-Olvera, 2008).*

A key role that S&OP is expected to perform is to ensure that the operational and strategic aspects are aligned. In the research undertaken one of the challenges identified was a lack of alignment between the overall strategy and what was occurring at an operational level. S&OP was therefore identified as a process that was not functioning as expected with system dynamics being applied to understand the underlying causes as well as identify and evaluate improvement opportunities. In the context of this study, it was found that system dynamics performed this task to an acceptable level. It further showed that considering both quantitative and qualitative factors made the process and model more insightful and beneficial to the organisation.

> *A requirement is for the S&OP process to be open, transparent and participatory. This motivates individuals to be involved and to serve their stakeholders needs. However, it is often found that functional distrust and poor behaviours complicates the process. These unhelpful dynamics are not only prevalent but are also persistent in industry*

During the interview process, the above themes of distrust and poor behaviour were commonly expressed. There was further comments that the driving force behind these themes were due to the leadership team driving the incorrect behaviours. The actions of the leadership team were cited as a contributing factor to the themes identified. This results in different functional teams being driven by different priorities dependent on the views of the direct line manager. This caused individuals not to be transparent and to rather focus on protecting their functional area and KPI’s. This creates a disconnect between the needs of the individual stakeholders and their teams versus the business needs.

> *Kristianto, Ajmal & Helo (2011) stated that focus is mostly made on quantitative modelling and considerations within the supply chain environment. Forrester (1986) states that whilst modelling of the physical sciences have seen advancements, modelling of the social sciences is lagging behind.*

One of the outputs of this study was to add to the research already done in modelling behavioural elements and policies with the aim of understanding their impact on the organisation. On reflection of the study and its outcomes, I can conclude that there is merit in taking a more holistic approach to modelling.

> *System dynamics is a discipline for seeing wholes, recognising patterns and interrelationships and learning how to structure these interrelationships in a more effective and efficient way (Huang et al, 2007). System dynamics is suitable in applications that consider the tactical and* strategic level instead of the operational levels (Rabeli, Sarmiento & Jones, 2001).

I have, however, found during the course of my study that system dynamics was also effective in modelling the operational activities that occur. There is very little doubt that system dynamics provides the tools and thinking to enable individuals to better understand the problem within its environment and to structure the different variables so that the system as a whole functions more seamlessly at an operational, tactical and strategic level. I would venture to state that once a strategic direction is set it is important for individuals to flawlessly execute at the operational level and to ensure that the business is on course. System dynamics was able to provide for these requirements effectively.

6.3.6 System Dynamics defined

Feedback systems' thinking is different from event oriented thinking because it strives for solutions that are "sympathetic" with their organisational and social environments. Solutions are not implemented in a vacuum and consideration is given to short and long term consequences. System dynamics highlights that using this approach gives thought to further factors by showing that often there is more going on then meets the eye (Morecroft, 2010).

What I have found in utilising the system dynamics approach is that the methodology lends itself to being primarily dependent on the mental database. This led to numerous interviews and discussions with stakeholders, which generated valuable information pertaining to both specific functions, the overall business as well as relationships, interactions and opinions about the current challenges being faced. All of this was incorporated into generating a model that adequately captured the realities found in the environment within which this problem resides. Due to system dynamics focusing on modelling a problem the understanding and solutions that emanated were cross functional and evaluated the impact across some of the key business KPI's.

Setting of model boundaries is important and system dynamics considers most factors as endogenous whilst other approaches consider key factors such as customer demand as exogenous (Akkermans & Dellaert, 2005). Whilst the external environment does contribute to demand fluctuations, internal policies, decisions and behaviour also contribute towards creating this imbalance between supply and demand. System dynamics states that the boundary of the model needs to be determined in a manner in which exogenous factors are included within the model boundaries. This therefore transforms exogenous factors into endogenous factors (Morecroft, 2010).

In the application of system dynamics to this problem, I, within reason tried to ensure that the correct boundaries within which S&OP resides were identified. This was done based on the information extracted from the mental database of individuals. Both customer demand and customer ordering were treated as endogenous variables with the outputs justifying the inclusion of these variables. The inclusion of these variables led to the organisation understanding the impact that they had on the overall business. Intuitively individuals knew that it had a major impact but were not necessarily clear on the size of the impact though most felt that the behaviours seen in the behaviour over time graphs of these variables were to a certain extent driven by the organisation. As noted in Chapter Five the policy interventions that showed the largest potential improvement in the business metrics was related to customer demand and customer ordering profiles.

> *Rather then predict the future, system dynamics models tell a consistent future story of the system based on the structure as provided by managers (Cagliano, DeMarco, Rafele, & Volpe, 2010).*

This is a rather profound statement as ultimately even the system dynamics model developed in this study was used to simulate optimization opportunities and their impact on the business in the future. There are therefore similarities to other modelling techniques. A key difference I found is that in developing a system dynamics model the aim is to ensure it reflects current reality and based on that current reality, what would the future look like if no changes were made. Once this is established then only is it acceptable to simulate other opportunities.

> *System dynamics is able to represent the real world. It can accept the complexity, non-linearity and feedback loop structures that are inherent in social and physical systems (Forrester, 1994).*

During the development and validation stages, I have found that system dynamics, if done properly, can represent reality. It adequately captures the dynamics that exist and can be used to run simulations across an extended period of time. What was interesting to note was that the behaviour over time graphs of the various metrics that were included in the model represented what was observed in the numerical database.

6.3.7 Relevance of System dynamics

> *Whilst other model building methodologies focus on the ideal end state, system dynamics reveals the way in which the model was reached to describe the current state and then moves to the future state (Forrester, 1994). System dynamics hence displays how the problem under consideration is generated in the real world giving the role players an in-depth understanding of the problem and the environment in which it is found.*

The realization reached during this study is that the benefit does not rest solely in the final model but rather in the process followed in getting to the end point. This process of model building is iterative and is based on the learnings gleaned from the mental database of individuals. In fact the process has stimulated further thoughts around tacit knowledge and knowledge management which typically sits in the minds of individuals and when they leave or resign, the knowledge is lost. Not to be discussed in this study but certainly thought must be given towards preserving this knowledge and making it available to the business. The process also gave an appreciation for the challenges faced by different functions

> *The linking of strategic decision making and feedback thinking is especially relevant given that the strategy and feedback worlds are complex and interdependent and makes mental simulation by individual's difficult (Richardson, 1999). It explores how bounded rational decisions often lead to unintended long term consequences. Organisations often work in a conflicting and suboptimal manner, in the sense of overall performance (Bullinger, Kuhner & Van Hoof, 2002).*

One of the learnings during this study and the discussions held were that as individuals we do not know all the answers and we cannot simulate the impact of decisions in our heads. Most individuals were driven by the KPI's that they were held accountable too and did not fully understand the overall impact. As an example the sales person drove turnover and hence when it came to driving sales would negotiate with the customer to purchase SKU's classified as "A" type SKU's given they generate the highest turnover value. However, during the discussions and analysis of the numerical database it was realized that the "C" type SKU had a higher gross margin but lower turnover whilst the "A" type SKU return a lower gross margin. The individual in the brand team however was driven by a KPI of gross margin (GM) and hence would prefer the "C" type SKU to be sold. System dynamics was able to make visible this conflicting dynamic which led to further discussion on solutions.

> *Bianchi & Bivona, (2002) further highlighted that should decisions be made to drive one success factor without consideration of the others the result will be a longer term failure or loss. The key here is that the interaction of a number of small events could have a high overall impact on the organisation (Repenning & Rudolph, 2002).*

As demonstrated by the model developed and policy interventions evaluated, fixing one area will not necessarily give the benefits expected. One needs to consider all factors both individually but also in conjunction with each other. This was done to a certain extent within the study to understand the relationships and feedback loops that were evident. Initially five scenarios were identified with a single variable being changed in each. Post the analysis of the outputs a further two scenarios were identified and supported the literature in that the outputs showed that combining certain variables gave better benefits.

> *Change and change management is a key component of many of today's industry leading organisations who look for better methods to compete. System dynamics can be used as a change management tool to get buy in for decisions (Wyland, Buxton & Fuqua, 2000). Senge & Sterman, (1990) stated that for new policies to come into effect, individuals must go through their own learning process, as this is essential to the change management process.*

Whilst I do agree with the statement one of the stumbling blocks encountered was that system dynamics contains its own specific jargon. When embarking on the utilisation of system dynamics within an organisation for the first time it is critical to take the time to ensure all stakeholders are given proper explanations into what system dynamics, why system dynamics is useful, the process to be followed, the inputs required and what they can expect in return. Due to most individuals and organisation experiencing time and resource pressures, I found that spending this time upfront was beneficial in ensuring the correct support and buy-in was achieved.

It is stated that those organisations that are able to integrate specific functions in line with their strategy generally have a better performance (O' Leary-Kelly & Flores, 2002). Studies show that increased integration between sales & marketing and operations helps to reduce overall operational costs and hence organisational performance. Often demand uncertainty and business strategy variables are seen as exogenous variables (O' Leary-Kelly & Flores, 2002). This, however, implies that these leverage points are seen as out of the control of the organisations and hence a mind-set of helplessness could set it. System dynamics states that it can be modelled as an endogenous variable.

S&OP as a business process covers both the demand and supply side of the business. It therefore makes sense for both broad areas to be understood and considered when opportunities are being looked for. It is widely acknowledged within the business that the retail sector in developing markets is volatile and commands a fair amount of respect and bargaining power. This has led to a sense of helplessness in the sense that individuals are happy to state that the customer behaviour and hence demand signal is out of the control of the organisation and the solution needs to be coming from within the business, normally the supply chain. During the course of this study and in discussions, what has come to the fore is that the organisation actually drives a fair amount of the behaviour and volatility seen in the demand signal and customer ordering behaviour. Given this insight, policy interventions were simulated with a conservative improvement in both the demand signal and customer ordering profiles being assumed. These showed significant improvements in business metrics when compared to other scenarios and the base model and is hence worthy enough to be pursued.

Guo, et al, (2001) emphasized the applicability of system dynamics as an appropriate approach to analysing the interactions and impact of various policies on the problem or case study selected. System dynamics is further able to model a problem, evaluate alternative as well as what needs to be done to prevent the negative future states from occurring.

As seen in previous discussions this study has shown that system dynamics is applicable with both tangible and intangible benefits being obtained from using system dynamics. The model was able to evaluate the impact of changes to key metrics in a manner that was tangible and could be shared whilst the intangible benefits revolved around the learning and insights gained by individuals.

6.3.8 System dynamics shortcomings reviewed

> *Stadtler, (2005) states that not only is the underlying mathematics a concern but focus needs to be given to inter disciplinary research. Statistical design would aid in improving the acceptance of the system dynamics models by other disciplines (Akkermans & Dellaert, 2005). This work needs to be extended to further cross functional problems.*

Given this learning, I incorporated certain elements of statistical analysis to evaluate the policy intervention outputs that were simulated. In this particular study the mean, standard deviation and minimum and maximum values were calculated and analysed. This balance between using a quantitative and qualitative approach to validating the model as well as evaluating scenario outputs proved to be a valuable approach as it was easier to explain to individuals and get buy-in.

> *The use of system dynamics in supply chain modelling has been very limited but with the increased complexity that organisations are facing recently system dynamics is gaining in popularity. Uncertainty is evident in all aspects of the supply chain making the application of system dynamics to supply chain related problems very applicable (Ashayeri & Lemmes, 2005).*

Naturally, this study does not cover the full extent of applications that system dynamics can be applied to but this study has contributed, by once again showing that system dynamics is a methodology that can be applied to organisations and supply chains to yield real benefits. One of the basic benefits that I was able to extract was to acquire an understanding of the current business dynamics, which could be shared with the various stakeholders within the organisation. This led to a more in-depth understanding of some of the drivers of the complexity mentioned, being able to identify potential solutions as well as to evaluate the interventions over the long term.

Daugherty, Gawe & Caltagirone, (2010) highlighted that cost will always be a primary influence in business decisions and hence system dynamics as a tool will need to demonstrate its usefulness. There is therefore a need to quantify the impact of modeling a social system and evaluating the impact of policy on decisions made on the overall supply chain efficiency and effectiveness.

Whilst this study did not focus on quantifying the cost of developing the model, I can state that with the experience gained during this study the time taken to work through the steps of developing and validating the model did not result in a direct financial invoice for the business but rather an investment in time. In this particular organisation, which supports educational advancement as well as continuously looking for ways to understand and optimize, acquiring individual's time during the normal course of business was acceptable. A limitation experienced though was that it was difficult to acquire the time from individuals in a short time frame. What I was able to do is model financial metrics into the model so that when a policy intervention was simulated I could determine the financial impact of the intervention. In this instance, the model performed to expectation and proved useful.

The literature suggests that system dynamics can be more powerful if quantitative methods from other approaches are included in the system dynamics approach (Akkermans & Dellaert, 2005).

I have found that the literature contains two opposing but similar points with regards to quantitative methods. On the one hand, mention is made that historically more focus has been on modelling the physical versus social system with the use of quantitative modelling. On the other hand, there exists criticism that system dynamics follows an approach that is more qualitative in nature. What this study has done which is stipulated by the system dynamics methodology is to use quantitative methods to build and validate the model. This has led to the acceptance of the model and outputs more readily as it also ensures a glass box versus a black box approach to modelling.

6.3.9 Applicability of Research topic

> *Due to the differences in complexity and environment that exist globally and within organizations the "one size fits all" approach to developing business and supply chain strategy is not the best option (Godsell, Diefenbach, Clemmow, Towill & Christopher, 2010). Lapide (2006) further states that supply chain excellence requires a context specific approach based on a strategic framework and set of underlying principles, and not a set of generic answers. The implication is that problems, decisions and behaviours in one product category are not necessarily acceptable to other categories.*

Given these statements, system dynamics is well suited to be applied in these conditions as it does not model a system but rather a specific problem within a particular environment. The model developed therefore gave insights into a specific problem as well as the mechanism to evaluate improvement options for the problem. This gives the users a more focused approach to a problem with a higher likelihood of success. I believe that given the fast paced world, businesses tend to want a “design once apply everywhere” approach, which tends to create more complexity given no two problems or environments are identical.

> *System dynamics forces users to view a manufacturing system at a relatively aggregated level of detail. This is conducive to the evaluation of strategic changes to a system. Unfortunately, the current literature suggests that system dynamics appears to not have been applied to its full potential in evaluating strategy scenarios (Lin, Baines, O'Kane & Link, 1998).*

In my opinion, system dynamics in the context of this study was applied in the relevant manner given the expectations of the organisation. Whilst it can be debated that the study could use other approaches, the approach used in this study certainly resulted in valuable outputs. I would argue that the success of system dynamics could be determined by its ability to answer the questions that is being asked, as well as providing insights into the problem that was not known previously and giving the user the tool to evaluate interventions.

Cagliano, DeMarco, Rafele, & Volpe (2010) highlighted that the number of practical applications, of system dynamics to supply chain related problems that can be found in current literature is limited.

Whilst there has been limited applications of system dynamics to supply chain related problems, I have found that the methodology and thinking that system dynamics encourages is relevant and can be utilised in other problem types and environment. This study has shown that system dynamics can be practically applied to business and supply chain related problems with tangible benefits. This was partially achieved by taking learnings from system dynamics applications across a range of disciplines and case studies.

The journey travelled during the course of this study resulted in a paradigm shift in my thinking and that of a few others. The world via the system dynamics lens certainly looks different and hence a new way of thinking is evident. There has been a change from the original approach, which was focused on switching between operational or strategic thinking to a more integrated and holistic manner of thinking. One in which relationships, business dynamics, feedback loops and consequences of actions across an extended time frame are considered. Make no mistake as an individual I still do not have the aptitude to simulate all of this mentally but it certainly helps in framing the questions and approach. It is the start of attempting to ask questions and understanding causal feedback loops which leads to further questions, discussions and insights, which are unearthed.

6.4 CONCLUDING REMARKS

This Chapter has focused on making a number of linkages, namely (1) The literature reviewed to the study conducted (2) The study to the problem statement and research questions (3) Insights and changes to thinking and approach (4) Applicability of system dynamics to S&OP.

As one would notice, the relevant insights and learnings gained from the literature review were highlighted and linked to the study conducted. In most instances, the current study, either supported the literature or the approach was refined to overcome the potential obstacle that the literature had identified. System dynamics certainly has a place in assisting organisations to understand problems within its environment and to be able to implement sustainable solutions.

There are a few conclusions that can be made due to this study with these being discussed in further detail in Chapter Seven. It is however worth mentioning that based on the work done, the study was able to address the problem statement by answering the research questions. The applicability and usefulness that was gained from system dynamics in this study can be confirmed and further applications are possible within the organisation.

As can be seen in this Chapter the learning curve has been steep with the thinking and approach of both myself and that of others being changed along the way. This was necessary to ensure that system dynamics was applied as per the literature yet remain relevant to the problem with the benefits being clearly visible. As a change management tool system dynamics proved to be suitable.

S&OP is considered to be a broad topic that spans across multiple functions both internally and externally to the business. The various parts of S&OP are sometimes treated in isolation with certain touch points being seen as mandatory though not all individuals involved in the S&OP process necessarily understand the end-to-end process. They certainly are not able to understand the impact of individual operational actions on the overall strategy. System dynamics has shown that it can be applied with success to this problem and is able to provide insights and a means to identifying and evaluating potential optimization interventions.

Chapter Seven will delve into the conclusions and recommendations that emanated from the overall study.

CHAPTER SEVEN: CONCLUSIONS AND RECOMMENDATIONS

7.1 INTRODUCTION

In the previous Chapter, I was looking to explain the findings in the context of the literature review conducted in Chapter Two and to highlight the linkages that exist between the literature and study conducted. The Chapter also went on to discuss how system dynamics contributed towards the modelling and understanding of S&OP within the organisation. This study was triggered by the need to understand the current impact of S&OP on the organisation and to formulate improvement interventions. This was largely driven by the need to continuously improve competitiveness in an environment that is increasingly become more complex, uncertain and demanding. In order to achieve this a key requirement is to understand the dynamics that are involved in the context of the problem and environment. It is with this awareness that the problem statement and research questions were formulated to guide the study.

Problem Statement: The intention of this research is to construct a system dynamics model to ascertain the impact of S&OP processes within an FMCG organisation.

It was also acknowledged that understanding the impact of S&OP within the organisation is not an easy task and there are a myriad of complexities that exist. Given the literature reviewed the system dynamics methodology was chosen as it offered the tools to capture the dynamics that were evident in a complex environment. One of the attractions to this methodology was that historically more quantitative models were selected for this type of application whilst system dynamics modelling considered the social or behavioural interactions as well.

Sources of data for this process stemmed from the mental, numerical and written databases with the mental database being the primary source of information. Field work with the use of questionnaires to facilitate data gathering and discussion was conducted and resulted in the S&OP boundaries being identified. Within these boundaries eight sectors were identified as key to ensuring the model captured the S&OP process together with its related relationships, feedback loops and dynamics, namely: (1) Organisation focus (2) Demand (3) Factory (4) Supply planning (5) Procurement (6) Customer ordering (7) Distribution (8) Management information. A number of behavioural aspects emerged during the course of the study with most seemingly stemming from the misalignment of KPI's as well as the conflicting focus areas by various stakeholders.

In view of the findings reached, we need to identify whether, and the extent to which this study has answered the research questions and therefore the problem statement.

7.2 REVISITING THE RESEARCH QUESTIONS

7.2.1 What are the casual relationships between S&OP policies and profitability of an organization?

S&OP is a recurrent process with the cycle covering a four week period and having a number of discussion and decision points within the business. The key relationships that were identified are:

- Supply planning

  Within the business, the planning function is seen as an integral part of ensuring that the correct inventory levels of SKU's are maintained. The planning function ultimately dictates what the factory should produce and when, whilst considering the various factors and resource constraints that may exist. One of the factors is adherence to the stock holding policy, which exists and is currently the equivalent of three weeks stock. This is based on the forecast which when volatile and continuously changes causes the stock covers to also be variable. The planner is then placed in a frustrating position of having to explain, when the stock holding policy is either exceeded resulting in cash being tied up or when the policy is not met resulting in service level losses. This sometimes leads to the policy not being adhered to with the planning teams using their own experience and discretion to determine ideal stock holding levels. Naturally, when this is done and works no questions are raised but there is an equal likelihood of getting this wrong, resulting in additional noise being created.

- Working capital

  To manage the cash flow within the business working capital targets both in terms of weeks cover stemming from the supply planning discussion above as well as a currency unit value equivalent are set. What this translates into is that the planner is also responsible to ensure the inventory levels does not exceed a certain value. As you can imagine trying to balance the stock holding policy defined in weeks cover and the working capital targets can be a very difficult task. Given the variability seen in both the forecast and customer ordering profiles, doing this is like a rollercoaster ride and ultimately leads to frustration. More time is spent explaining the over or under situation then attempting to understand root cause and identifying a sustainable solution. Employees are placed in a situation in which they are constantly firefighting and being operational versus searching for sustainable solutions.

- Sales and turnover

  The S&OP process typically culminates into a weekly sales volume forecast for the two year period and is then converted into an expected turnover target. These are tracked and reported on a weekly, monthly and Year to Date (YTD) basis. What does frequently occur is that when the actual sales are falling behind target and month end is approaching instructions are given to the sales team to drive sales in those categories that returns a higher turnover value. The product category on which this study was based is one of those categories. This leads to exceptions or jab orders being accepted even though it is over and above the forecast. The knock on impact is that inventory levels are depleted and given the lead to product further service level and turnover losses are experienced in the following weeks and months. This results in a vicious cycle.

- Planning frozen period

  As per one of the S&OP policies, the first three month window period is locked and hence no changes in the demand or production plans should occur. The rationale behind this is to ensure the stability of the supply chain as well as to accommodate the various lead times to plan, procure material, produce and distribute the products that manifests itself. However given the variability experienced and the sales drives that occur this rule is often ignored creating further inefficiencies within the organisation.

- Distribution and customer service

  The lead times to deliver customer orders from the time of order placement to delivery of the products vary between 48 and 72 hours dependent on customer proximity to the warehouse. The service level target that is expected is 88%. Customer orders can be placed before 1pm on any given weekday with the lead time being measured from the 1pm cutoff. For the most part customer orders are not checked against the original forecast, which means that one customer can order more then what they originally forecasted for resulting in subsequent customers not receiving the minimum quantity that they originally requested. From a customer ordering perspective the general rule followed is a first come first serve basis. When jab or exception orders are received, the distribution team has to expedite these orders in a shorter lead time resulting in further expense.

- Suppliers service level agreements (SLA)

  Suppliers have to adhere to an SLA, which has been set and agreed on with the business. This SLA is based on the forecast that they receive and they have to hold material that is equivalent to four weeks. A similar problem is experienced to that within the supply planning area in that the variability creates uncertainty and is difficult for the organisation to maintain the correct stock levels. This is compounded by the supplier also being constrained by their own lead times as well as internal inefficiencies.

- S&OP procedure

  The S&OP process contains the various procedures that must be followed per cycle. It stipulates the meetings to be held and who should attend, together with the expected agenda, inputs and outputs. These are structured so as to ensure that the demand forecast for the two year period is calculated in a robust manner, which then feeds into the supply related meetings in which the supply chain assesses its ability to meet the demand forecast. The effectiveness of the meeting is largely dependent on having the correct attendance and individual engagement, preparedness and contributions. It is worth mentioning that the brand team is not directly involved in any of these meetings even though they are responsible for determining overall brand strategy. This results in misalignment.

7.2.2 What are the organizational variables that have an impact on the effectiveness of S&OP within an organization?

During the data collection and model building stages the variables that were to form the inputs of the model were identified. The two key variables that were identified as having a substantial impact on the effectiveness of S&OP within the organisation are:

- Demand forecast
  The demand forecast is the key signal that drives the rest of the business and is meant to provide the business with a view of customer expectation and to hence prepare themselves to satisfy that expectation. Simply stated the organisation cannot prepare adequately when a high degree of variability is experienced. Preparing for this variability also comes with a level of inefficiency and cost. The organisations ability to forecast demand is extremely poor and is reflected in the low forecast accuracy.

- Customer ordering
  The erratic nature of the customer ordering profile leads to the business more often then not having to react to these changes due to not having the correct inventory levels. It is worth noting that whilst it is difficult to quantify the reasons for the erratic ordering profile is driven by both the customer behaviour as well as the actions of individuals within the organisation.

It is worth mentioning that in scenario eight *(Titled Infinite everything)* six variables, including the demand forecast and customer ordering variables, were changed. Two variable (demand and customer) have been described above and have shown that improvements in these variables does have a tangible impact on the key metrics. The remaining four variables, namely: (1) factory capacity (2) supplier capacity (3) organisational stock (4) supplier stock holding, if increased substantially also shows a benefit though practically the organisation would not approve given the high financial investment impact.

Whilst not variables within the model, a few themes came out very strongly during the course of this study has having an impact on S&OP effectiveness within the organisation, namely: (1) Leadership (2) Conflicting KPI's (3) Individual behaviour.

- Leadership behaviour, operational vs strategic target setting
  Alignment and ensuring consistency of behaviour and actions has to start at the highest level within the organogram and then can be cascaded. This is the start of ensuring that the operational activities and strategic targets set are aligned and that the correct level of focus is being given to the entire two year period.

- Conflicting KPI's
  One of the key themes that surfaced during the data gathering process was the conflicting KPI's that various functions were governed by. This led them to taking the seemingly correct actions and decisions for their functions but had a negative impact on the business.

- Individual behaviour
  It was found that individual behaviour was primarily driven by the conflicting KPI's as mentioned above as well as the short term leadership instructions that was cascaded. There is also a lack of understanding on the overall business impact that their decisions or actions would have.

7.2.3 How do current behavioural patterns affect the organisation when compared to an S&OP process that is implemented and followed rigorously?

The behaviours within each sector that were identified as having the most impact were:

- Demand:
  The organisation is accepting of the reality that volatility is inherent and hence have a low forecast accuracy expectation. The status quo is therefore accepted. There is a view that there are many exogenous variables such as market volatility and consumer buying patterns being variable though this is debatable. It is also found that the full two year period is not forecasted for with the same level of accuracy and detail. More attention is given to year one.

- Customer ordering:
  The month and year end sales push that is common results in promotions and deals being given to customers. These were not originally in the demand forecast and hence the organisation cannot accommodate the total upswing in volume. Promotions are also not adhered to by customers who further reduce the recommended selling price to drive sales.

- Supply planning:
  There are working capital targets as well as stock holding policy targets (number of weeks cover) which drive how the planning is done. This is done in an attempt to give boundaries to the supply chain, as the business would not want to carry to much or too little inventory levels. When the stock holding policy is on target and the associated working capital value is below the stipulated value all is acceptable. However if one of these two are in a state of imbalance there is the potential to reduce the amount of stock held to meeting the working capital target value, which then results in the actual weeks cover being lower then expected.

- Factory:
  The aim of the factory would be to continuously improve efficiencies and drive down conversion costs. One of the drivers of cost is introducing complexity and changes to the

factory. The factory would therefore prefer no changes to the 3 month production plans as this is meant to be a frozen period as dictated by the S&OP policies. There would also be a preference for minimizing changeovers and lengthening production runs.

- Procurement:
  Even though a long term material forecast if given to suppliers the erratic and ever changing forecasts results in the supplier not being able to meet service level agreements. As mentioned previously whilst this is evident supplier inefficiencies also exist. This volatility sometimes leads to a blame culture with the supplier often looking to justify their actions and detracts from a relationship that is more collaborative.

7.2.4 What are the key factors that if leveraged can be used to ensure alignment between current practices and organisational policies and strategies?

Five key factors that were identified as leverage points which if optimized would ensure more alignment within the organisation.

Customer orders and demand forecast:

There needs to be a mechanism to track customer orders versus the demand forecast that was reached. This, however, must translate into the customers and sales teams being held accountable to this demand with variations needing to be understood and approved. By the same token, the organisation must be able to commit to the customer that the demand will be satisfied. This will prevent over ordering from one customer resulting in another customer losing out. It will also drive variability reduction within these two areas. If the organisation were able to more closely align customer ordering profiles with the original demand forecast the variability would reduce resulting in a positive impact to the KPI's discussed. Whilst one may question how practical it is to assume that this is achievable, I have found that within this particular organisation there are a few internal functions that liase and drive collaboration opportunities between the customer and organisation. These mechanisms needs to be leveraged further. Given the outputs of the system dynamics model and scenarios evaluated in previous chapters it is evident that focus on these two variables would realize tangible benefits.

Alignment of KPI's and metrics:

Conflicting KPI's should be removed. This is critical to drive the correct behaviours as well as to drive a one-team mindset. During the course of the data collection process, which resulted in numerous interviews the common theme that was extracted from the mental database of individuals, was the lack of alignment in what individuals had to achieve. This was further supported by the analysis of the numerical and written database, which revealed that different sub-functions within the organisation had different KPI's against which their performance was evaluated. This invariably led to decisions being made based on what was best for a sub-function with little or no consideration given to the holistic business impact. Key conflicting KPI's identified were:

- Profitability versus Turnover (TO)
- Sales or turnover target versus forecast accuracy or bias
- Service level versus working capital

These invariably resulted in different functions taking actions and decisions to ensure they met their particular KPI.

Gatekeeping and S&OP meetings:

During the interviews conducted as well as during the scrutiny of the S&OP process one of the views that surfaced was that there was no consistency concerning the meeting outputs. Similarly, it was found that the volume forecast once converted to an expected financial value was subject to change when presented to senior stakeholders. These changes were not always cascaded to all relevant functions further resulting in individuals pursuing differing targets. The inputs and outputs at each of these meetings needs to be very clear with the outputs needing to be validated signed off and communicated. Potentially if they are not then the process should not proceed until they are. Whilst this will create some anxiety in the short term, it will become more palatable over time. This needs to be conducted at the various stages of the S&OP process as well as at the various decision levels to ensure adherence to the plan and to drive the correct behaviours. The meetings should also continuously be comparing the S&OP outputs across the two year period to the strategic objectives. This would serve as an early warning system to identify any deviations. The agenda and expected outputs of each meeting should be checked for accuracy and robustness across the full two year S&OP period.

Alignment on expected growth between the brand and sales teams:

Whilst conducting the study it was found that the brand teams were responsible to determine the overall growth strategy of a particular brand across a five year period. They however were not included within the S&OP process thought the sales teams were involved in determining the demand forecast. This resulted in misalignment between what the sales team thought the customers would order versus what the strategic business ambition was. Inclusion of the brand team into the process is necessary to ensure that there is alignment between the strategic growth envisioned versus the output of the S&OP process. In the current scenario there is often a disconnect between what the sales team drive in terms of growth and what the brand teams expect. Normally the sales teams have a lower growth than that of the brand teams.

S&OP final sign-off:

Each S&OP cycle should culminate in a detailed discussion with the board to understand the demand and supply plan, the detail behind how this will be achieved and a comparison of this output to the overall strategy. During the study, it was found that there is often misalignment between these areas, probably driven by the lack of a detailed discussion at board level. Given this as well as the insights gained from individuals during the interview process it is evident that most consider leadership as playing a critical role in ensuring that final sign-off and alignment is achieved.

7.2.5 Is system dynamics modelling a suitable tool that can be used to simulate this particular supply chain problem?

This study has proven that system dynamics is a suitable tool in this particular application with this statement being based on the process followed to develop the model, the model itself as well as the use of the model.

The model development process was robust and followed a methodological process as per that in the literature. This process covered both the development steps as well as testing techniques, which showed the model as being plausible. The validation process looked at using both quantitative and qualitative aspects to evaluate if the model was plausible and fit-for-purpose. These tests were categorised into three areas, namely (1) tests of behaviour (2) tests of structure (3) test of learning. The process followed encouraged discussion, which led to the model framework (areas and sectors) being identified followed, by the model development, testing and use.

The outputs of the system dynamics model adequately reflected reality. In any modelling approach, it is often said that to deem a model valid, it must be plausible, fit for its intended purpose and sufficiently captures the dynamics that are evident in the real world environment. The model developed was shown to satisfy these requirements via the various tests described in previous chapters.

The interventions identified and simulated pointed to solutions that were intuitively known but not quantified previously. An example of this is that the demand numbers and customer behaviour has a major impact on the business but is difficult to resolve. One of the benefits of the study is highlighting the optimization benefits that can be gained by optimizing these areas, which should encourage the business to focus more in this area. The model was also able to lay certain misconceptions to rest. One of these were that if capacity was increased then there would be more inventory and hence higher service levels.

The model was able to capture feedback loops and the dynamics that are inherent within the organisation and S&OP process. This was evident when validating the model as the behaviour over time graphs of the model were similar to that obtained from the numerical and mental databases. It was further used as a learning tool and stimulated both discussion and learning. The interventions evaluated were completed using certain quantitative evaluation techniques as well as the behaviour over time graphs.

7.3 CONTRIBUTIONS OF THIS STUDY

Via this study, I was able to demonstrate the following:

- I was able to show how system dynamics, which considers social interactions and behaviours, can be applied in a pragmatic manner to a cross functional and business wide problem. The approach I used to develop the model was two pronged and included both a quantitative and qualitative approach. The validation of the model as well as evaluation of the various policy interventions also considered quantitative measures. This approach I believe made system dynamics more acceptable to stakeholders and buy in to the picture that system dynamics reflected was more readily accepted because the discussion was not purely subjective or qualitative in nature.
- The policy interventions that were simulated using the model highlighted that tangible benefits are possible. Whilst these were in certain cases known, it was not well quantified. The intervention in which the demand and customer ordering profiles are optimized shows that if more focus is given to these areas then the organisation can expect benefits across the business metrics. The study should encourage the business to focus more in this area.
- During the study and whilst completing the field work one of the misconceptions that were identified is that if capacity was increased then there would be more inventory and hence higher service levels. Most thought this was the answer. What the model showed though was that no major benefits could be expected
- One of the methodological contributions was whilst I did follow the Sterman process I acknowledged and negated one of the criticisms of system dynamics modelling. This criticism was that system dynamics was based on modelling social systems and the testing and evaluation techniques relied on tended to be qualitative in nature. Over and above the stipulated checks and balances, I ensured that I always compared the model to the real world environment to ensure practical significance as well as used statistical measures when evaluating intervention outputs versus relying solely on behaviour over time graphs.

- The study further showed how system dynamics is able to consider and model both operational and strategic thinking for this particular supply chain and business wide problem. This links back to firstly walking the process to understand the detail followed by taking an elevated view of the problem within its environment, which in the study was referred to as the 5000 metre, and 10 000 metre views. This enabled the model to be relevant to capturing both the operational dynamics as well as the more strategic or policy driven dynamics.
- Via this study, I was able to further the application of system dynamics to supply chain related problems. The strength of the study rested in the fact that it was not a theoretical exercise but resulted in the system dynamics software being used to generate a working model. The study showed the applicability of applying system dynamics to such a problem and that it is able to adequately capture the complexities and dynamics that are present followed by the ability to suitably apply the model.
- This study highlighted that when applied to the supply chain and S&OP related problems there is benefit in understanding the impact of various decisions together versus evaluating a decision in isolation. Using this approach has shown substantial business benefits are possible. It also highlighted that if policies are put in place to control both the demand predictions and customer ordering patterns within a narrower band there would be tangible benefits.

7.4 LIMITATIONS OF THIS STUDY

The first limitation was with regards to change management with one of the stumbling blocks encountered was that system dynamics contains its own specific jargon as well as requires the time of individuals. When embarking on the utilisation of system dynamics within an organisation for the first time it is critical to take the time to ensure all stakeholders are given proper explanations into what system dynamics, why system dynamics is useful, the process to be followed, the inputs required and what they can expect in return. Due to most individuals and organisations experiencing time and resource pressures, I found that spending this time upfront was beneficial in ensuring the correct support and buy-in was achieved. This however was a time consuming exercise as getting time in individuals diaries was a challenge. It was difficult to acquire the time from individuals within a short time frame. Using system dynamics more broadly would only be advisable once it was embedded as one of the standard ways of evaluating problems. This would result in better resource allocation and would become a part of an individual's roles and responsibilities versus an add-on to their current role.

The second limitation that was identified was in regards to the customer ordering sector, in which a holistic view was taken for this study. One of the dynamics that surfaced was that sometimes one customer over ordered and if they placed their orders first, they would get the bulk of the stock resulting in orders from other customers failing or they get partial stock. This element can be modelled in system dynamics to understand the extent to which this occurs and the impact thereof.

The third limitation was that the study was done on a basket of SKU's within a product category and hence was done at an aggregated level. There is an opportunity to break this down to a different family product level, which may reveal further insights. Time and resources within the organisation did not permit this approach hence I opted for a more pragmatic approach.

The organisation did not want mention made of its name, individuals, and product category or to use financial data from the current numerical database hence certain assumptions were made.

7.5 RECOMMENDATIONS TO THE ORGANISATION

The following are some of the recommendations that emanated from the study:

7.5.1 Leadership

Throughout the study one of the common themes was the role the leadership team played in driving the correct behaviours. Individuals often cited the behaviour of the leader being the biggest driver to how other employees behaved.

- The leadership team needs to be very clear on the organisation's strategy and to ensure that the operational and tactical plans are always aligned to this strategy. must also, even though there are short term objectives, not lose sight of the strategy and not be tempted to make decisions, which would result in short term gains but medium to longer term losses. This needs to be a top down approach to ensure alignment and buy-in to the principle that all decisions made must not be done in a silo but to ensure that the actions contributes to the overall business strategy.

- To achieve this one of the recommendations would be to align KPI's across the business, which is currently leading to misalignment, cynicism, and distrust within functions. This alignment process would also naturally lead to a rationalization of KPI's that are currently being measured which are numerous and contributes to the conflict and misalignment. I believe that this will promote authentic and professional leadership across all levels within the organisation, which will translate into the correct decisions being taken for the business versus driving short term gains. The aim is for individuals to consistently be taking a holistic business view when taking decisions as well as ensuring that there is sustainable bottom line benefits. There is a need for consistent messages to be communicated across the business. The incentives and motivations that are put in place must be structured such that they do not drive the wrong behaviour but rather encourages individuals working towards a common goal.

7.5.2 S&OP structure

- The S&OP structure is available and therefore does not to be reinvented. What does need to be changed is for the S&OP process to be followed more religiously. Over time, the exceptions have become the norm with the result that no particular individual can tell the difference. I would go as far as to advocate that the S&OP process must be made more mechanistic with gatekeeping controls at various stages. This will take away peoples propensity to break or bend the rules based on their interpretation. I would caution though that exceptions and creative thinking must be catered for. The meetings that are a contributor to the S&OP process needs to be defined and followed. The purpose of the meeting must be very clear and communicated to all involved with each meeting culminating in a sign off process. This must be done at various levels within the organisation. The outputs of each meeting should be checked for accuracy and robustness to ensure that the full S&OP period of two years is given the same level of attention and rigour.

- The brand team needs to be included as key contributors to the S&OP process given they define overall brand strategy and hence drive growth in the market. This will ensure that there is alignment between the strategic growths they envision versus what the S&OP is showing as an output.

7.5.3 Demand and customer profiles

- Identify specific actions that can be taken to better control the demand and customer ordering profiles as improvements in these areas showed a high potential for benefits within the model. First a means of tracking customer orders versus the demand forecast must be identified. This can then be used to monitor customer orders versus the forecast with deviations being understood and action taken. The action at a high level must result in the customers and sales teams being held accountable to this demand. Variations must hence be treated as an exception with an approval process. By the same token, the organisation must be able to commit to the customer that the demand will be satisfied. This will prevent over ordering from one customer resulting in another customer losing out. It will also drive variability reduction within these two areas.

- Evaluate the impact of changing the stock holding policy from the current, in which the target is set in weeks to a physical stock holding quantity. One of the reasons for this is that the current policy which is in week's equivalent is dependent on the forecast, which due to its erratic nature creates additional work and frustration within the planning area.

7.6 RECOMMENDATIONS FOR FUTURE STUDY

Recommendations for future study would be:

- Given that the organisation that this study is based on has multiple product categories, I would recommend that a system dynamics model be completed for other product categories. This can be used to corroborate the findings of the current study and further enhance understanding of the various dynamics that are in existence. It would serve as a cross reference and identify if certain behaviours are chronic across the business.

- A benchmarking exercise should be completed to compare the current study to other branches of the organisation, which are based in other developing countries across the globe. This in itself would be extremely beneficial as if certain behaviours are not seen in these countries then learnings can be taken from those countries. These learnings can then be adapted to the conditions within which the current organisation operates.

- A further recommendation would be to complete the model at a level lower then that done within this study. The current model looks at the entire product category whilst what I am suggesting is that the model be developed at either a sub category (SKU type A, B or C) or SKU level. The primary reason for this suggestion is that this will in all probability yield further insights and behaviours. This recommendation is triggered by one of the findings of the study in which it was found that the "A" SKU was driven from a sales perspective due to the high turnover they brought in, yet the "C" SKU gave the higher gross margin.

- Gather input from the customer to ensure buy in as the current study suggests that customer ordering is an area in which there exists substantial opportunity for improvement.

- Future research into investigating how knowledge management and tacit knowledge is preserved within an organisation should be undertaken. The system dynamics process has stimulated further thoughts around tacit knowledge and knowledge management, which typically sits in the minds of individuals and when they leave or resign, the knowledge, is lost. This was not within the scope of this study but certainly, thought must be given towards preserving this knowledge and making it available to the business.

7.7 CONSIDERATIONS IN THE APPLICATION OF THE SYSTEM DYNAMICS METHODOLOGY

Applying system dynamics within an organisation must be endorsed by senior leaders within the organisation, to ensure that the support is driven from top down to the relevant teams. This will ensure the project receives the correct priority and support. Team members must be assigned to the project with due consideration given to their workloads and constraints.

Whilst system dynamics proved to be a suitable tool that was adequate in modelling the problem, it must be noted that system dynamics models a specific problem within a specific environment with specific boundaries that needs to be defined. What this translates into is that any system dynamics practitioner or organisation must not have the expectation that a model could be developed once and tweaked for deployment in other applications or problems. This is especially important given that the literature and study completed show that each problem has very different dynamics which the process with reveal.

From the onset of this study, it was recognized that the problem was complex and attempting to piece the fragments together was going to an onerous task. The approach adopted with input from the team was to first answer "What the organisations purpose was?" which resulted in a sector. Once this was done, a 5000 metre view was taken resulting in the identification of the various areas described in Chapter Four. Next came the 10 000 metre view, which resulted in the eight sectors being identified. The rest of the steps to build the detail into the model has been described earlier in this study. A key consideration that was utilised was the benefit of identifying the jigsaw puzzle pieces and to do one piece at a time.

Whilst a high reliance is placed on the mental database as a source of inputs, the use of inputs and data from the numerical and written databases were also critical. Combining and continuously reflecting on the behaviour over time graphs from the model versus the numerical database contributes towards gaining buy-in. This transitioned into the use of quantitative assessment tools, which further showed statistical significance versus practical significance.

7.7 CONCLUDING REMARKS

In today's VUCA world (Volatile, Uncertain, Complex and Ambiguous), organisations have to continuously seek creative and innovative ways to optimize and become more competitive. Organisations are under pressure to not strive to maintain the standard but to find ways to continuously raise the standard. One of the underpinning methodologies in the organisation in which this study was conducted is S&OP, which is meant to ensure the operational and tactical plans are aligned and deliver on the strategic intent. Given the importance of S&OP, an opportunity to understand its impact on the business was identified. System dynamics was identified as a possible tool that could be applied. During the literature review it was found that on the one end system dynamics was not as widely used on supply chain related problems though it seemed relevant and on the other it considered qualitative factors as well, which went against the more conventional modelling techniques which relied primarily on quantitative modelling of the physical world.

System dynamics was used to understand the current impact of S&OP on the organisation with a view that once understood; opportunities for improvement could be identified and evaluated. This process allowed us to identify and appreciate the myriad of complex feedback loops and behaviours that were evident. It also showed how system dynamics is able to consider the operational, tactical and strategic factors as inputs into developing and using the model. System dynamics was able to engage three main categories for information, namely: (1) Mental database of individuals (2) Written database containing the policies and procedures (3) Numerical database containing historical figures, KPI's and trends. This enabled a proper understanding of S&OP within the context of the organisation. Once this was achieved policy interventions were identified, simulated and evaluated to determine which scenario/s gave the best results.

The process followed in the course of this study has certainly contributed towards understanding the problem and contributed towards a way of thinking that is more holistic and forces one to consider a problem through a different lens.

REFERENCE LIST

Ackere, A van., Haxholdt, C., and Larsen, E.R., 2006. Long term and short term customer reaction: a two stage queuing approach. Systems Dynamics Review, Vol. 22, No. 4, pp.349-369.

Affan Badar, M., Sammidi, S. and Gardner, L., 2013. Reducing the bullwhip effect in the supply chain: A study of different ordering strategies. The Journal of Technology Studies, Vol. 39, No.1.

Alizadeh, P., 2012. The role of forecasting parameters in reducing bullwhip effect. Advances in production Engineering and Management, 7, pp.177-186.

Ashayeri, J. and Lemmes, L., 2005. Economic Value Added of supply chain demand planning: A System dynamics simulation. Robotics and Computer-Integrated Manufacturing, 22, pp.550-556.

Angerhofer, J.A., and Angelides, M.C., 2000. Systems Dynamics modelling in Supply Chain Management: Research Review. Proceedings of the 2000 Winter Simulation Conference, Vol. 1, pp.342-351

Akkermans, H. and Dellaert, N., 2005. The rediscovery of industrial dynamics: the contribution of system dynamics to supply chain management in a dynamic and fragmented world. System Dynamics Review Vol. 21, NO. 3, pp.173-186.

Azadeh, A., Layegh, J., and Pourankooh, P., 2010. Optimal model for Supply chain system controlled by Kanban under JIT philosophy by integration of computer simulation and genetic algorithm. Australian Journal of Basic and Applied Sciences, 4(3), pp.370-378.

Barlas, Y., 1994. Model validation in system dynamics. Proceeds international conference on System Dynamics. pp.1-10.

Barratt M., 2004. Understanding the meaning of collaboration in the supply chain. Supply Chain Management: An International Journal, Vol. 9, pp.30-42.

Baumann, F., and Andraski, A.J., 2010. Collaborate externally and internally in CPFR and S&OP, two planning vehicles are better than one. Industrial Engineer, pp.37-40.

Bhattacharya, R., and Bandyopadhyay, S., 2011. A review of the causes of bullwhip effect in a supply chain. Int J Adv Manuf. Technol, 54, pp1245-1261

Bianchi, C., and Bivona, E., 2002. Opportunities and pitfalls related to e-commerce strategies in small-medium firms: a system dynamics approach. Systems Dynamics Review, Vol. 18, no. 3, pp.403-429.

Bijvank, M., and Vis, I.F.A., 2011. Lost-sales inventory theory: A review. European journal of Operational research. Pp.1-13.

Botes, V.L., 2009. Research Design and Methodology (online), Chapter 6 pg 132. Available Online

Braun, V., and Clarke, V., 2006. Using thematic analysis in psychology. Qualitative research in Psychology, Vol.3, No. 2, pp77-101

Braunscheidel MJ and Suresh NC. (2009). The organisational antecedents of a firm's supply chain agility for risk mitigation and response. Journal of Operations Management, 23, pp.119-140.

Bullinger, H., Kuhner, M., and Van Hoof, A., 2002. Analysing supply chain performance using a balanced measurement method. International Journal of Production Research, Vol. 40, no 15, pp.3533-3543.

Buxey G., 2003. Strategy not tactics drives aggregate planning. Int J Production Economics, Vol.85, pp.331- 346.

Cagliano, A.C., DeMarco, A., Rafele, C., and Volpe, S., 2010. Using system dynamics in warehouse management: a fast fashion case study. Journal of Manufacturing Technology Management, Vol. 22, Iss. 2, pp.171-188.

Chakravorty, S.S., 2012. From battlefield to Shop Floor. Industrial Engineer.

Chen, F., Drezner, Z., Ryan, J.K., and Simchi-Levi, D., 2000. Quantifying the Bullwhip Effect in a simple Supply Chain: The impact of forecasting, lead times, and information. Management Science, Vol. 46, No 3, pp.436-443.

Chen, F., Drezner, Z., Ryan, J.K., and Simchi-Levi, D., 2000. “The impact of exponential smoothing forecasts on the bullwhip effect,” Naval Research Logistics, vol. 47, pp.269–286.

Chen-Ritzo, C.H., Ervolina, T., Harrison, T.P. and Gupta, B., 2010. Sales and operations planning in systems with order configuration uncertainty. European Journal of Operations Research, 205 (3), pp.604-614.

Christopher, M., 1992. Logistics and Supply chain Management. Financial Times, Pitman, London.

Cox, J.F. and Blackstone, J.H., 2002. APICS Dictionary, Tenth ed. APICS, Alexandria, va, USA.

Coyle, R.G., 1992. A system dynamics model of aircraft carrier survivability. System Dynamics Review, Vol. 8, No.3, pp.193-212.

Closs, D.J., Nyaga, G.N. and Voss, M.D., 2010. The differential impact of product complexity, inventory level, and configuration capacity on unit and order fill rate performance. Journal of Operations Management, Vol.28 (l), pp.47-57.

Daugherty, P.J., 2011. Review of logistics and supply chain relationship literature and suggested research agenda. International Journal of Distribution and Logistics management, Vol. 41, no. 1, pp.16-31.

Daugherty, P.J., Gawe, S.J., and Caltagirone, J.A., 2010. A real world look at SCM. Supply Chain Management Review.

Disney, S.M. and Towill, D.R., 2003. The effect of vendor managed inventory (VMI) dynamics on the Bullwhip effect in supply chains. International J. production Economics, 85, pp.199-215.

Fixson, S., 2005. Product architecture assessment: A tool to link product, process and supply chain design decisions. Journal of Operations Management, 23, pp.345-369.

Forrester, J.W., 1971. Counterintuitive behaviour of social systems. Technology Review, Vol. 73, No 3. pp.52-68.

Forrester, J.W., 1986. Lessons from system dynamics modelling. The 1986 International Conference of the System Dynamics Society. Sevilla, October, 1-16

Forrester, J.W., 1994. System dynamics, systems thinking, and soft OR. System Dynamics Review Vol. 10, no. 2-3.

Fugate, B.S., Stank, T.P. and Mentzer, J.T., 2009. Linking improved knowledge management to operational and organisational performance. Journal of Operations Management, 27, pp.247-264.

Ganesh, M., Raghunathan, S. and Rajendran, C., 2008. The value of information sharing in a multi-product supply chain with product substitution. IIE transactions, 40, pp.1124-1140.

Gavimeni, S., 2006. Price fluctuations, information sharing, and supply chain performance. European Journal of Operations Research, Vol 174, Issue 3, pp. 1651-1663.

Ge, Y., Yang, J.B., Proudlove, N. and Spring, M., 2004. Systems dynamics modelling for supply-chain management: A case study on a supermarket chain in the UK. International transactions in Operation Research, 11, pp.495-509.

Godsel, J., Diefenbach, T., Clemmow, C., Towill, D., and Christopher, M., 2011. Enabling supply chain segmentation through demand profiling. International journal of Physical distribution and Logistics management, Vol. 41, No 3, pp.296-314

Goldratt, E.M. and Cox, J., 2004. The Goal, A process of ongoing improvement. Library of Congress cataloging

Gruen, T.W., Corsten, D. and Bharadwaj, S., 2002. Retail out-of-stocks: A worldwide examination of extent causes and consumer Responses. Grocery Manufacturers of America.

Guo, C.H., Lui, L., Huang, G.H., Fuller, G.A., Zou, R. and Yin, Y.Y., 2001. A systems dynamics approach for regional environmental planning and management: A study for the Lake Erhai Basin. Journal of Environmental Management, 61, pp.93-111.

Ho, T. and Tang, C.S., 1998. Product Variety management: Research advances. Kluwer Academic Publishers, Norwell, MA.

Holland, W. and Sodhi, M.S., 2004. Quantifying the effect of batch size and order errors on the Bullwhip effect using simulation. International Journal of Logistics Research and Applications: A Leading Journal of supply chain management, 7:3, pp.251- 261.

Huang, M., IP, W.H., Yung, K.L., Wang, Z. and Wang, D., 2007. Simulation study using system dynamics for a CONWIP-controlled lamp supply chain. Int J adv. Manuf Technol, Vol32, pp.184- 193.

Kanungo, S. and Jain, V., 2008. Modelling email use: a case of email system transition. Systems Dynamics Review, Vol.24, No.3, pp.299-319.

Kim, C.O., Jun, J., Baek, J.K., Smith, R.L., and Kim, Y.D., 2005. Adaptive inventory control models for supply chain management. Int J Adv Manuf Technol, 26, pp.1184-1192.

Kristianto, Y., Ajmal, M.M., and Helo, P., 2011. Advanced planning and scheduling with collaboration processes in agile supply and demand networks. Business process management journal, Vol. 17, No 1, pp.107-126.

Kopczak, L.R. and Johnson, M.E., 2003. The supply chain management effect. MIT Sloan Management Review, Spring 2003, pp.27-34.

Kunc, A., 2008. Achieving a balanced organisational structure in professional service firms: some lessons from a modelling project. Systems Dynamics Review, Vol. 24, No. 2, pp.119-143.

Lapide, L., 2006. "MIT's SC2020 project: the essence of excellence". Supply Chain Management Review, Vol. 10, No.3, pp.18-24.

Lawrence, M. and O'Connor, M., 2000. Sales forecasting updates: how good are they in practice. International Journal of forecasting, 16, pp.369-382.

Ledet, W. and Paich, M., 1994. Rational considerations: System Dynamics model – The manufacturing game. Goal/QPC Conference.

Lee, H.L., Padmanabhan, P. and Whang, S., 1997. Bullwhip effect in a supply chain. Sloan Management Review, vol. 38, pp.93-102.

Leedy, P.D. and Ormrod, J.E., 2010. Practical Research: Planning and Design. Pearson Education, Inc. Ninth Edition.

Lim, J.S. and O' Connor, M., 1995. Judgemental adjustment of initial forecasts: its effectiveness and biases. Journal of Behavioural Decision Making, 8, pp.149-168.

Lin, C., Baines, T.S., O'Kane, J. and Link, D., 1998. A generic methodology that aids the application of system dynamics to manufacturing system modelling. International Conference on SIMULATION, Conference publication, No, 457, IEE, 1998.

Lune-Reyes, L.F. and Andersen, D.L., 2003. Collecting and analysing qualitative data for system dynamics: methods and models. System Dynamics Review, Vol. 19, No 4, pp.271-296.

Lyneis, J.M., Cooper, K.G., and Els, S.A., 2001. Strategic management of complex projects: a case study using system dynamics. Systems Dynamics Review (Wiley), Vol. 17, No 3, pp.237-260.

Lyneis, J. and Madnick, S., 2008. Preventing accidents and building a culture of safety Insights from a simulation model. Working paper CISL#2008-03.

Malhotra, M.K. and Sharma, S., 2002. Spanning the continuum between marketing and operations. Journal of Operations Management, 20, pp.209-219.

Malin, A., 1997. Cultural dimensions in logistics management: a case study from the European automotive industry. Supply Chain Management, 2 (2), pp.76-87.

Marshall, M.N., 1996. Sampling for qualitative research. Family Practice, Vol. 13 (6), pp.523

Martinez-Olvera, C., 2008. Methodology for realignment of supply chain structural elements. Int. J. Production Economics, 114, pp.714-722.

Marquez, A.C., 2010. Dynamic Modelling for Supply Chain Management; Dealing with front end, back end and integration issues. Springer-Verlag London Limited.

Martis, M S (2006) "Validation of Simulation Based Models: A Theoretical Outlook" The Electronic Journal of Business Research Methods. Vol. 4, Issue 1, pp.39 -46, available online at www.ejbrm.com

McCullen, P. and Towill, D., 2002. Diagnosis and reduction of bullwhip in supply chains. Supply Chain Management: An international Journal, vol. 7, pp.164-179.

McGarvey, B. and Hannon, B., 2004. Dynamic modeling for business management, an Introduction. Springer-Verlag New York, Inc.

McMillan, J.C. and Schumacher, S., 2010. Research in Education, 7th edition. Pearson

Metters, R., 1997. Quantifying the bullwhip effect in supply chains. Journal of Operations Management, 15, pp.89-100.

Meyers, R.A., 2011. Complex Systems in Finance and Econometrics. Springer Science + Business Media, LLC.

Minami, N.A. and Madnick, S., 2009. Dynamic analysis of combat vehicle accidents. System Dynamics Review, Vol. 25, No.2, pp.79-100.

Mingers, J. and White, L., 2010. A review of the recent contribution of systems thinking to operational research and management science. European Journal of Operational Research, 207, pp.1147- 1161.

Morecroft, J.D.W., Lane, D.C. and Viita, P.S., 1991. Modeling growth strategy in a biotechnology start-up firm. Systems Dynamic Review, 7, No.2, pp.93-116.

Morecroft, J., 2011. Strategic Modelling and Business Dynamics, A feedback systems approach. John Wiley and Sons

Morecroft, J., 2010. Systems approaches to Managing Change: A practical guide. The Open University 2010.Copyright John Wiley and sons limited.

Nienhaus, J., Ziegenbein, A. and Duijts, C., 2003. How Human behaviour amplifies the Bullwhip effect: a study based on the beer distribution Game online. Centre for Enterprise Sciences (BWI), Swiss Federal Institute of Technology (ETH), Zurich.

O' Leary-Kelly, S.W. and Flores, B.E., 2002. The integration of manufacturing and marketing/sales decisions: impact on organisational performance. Journal of Operations Management, 20, pp.221-240.

Olhager, J., Rudberg, M. and Wilner, J., 2001. Long term capacity management: Linking the perspectives from manufacturing strategy and Sales and operations planning. Int. J of Production Economics, pp.215- 225.

Oliva, R. and Sterman, J.D., 2001. Cutting corners and working overtime: Quality erosion in the service industry. Management Sciences, Vol. 47, No.7, pp.894-914.

Oliva, R. and Watson, N., 2011. Cross-functional alignment in supply chain planning: A case study of sales and operations planning. Journal of Operations Management, 29, pp.434-448.

Pagell, M., 2004. Understanding the factors that enable and inhibit the integration of operations, purchasing, and logistics. Journal of Operations Management, 23, pp.459-487.

Pay, R., 2010. Avoiding obsolete Inventory. Industry Week.

Rabeli, L., Sarmiento, A. T. and Jones, A., 2011. Stability of the Supply Chain using System Dynamics simulation and the accumulated deviations from equilibrium. Modelling and Simulation in Engineering. Article ID 603632, 10 pages.

Raman, A. and Watson, N., 2004. Managing global supply chains. in: Quelch JA, Deshpande R (eds) The Global Market: Developing a strategy to Manage Across Borders. Jossey-Bass, San Francisco, CA. pp. 263-287.

Ranganath, B.J. and Lewlyn, L.R., 2008. System Dynamics: Theory and case studies. IK international publishing house PvT. Ltd.

Rao, A., Carr, L.P., Dambolena, I., Kopp, R.J., Martin, J., Rafii, F., and Schlesinger, P.F., 1996. Total Quality management: A cross functional Perspective. John Wiley and Sons. pp.188-190.

Repenning, N.P., Goncalves, P., and Black, L.J., 2001. Past the Tipping Point: The persistence of fire fighting in Product Development. California Management Review, Vol. 43, No4, pp.44-63.

Repenning, N.P. and Sterman, J.D., 2001. Nobody ever gets credit for fixing problems that never happened: Creating and Sustaining process Improvement. California Management Review, Vol43, No. 4, pp.64-88.

Repenning, N.P. and Rudolph, J.W., 2002. Disaster dynamics: Understanding the role of quantity in organisational collapse. Administrative science quarterly, Vol. 47, No. 1, pp.1-30.

Richardson, G.P., 1999. Reflections for the future of system dynamics. The Journal of the Operations Research Society, Vol. 50, No 4, pp.440 – 449.

Richardson, G.P., 2011. Reflections on the foundations of system dynamics. System Dynamics Review, Vol. 27, no 3, pp.219-243.

Ross, A., 2003. Creating Agile Supply. IEE Manufacturing Engineer.

Rouwette, E.A.J. and Vennix, J.A.M., 2006. System Dynamics and Organizational Interventions. Systems Research and Behavioural Science, Syst. Res. 23, pp.451-466.

Russel, R.S. and Taylor, B.W., 2006. Operations Management, Quality and competitiveness in a global environment. John Wiley and Sons. 5th edition, 108-111.

Schwartz, B., 2000. Self determination: the tyranny of freedom. American Psychologist 55 (l), pp.79-88.

Senge, P.M. and Sterman, J.D., 1990. Systems thinking and organisational learning: Acting locally and thinking globally in the organisation of the future. System dynamics, pp.1007-1022.

Shen, H. and Huang, J.Z., 2008. Forecasting time series of inhomogeneous poisson processes with application to call center workforce management. The Annals of Applied Statistics, Vol. 2, No. 2, pp.601-623.

Shukla, R.K., Garg, D., and Agarwal, A., 2011. Understanding of supply chain: A literature review. International Journal of engineering Sciences and Technology, Vol. 3, pp.2059-2072.

Spens, K.M. and Bask, AH., 2002. Developing a framework for Supply Chain Management. International Journal of Logistics Management, Vol. 13, Number 1.

Stadtler, H., 2005. Supply chain management and advanced planning - basics, overview and challenges. European Journal of Operational Research, 163, pp.575-588.

Sterman, J.D., 1989 Modeling managerial behaviour: Misperceptions of feedback in a dynamic decision making experiment. Management Science, Vol. 35, No 3, pp.321- 339.

Sterman, J.D., 2000. Business Dynamics: Systems thinking and modelling for a complex world, Boston, Irwin McGraw Hill.

Suryani, E., Chou, S., Hartono, R., and Chen, C.H., 2010. Demand scenario analysis and planned capacity expansion: A system dynamics framework. Simulation modelling practice and Theory, 18, pp.732-751.

Sun, H.X. and Ren, Y.T., 2005. The impact of forecasting methods on bullwhip effect in supply chain management, IEEE.

Thome, A.M.T., Scavarda, I.F., Fernandez, N.S., and Scavarda, A.J., 2012 Sales and Operations planning: A research synthesis. Int. J. Production economics, 138

Turner, D., 2010 Qualitative Interview Design: A practical guide for Novice Investigators. The Qualitative report, Vol. 15 (3), pp.754.

Van Landeghem, H. and Vanmaele, H., 2002. Robust planning: a new paradigm for demand chain planning. .Journal of Operations Management, 20, pp.769- 783.

Wright, D. and Yuan, X., 2007. Mitigating the bullwhip effect by ordering policies and forecasting methods. Int. Journal of Production Economics, 113, pp.587-597.

Wyland, B., Buxton, K., and Fuqua, B., 2000. Simulating the Supply Chain. IIE Solutions, Vol. 32, Issue 1.

Zylstra, K., 2005. Distribution made Lean. Industrial Engineer. pp.31-35.

Zhang, X., 2004. The impact of forecasting methods on the bullwhip effect. International Journal of Production Economics, vol. 88, pp.15-27.

APPENDIX 1: INFORMED CONSENT LETTER

UNIVERSITY OF KWAZULU-NATAL
GRADUATE SCHOOL OF BUSINESS AND LEADERSHIP

Doctor of Business Administration (DBA) Research Project

Researcher:	Kenneth Moodley	(0836465408)
Supervisor:	Dr Shamim Bodhanya	(031 2601615)
Research Office:	Ms Xolile Kunene	(031 2602784)
Research Office (Ethics):	Mariette Snyman	(031 2608350)

Dear Respondent,

I, Kenneth Moodley am a Postgraduate student in Leadership and Management, at the Graduate School of Business and Leadership, of the University of KwaZulu-Natal. You are invited to participate in a research project entitled: "A system dynamics model to explore the impact of S&OP processes within an FMCG organisation". The objectives of this study are:

- Further application of system dynamics within a supply chain environment. The literature has shown that research is mostly made of quantitative modelling and considerations within the supply chain environment (Kristianto, Ajmal & Helo, 2011).
- To gain an in-depth understanding of the impact that S&OP decisions and policies have on the business
- To demonstrate that system dynamics can be used as a business tool to drive improvements and ensure alignment between policies, procedures and decisions to ensure organisational profitability
- To use the model as a learning laboratory to improve and change individual behaviour, which will ensure that decisions made result in sustainable medium to long-term benefits.

- To use the system dynamics model to gain and share insights into the problems being experienced and to use it as a change management tool

Through your participation, I hope to understand how current policies impact the S&OP process within the organisation, the impact on business performance and the identification of improvement opportunities. The results of the interview / questionnaire / focus group are intended to contribute to the development of a System dynamics model, which will aid me in completing the objectives of this study.

Your participation in this project is voluntary. You may refuse to participate or withdraw from the project at any time with no negative consequence. There will be no monetary gain from participating in this survey/focus group. Confidentiality and anonymity of records identifying you as a participant will be maintained by the Graduate School of Business and Leadership, UKZN.

If you have any questions or concerns about completing the questionnaire or participating in the interview or focus group or about participating in this study, you may contact me or my supervisor at the numbers listed above.

The interview or focus group should take about 45 minutes to an hour. I hope you will take the time to complete this questionnaire / participate in the interview / focus group.

Sincerely

Investigator's signature_________________________ Date_________________

This page is to be retained by the participant

UNIVERSITY OF KWAZULU-NATAL
GRADUATE SCHOOL OF BUSINESS AND LEADERSHIP

Doctor of Business Administration (DBA) Research Project

Researcher:	Kenneth Moodley	(0836465408)
Supervisor:	Dr Shamim Bodhanya	(031 2601615)
Research Office:	Ms Xolile Kunene	(031 2602784)
Research Office (Ethics):	Mariette Snyman	(031 2608350)

CONSENT

I……………………………………………………………………………(full names of participant) hereby confirm that I understand the contents of this document and the nature of the research project, and I consent to participating in the research project.

I understand that I am at liberty to withdraw from the project at any time, should I so desire.

I hereby consent/do not consent to record the interview.

SIGNATURE OF PARTICIPANT DATE

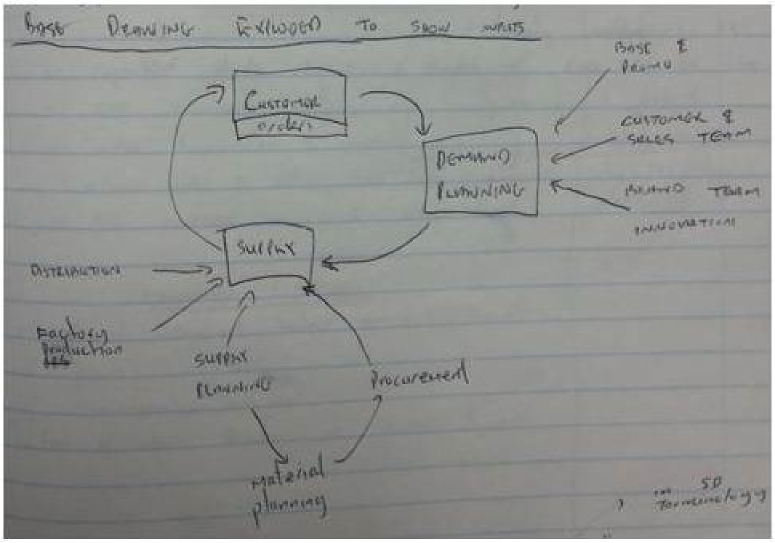
……………………………………………………………………………………………………

This page is to be retained by the researcher

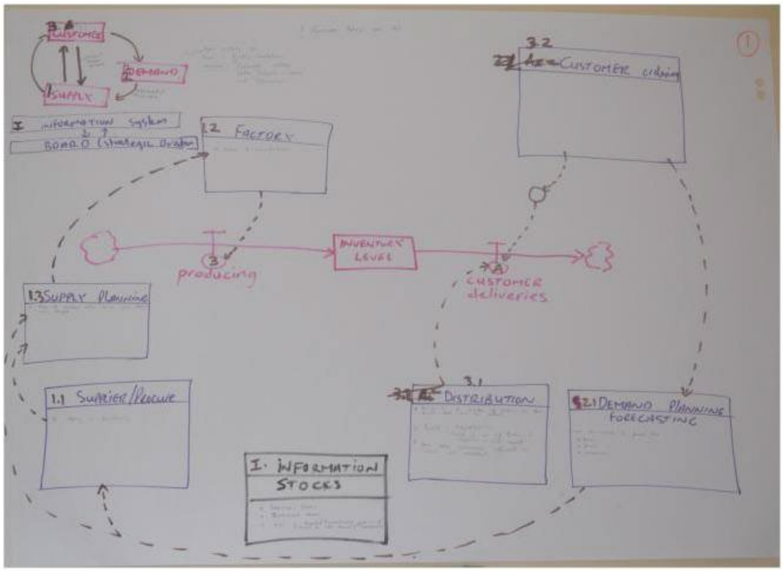
APPENDIX 2: INTERVIEW SCHEDULE

1. Can you start by introducing yourself?
    a. Name,
    b. position,
    c. department,
    d. brief overview of experience
2. What is your understanding of S&OP as per the way it should work?
3. What is your understanding of S&OP relative to your department and position? What are the differences?
4. How does S&OP work in reality (if different from the above)?
5. How do you think S&OP should work?
6. Is there a difference between how S&OP should work versus how it actually works
7. What goes wrong?
8. What behaviours currently impact S&OP in a positive or negative manner?
9. Why do you think it does not work as it should? What are the causes?
10. Do you think the way S&OP works currently impacts profitability within this category?
11. If the answer to the above is “Yes”, do you think that the current ways of working leads to a positive or negative impact on profitability
12. What are your KPI’s?
13. Which KPI’s do you think is most impacted by S&OP?
14. Which department or function is responsible for S&OP to function as intended?
15. If fixed what do you think would be the benefits of an S&OP process that works?
16. What would you fix to get S&OP to work?

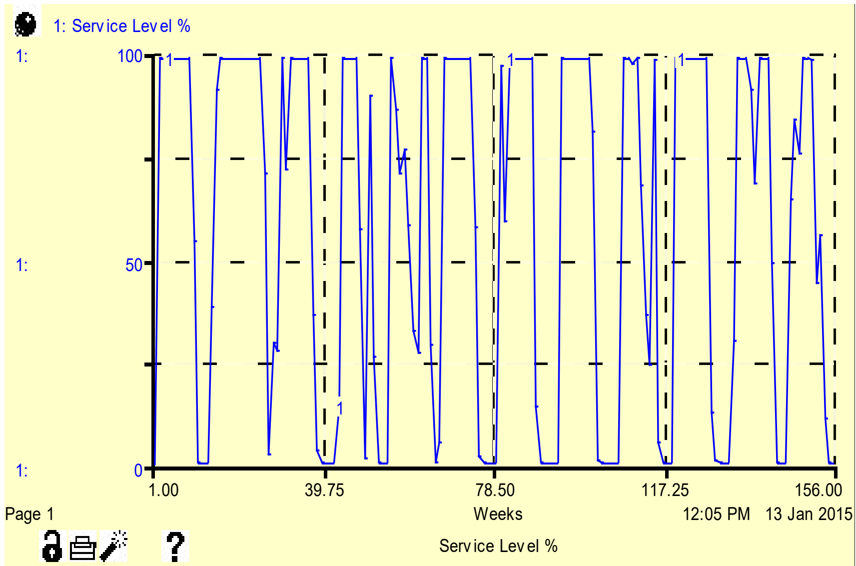
APPENDIX 3: HELICOPTER VIEW (5000 METRE) SHOWING FURTHER INPUTS

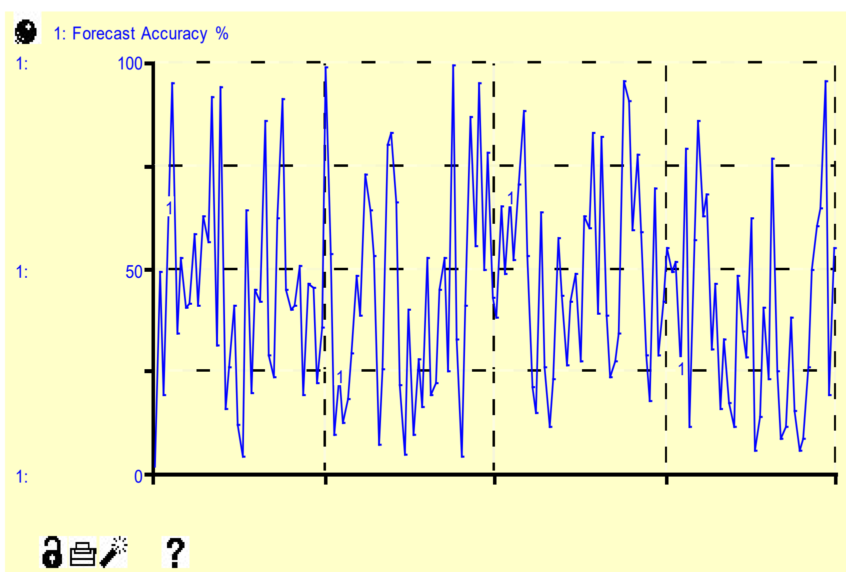


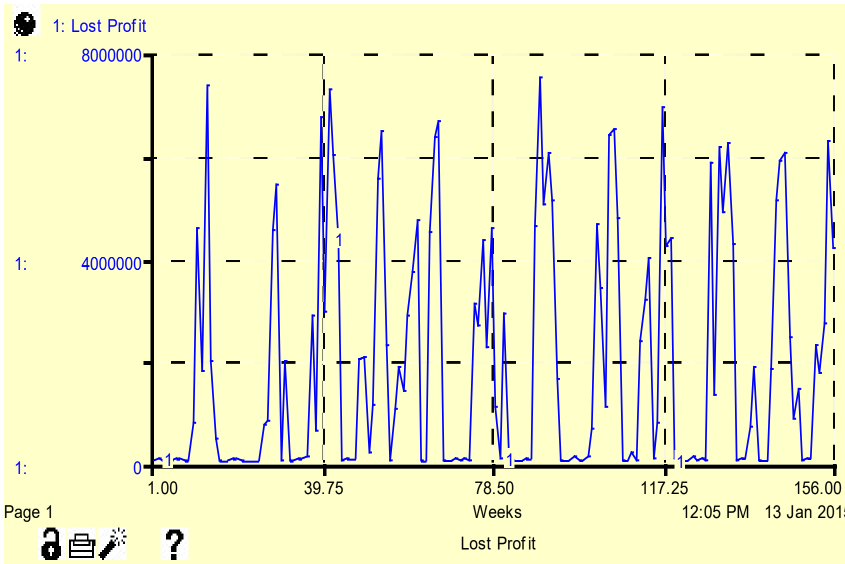
APPENDIX 4: HELICOPTER VIEW (10 000 METRE) SHOWING CORE SECTORS



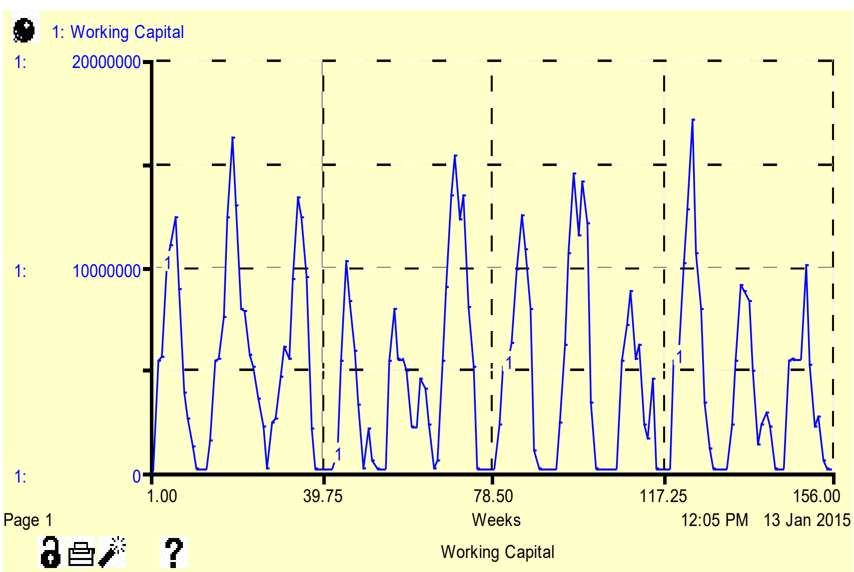
APPENDIX 5: BASE MODEL – BEHAVIOUR OVER TIME GRAPHS



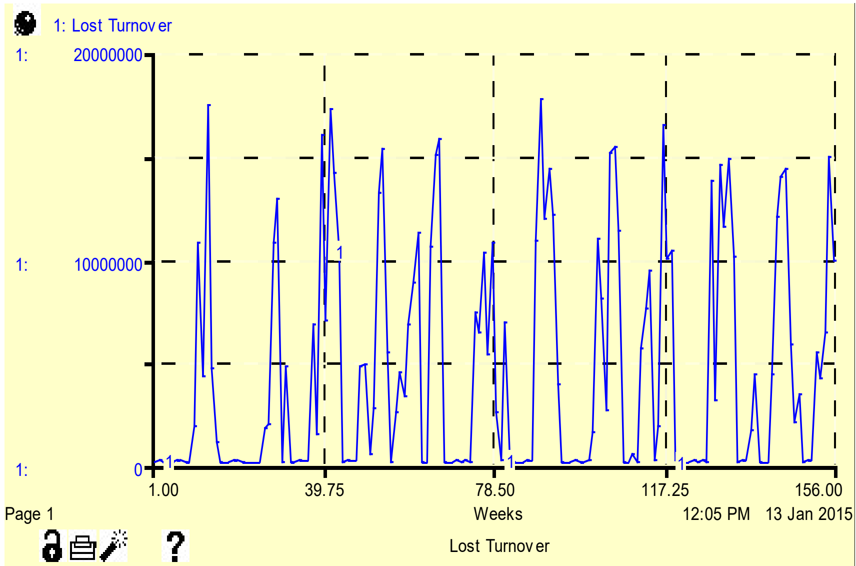




1: Lost Profit
1: 8000000
1: 4000000
1: 0
1.00
39.75
78.50
117.25
156.00
Page 1
Weeks
12:05 PM 13 Jan 2015
Lost Profit



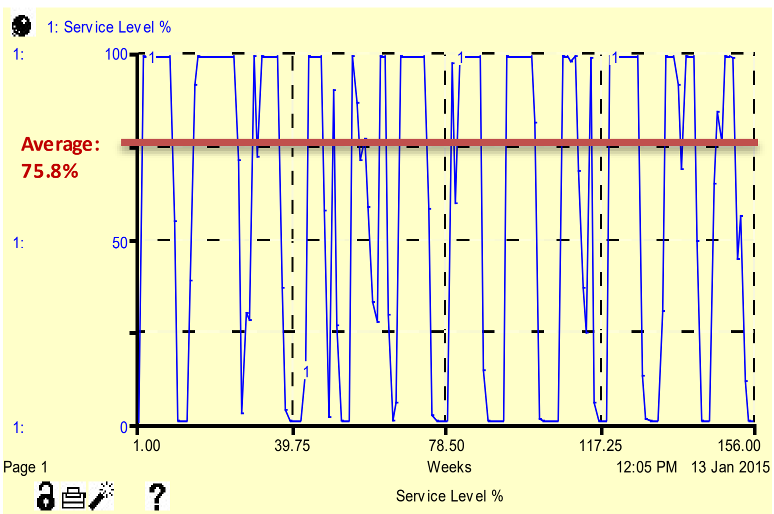
1: Working Capital
1: 20000000
1: 10000000
1: 0
1.00
39.75
78.50
117.25
156.00
Page 1
Weeks
12:05 PM 13 Jan 2015
Working Capital


1: Lost Turnover
1: 20000000
1: 10000000
1: 0
1.00
39.75
78.50
117.25
156.00
Page 1
Weeks
12:05 PM 13 Jan 2015
Lost Turnover

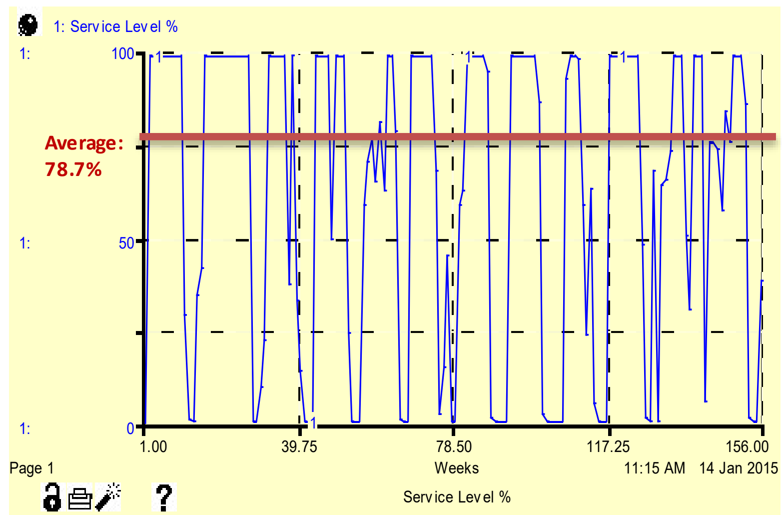
APPENDIX 6: SCENARIO 1 – BEHAVIOUR OVER TIME GRAPHS

Scenario 1: Service level graphs

Base Model

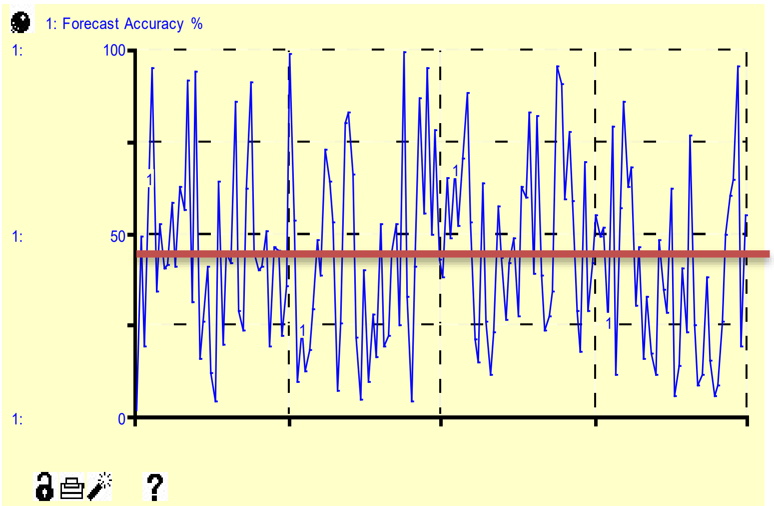


Scenario 1

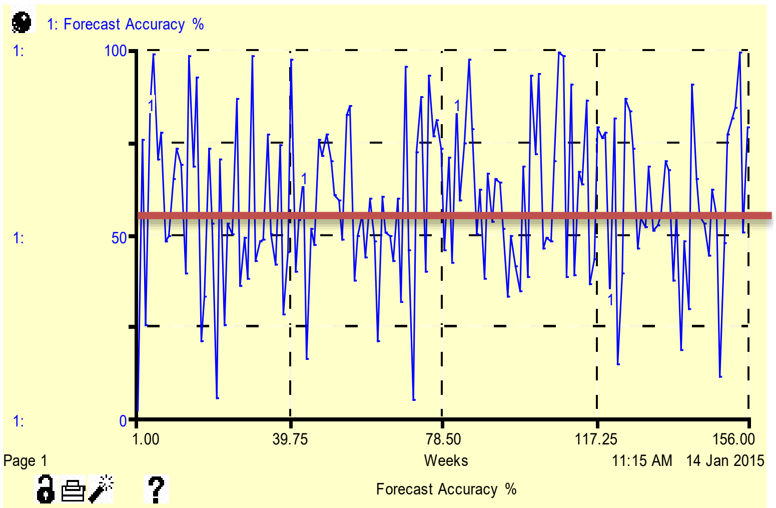


Scenario 1: Forecast accuracy graphs

Base Model

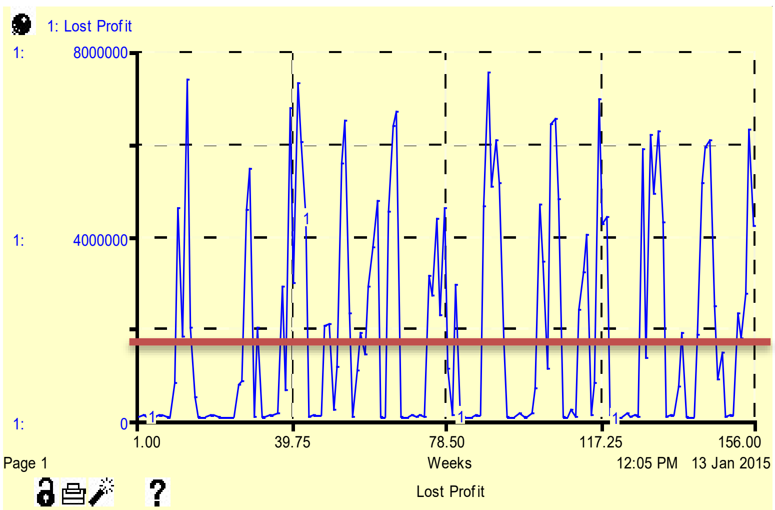


Scenario 1

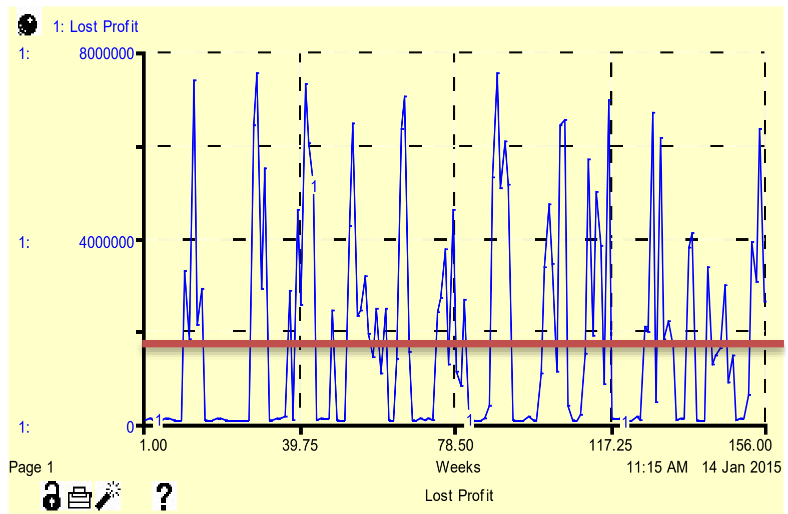


Scenario 1: Lost profit graphs

Base Model

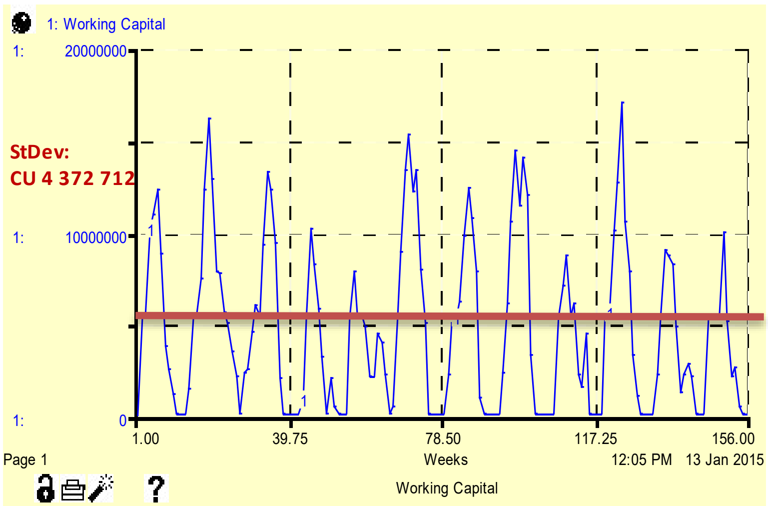


Scenario 1

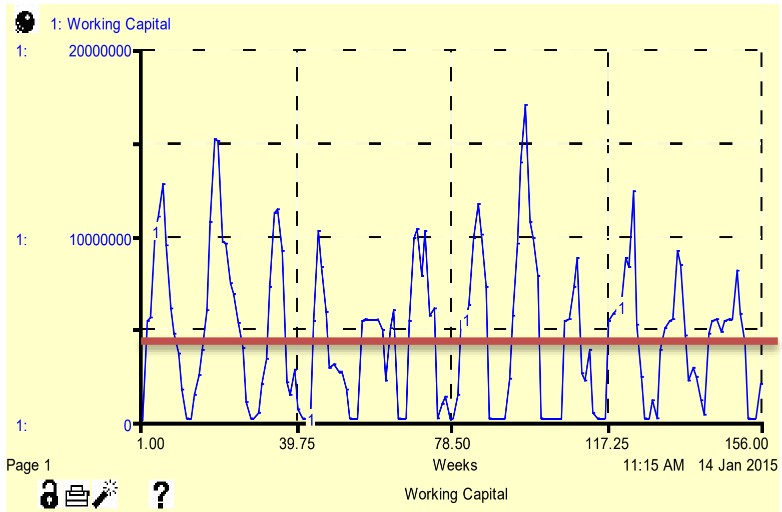


Scenario 1: Working capital graphs

Base Model

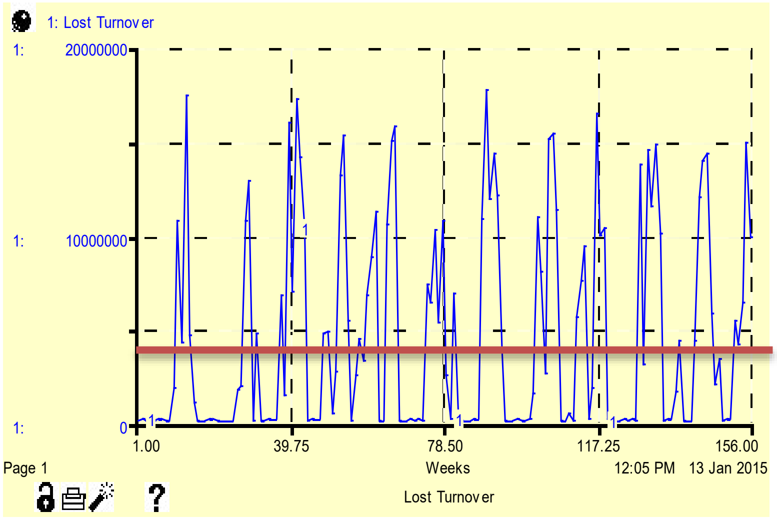


Scenario 1

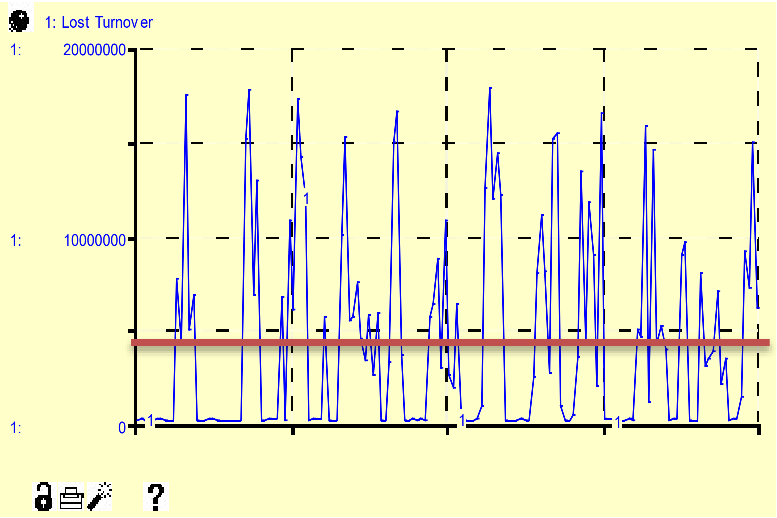


Scenario 1: Lost turnover graphs

Base Model



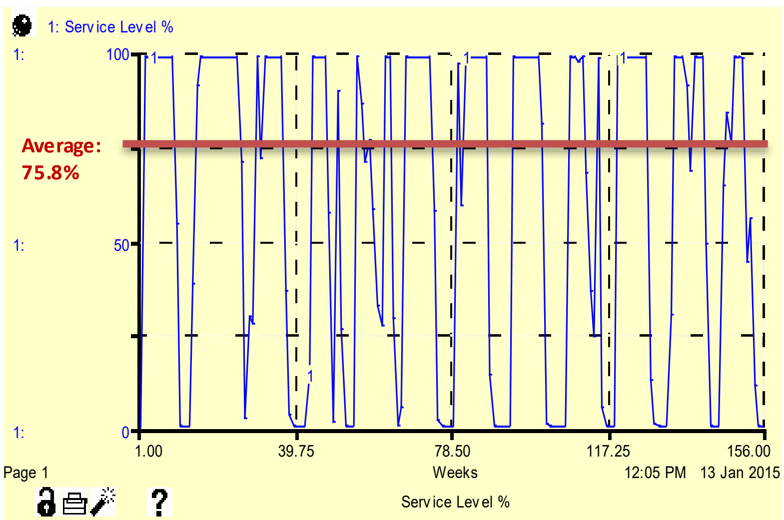
Scenario 1



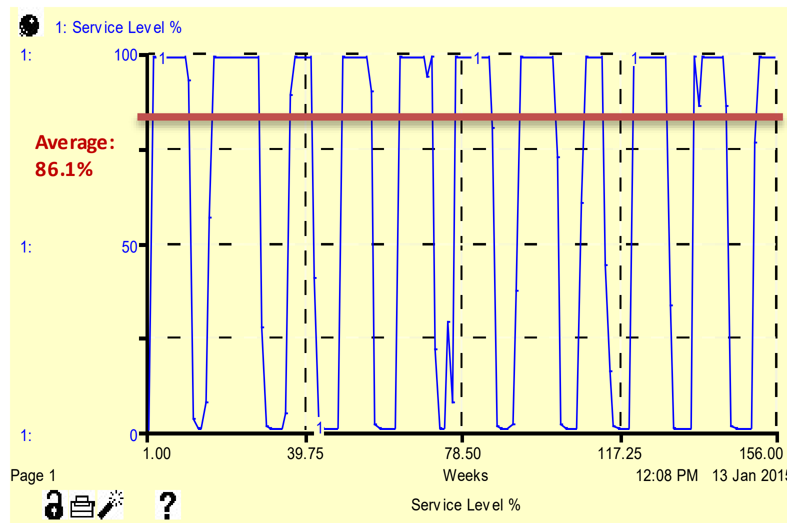
APPENDIX 7: SCENARIO 2 – BEHAVIOUR OVER TIME GRAPHS

Scenario 2: Service level graphs

Base Model

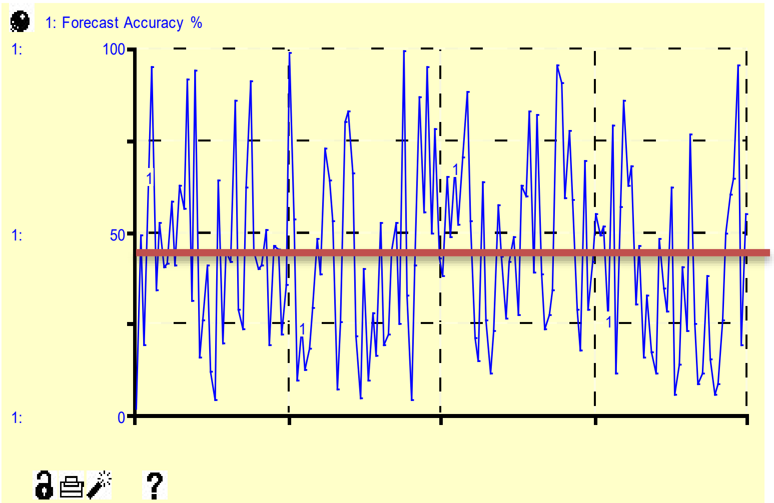


Scenario 2

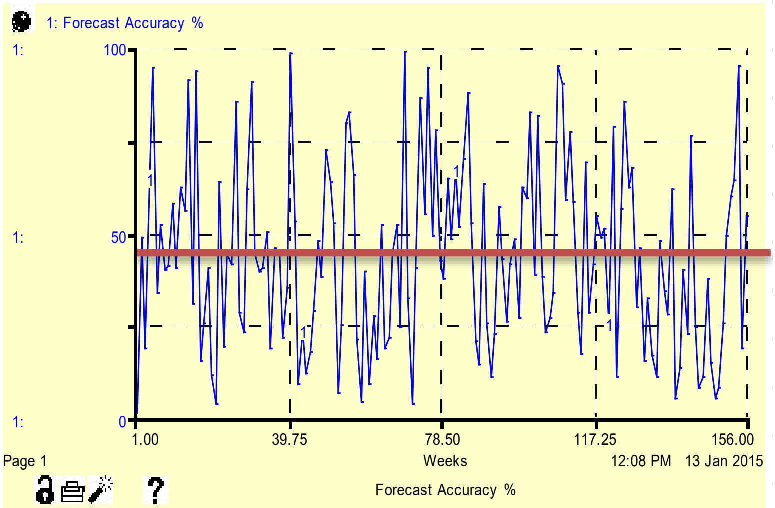


Scenario 2: Forecast accuracy graphs

Base Model

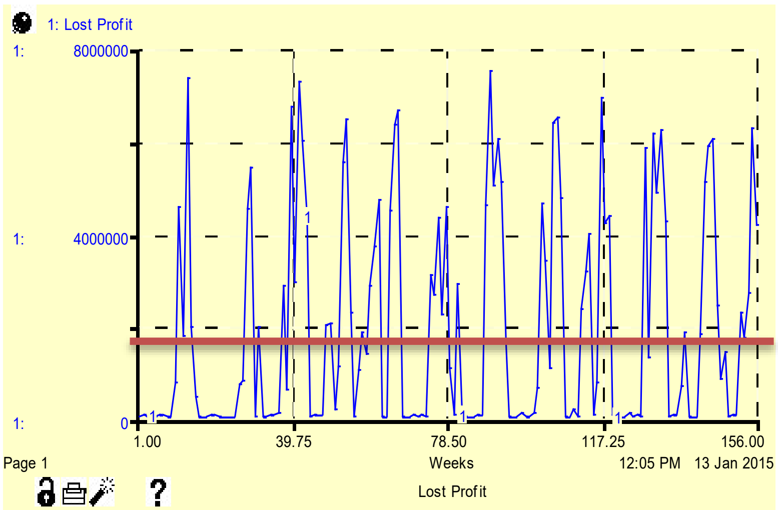


Scenario 2

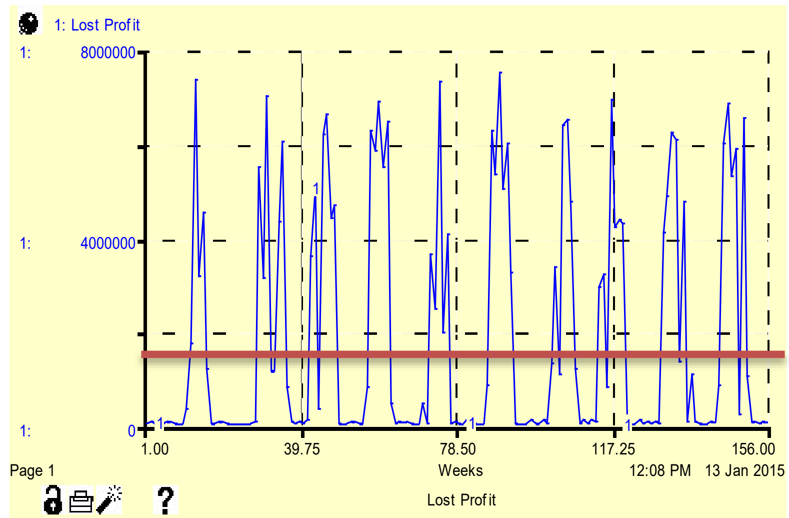


Scenario 2: Lost profit graphs

Base Model

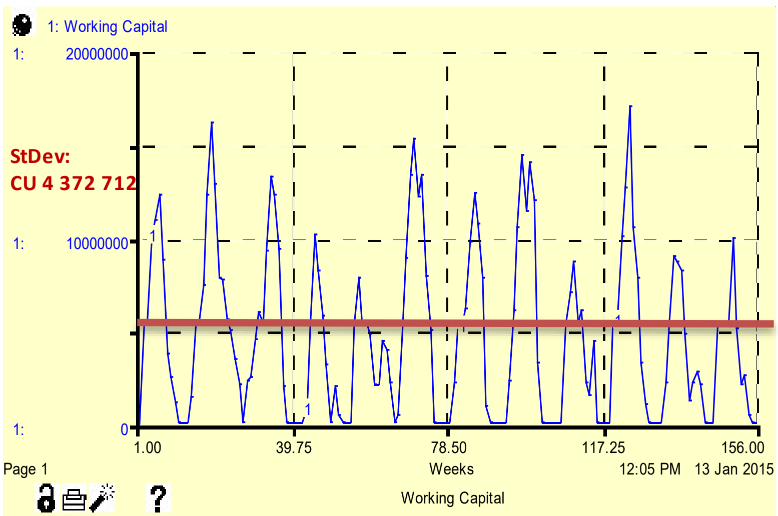


Scenario 2

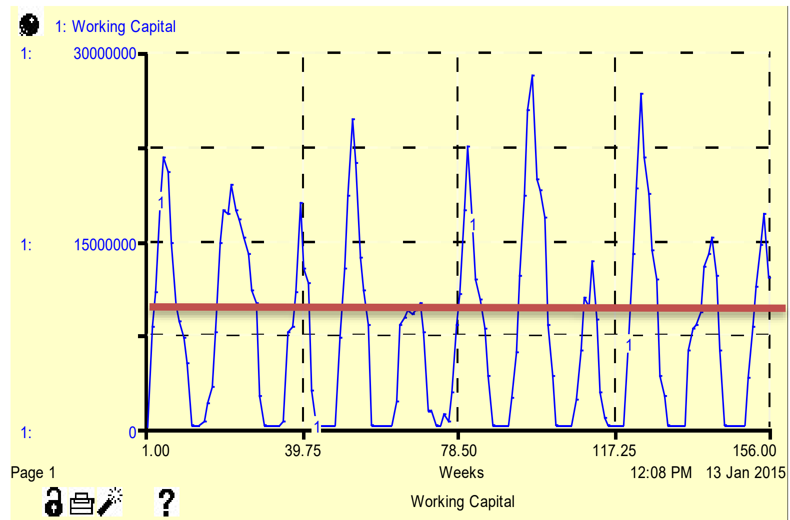


Scenario 2: Working capital graphs

Base Model



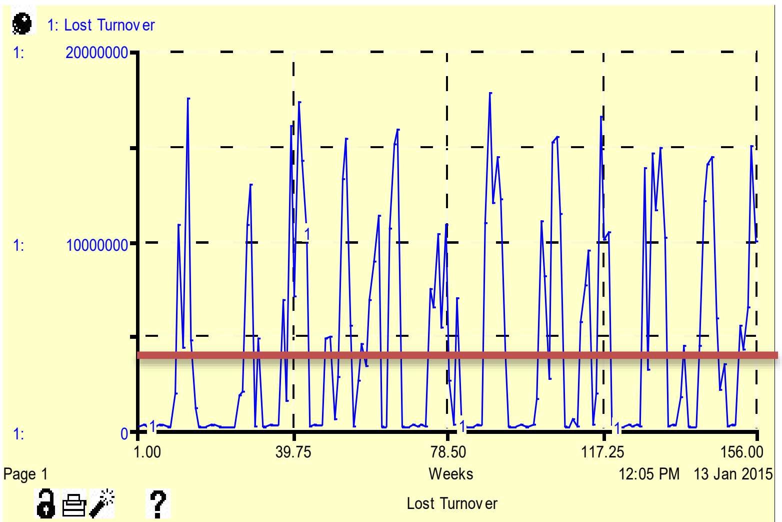
Scenario 2



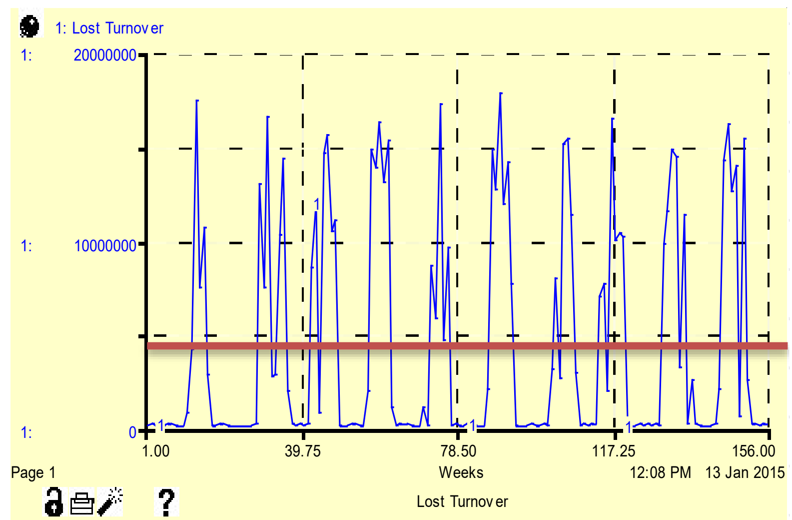
Note that the Y axis between the above base and scenario graphs are not equal

Scenario 2: Lost turnover graphs

Base Model



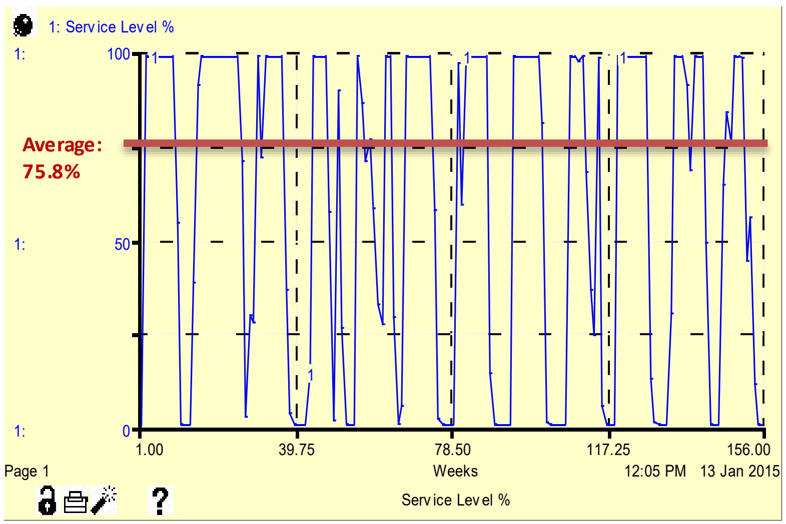
Scenario 2



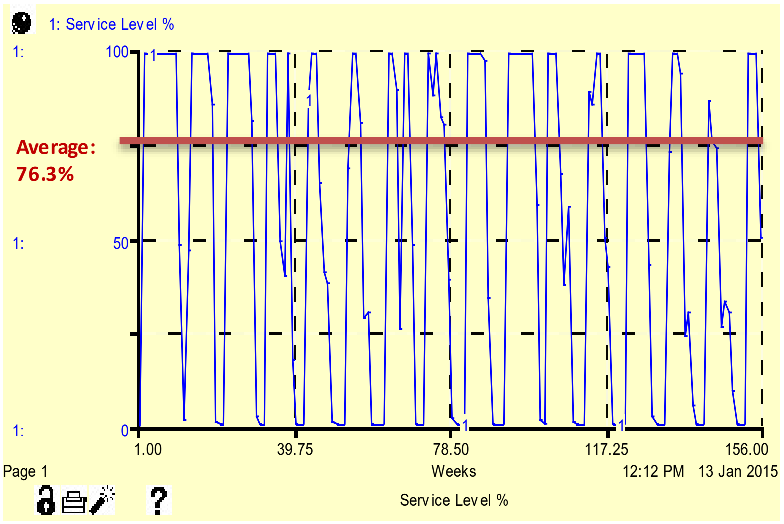
APPENDIX 8: SCENARIO 3 – BEHAVIOUR OVER TIME GRAPHS

Scenario 3: Service level graphs

Base Model

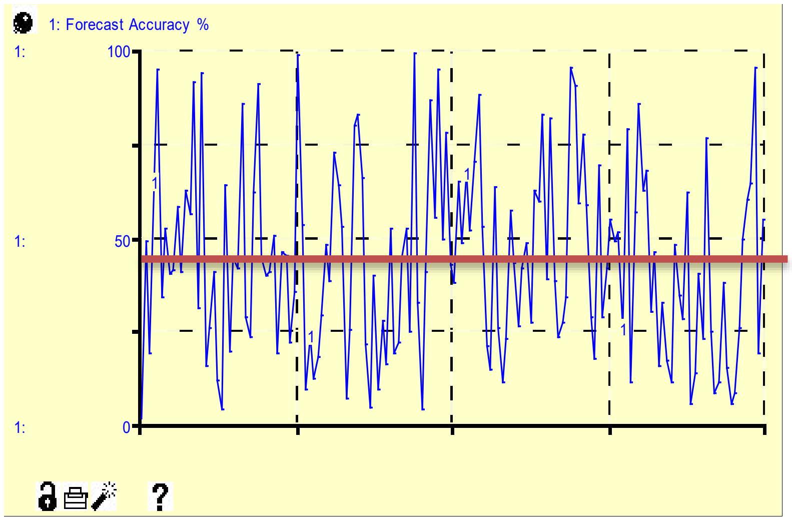


Scenario 3

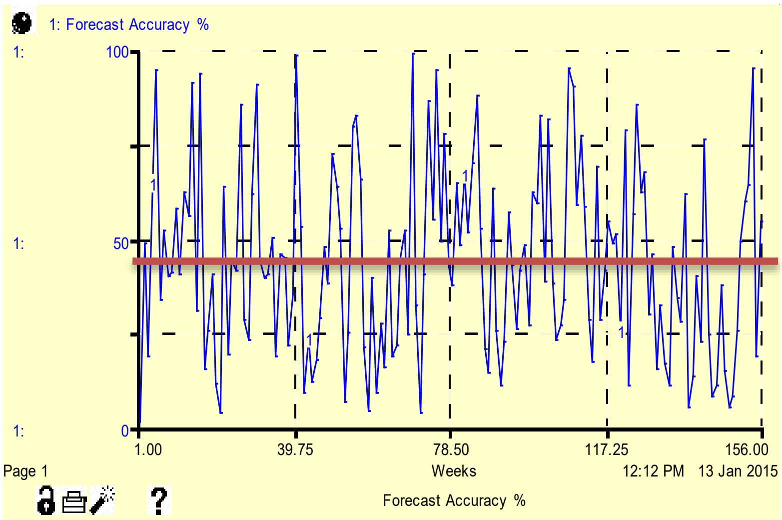


Scenario 3: Forecast accuracy graphs

Base Model

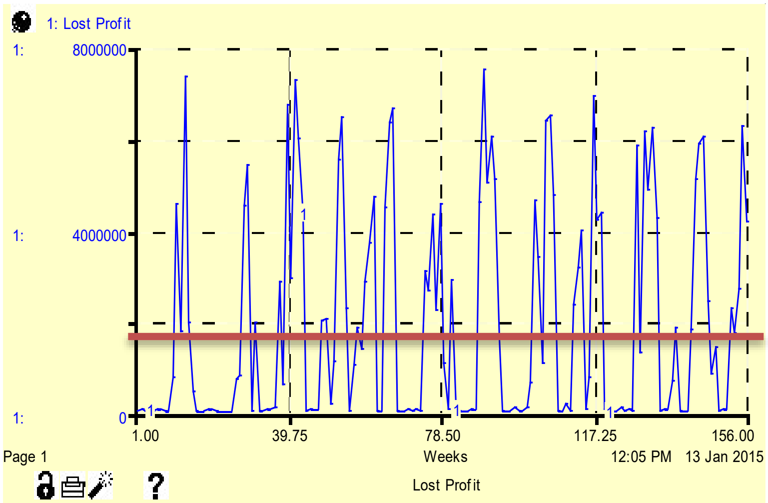


Scenario 3

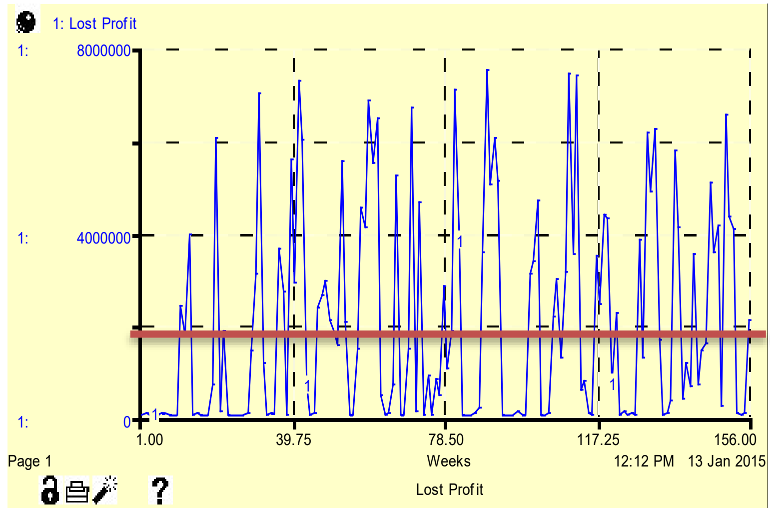


Scenario 3: Lost profit graphs

Base Model

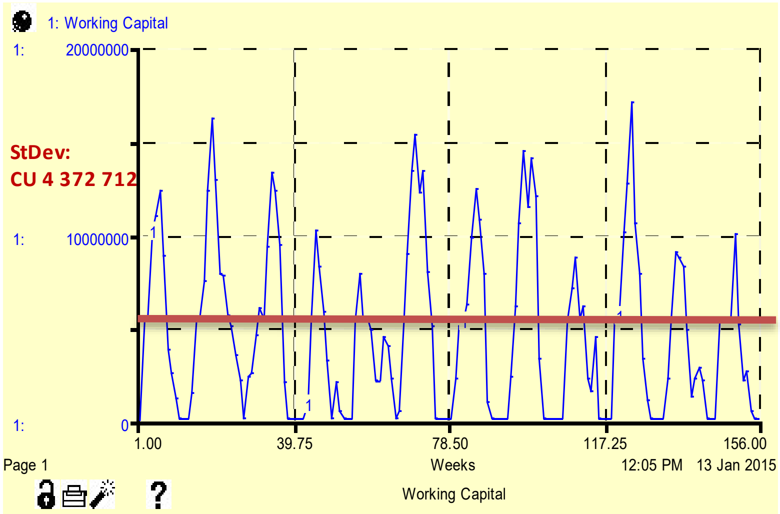


Scenario 3

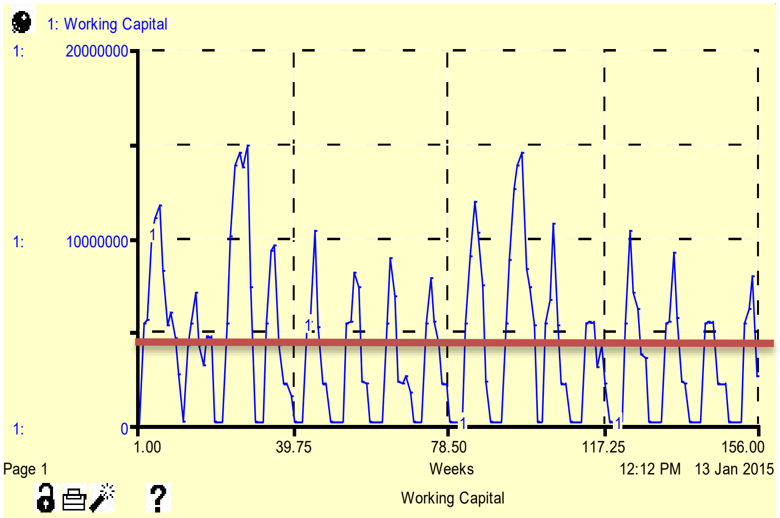


Scenario 3: Working capital graphs

Base Model

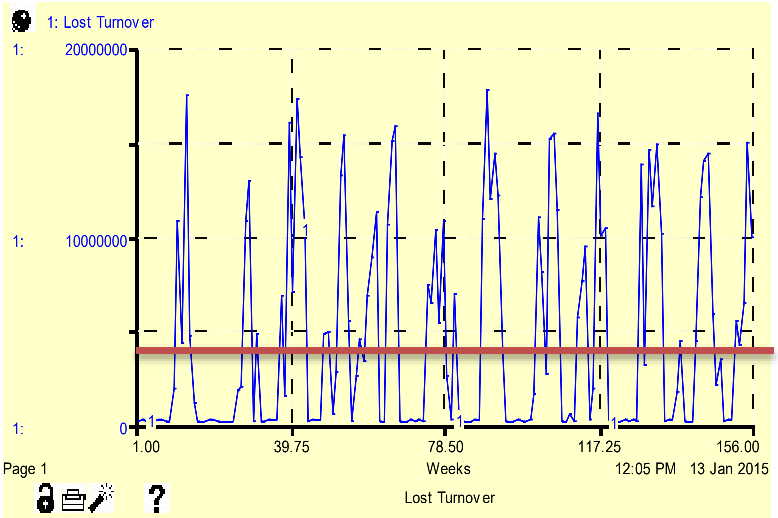


Scenario 3

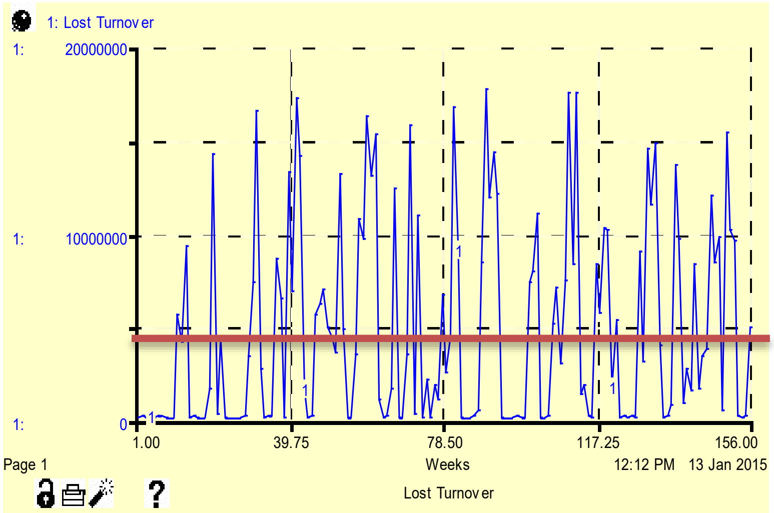


Scenario 3: Lost Turnover graphs

Base Model



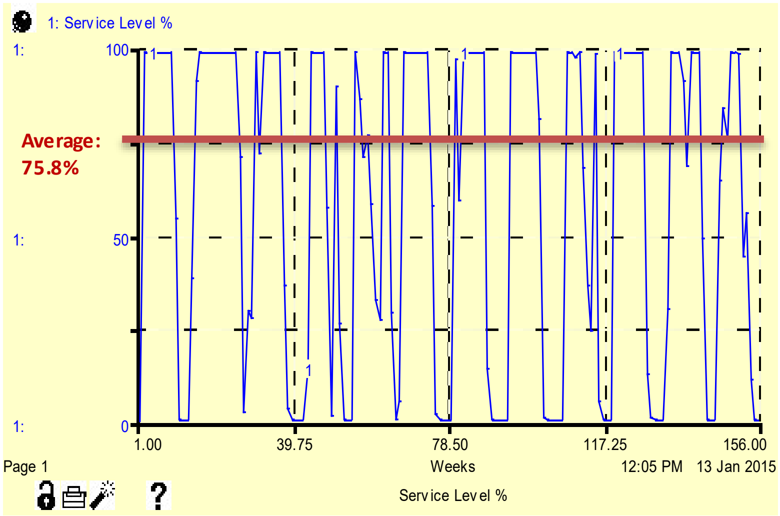
Scenario 3



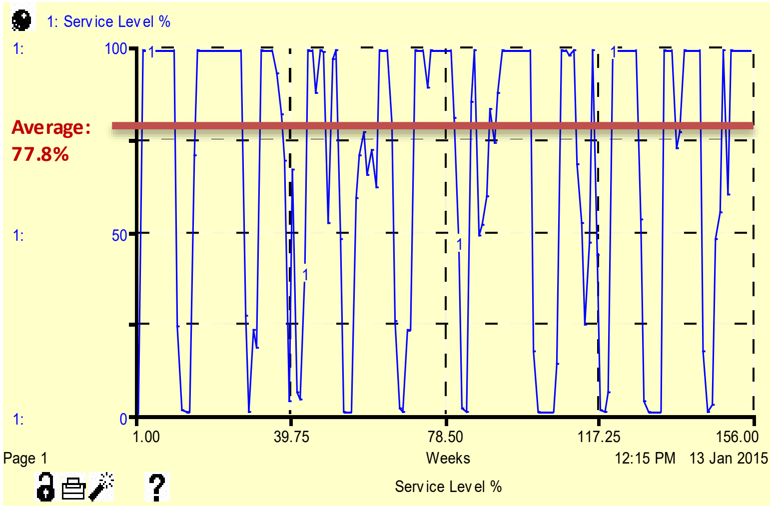
APPENDIX 9: SCENARIO 4 – BEHAVIOUR OVER TIME GRAPHS

Scenario 4: Service level graphs

Base Model

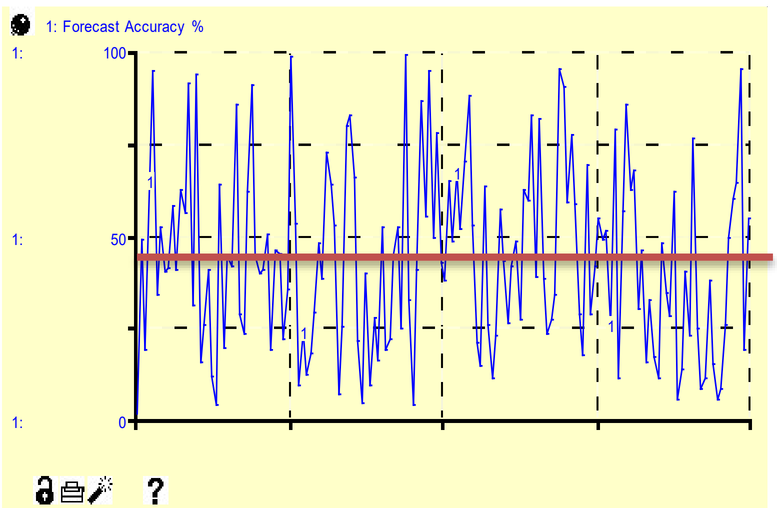


Scenario 4

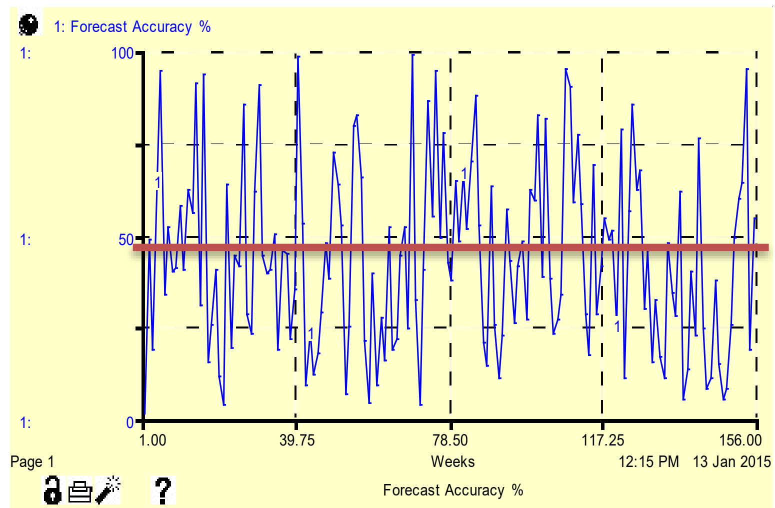


Scenario 4: Forecast accuracy graphs

Base Model

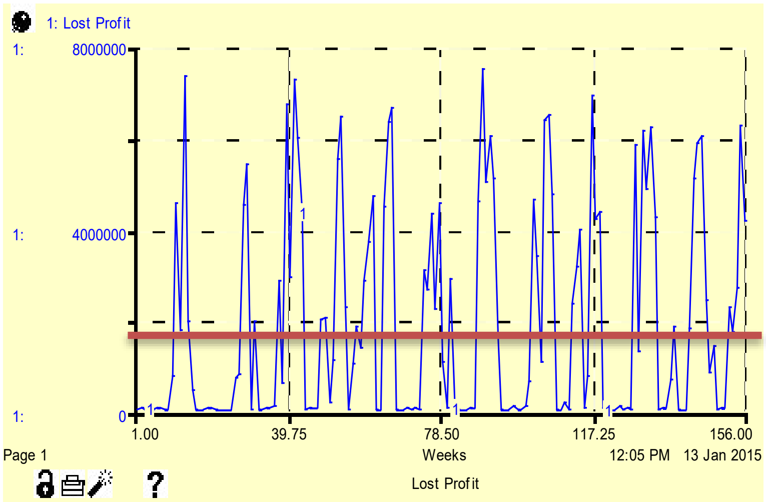


Scenario 4

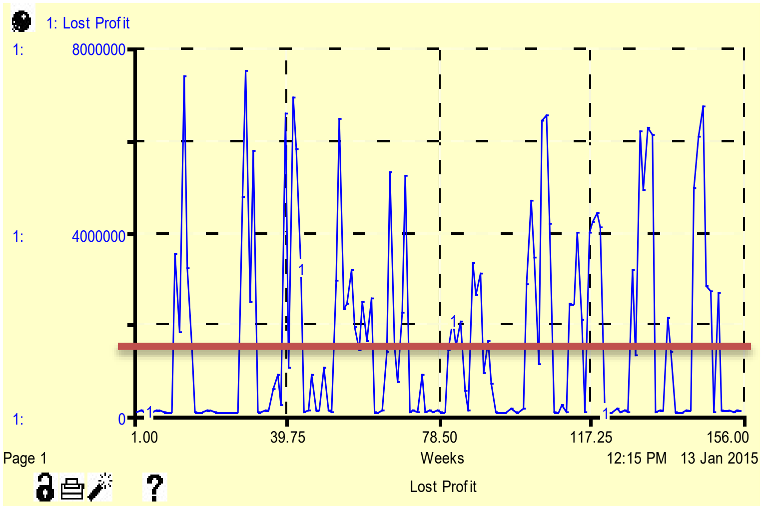


Scenario 4: Lost profit graphs

Base Model

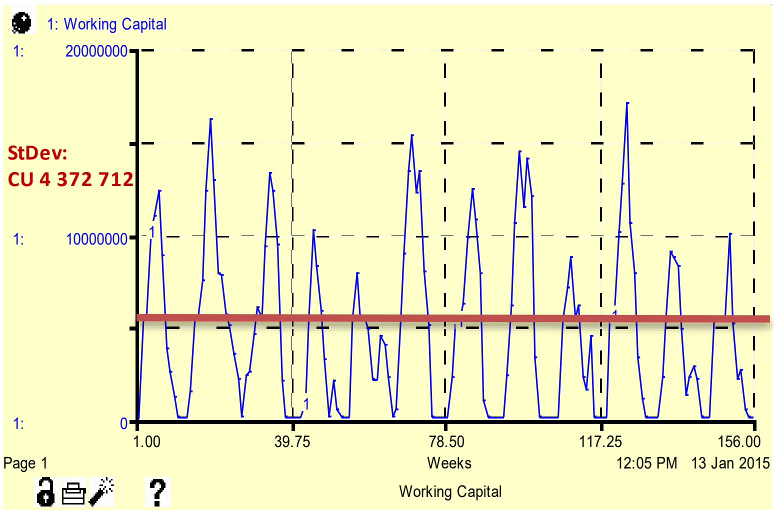


Scenario 4

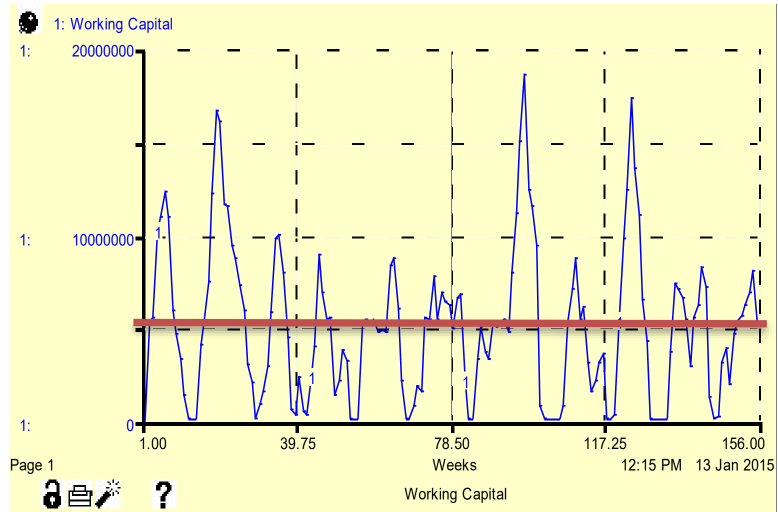


Scenario 4: Working capital graphs

Base Model

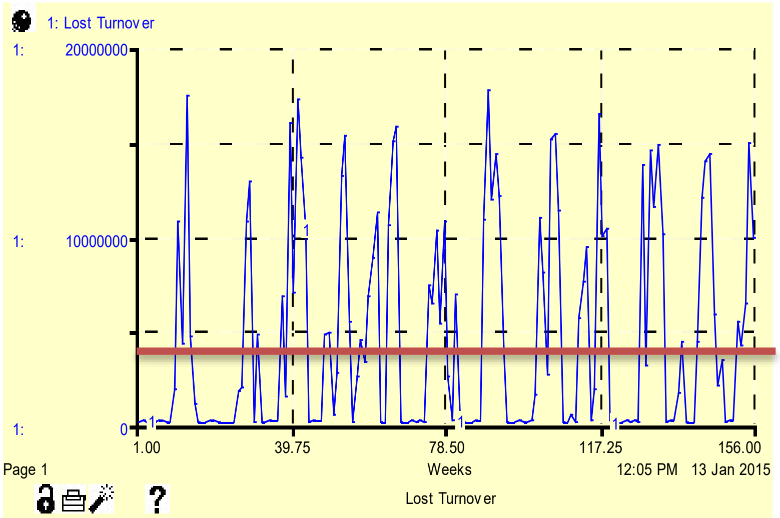


Scenario 4

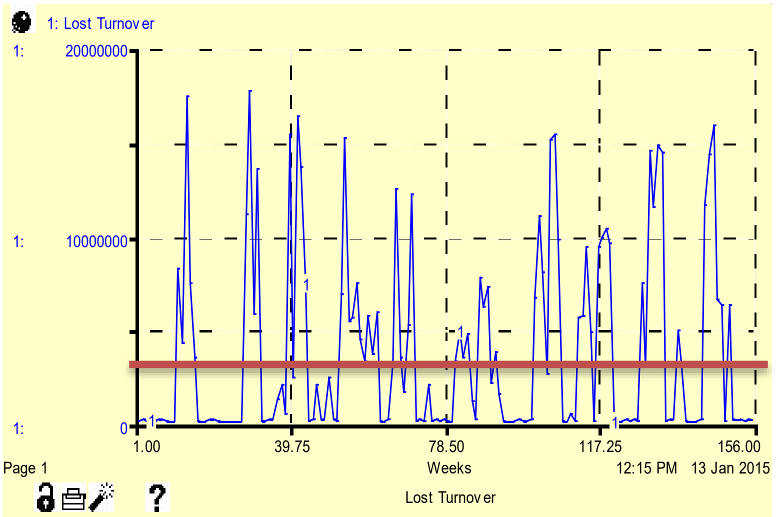


Scenario 4: Lost turnover graphs

Base Model



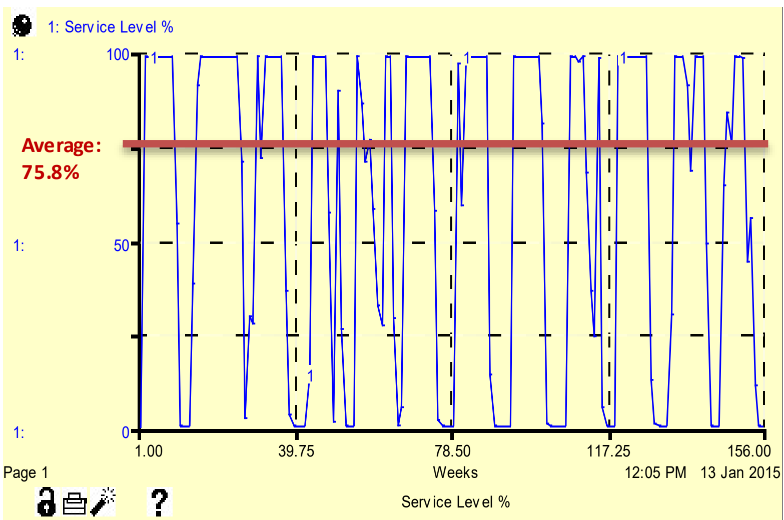
Scenario 4



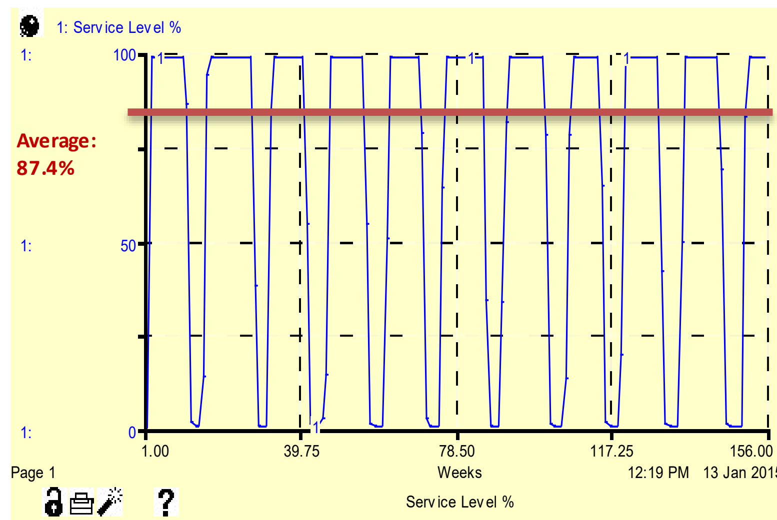
APPENDIX 10: SCENARIO 5 – BEHAVIOUR OVER TIME GRAPHS

Scenario 5: Service level graphs

Base Model

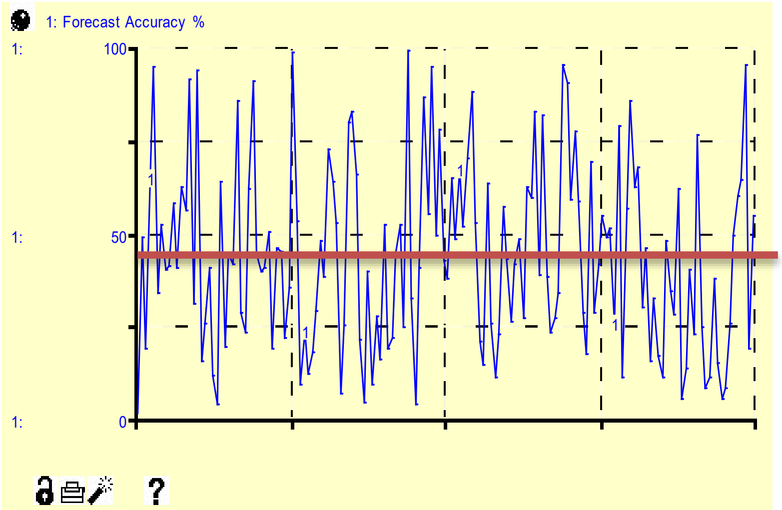


Scenario 5

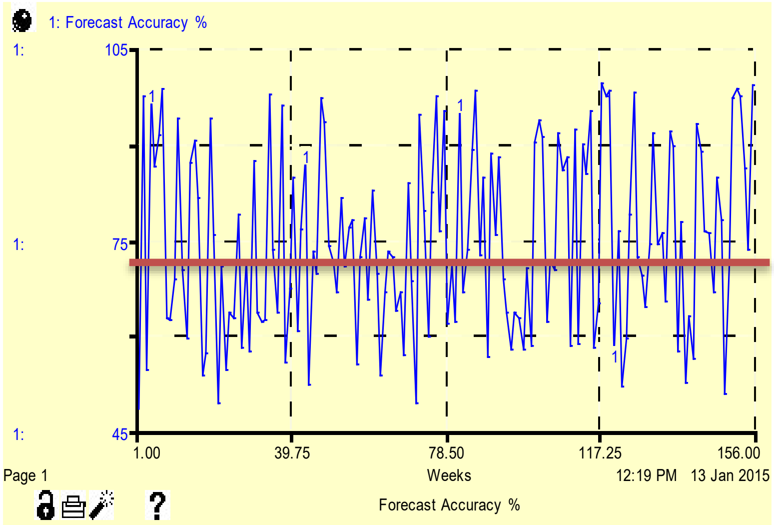


Scenario 5: Forecast accuracy graphs

Base Model



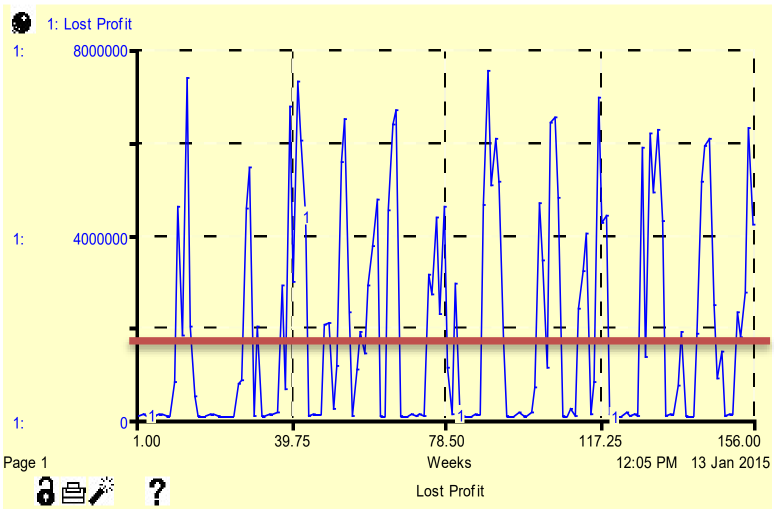
Scenario 5



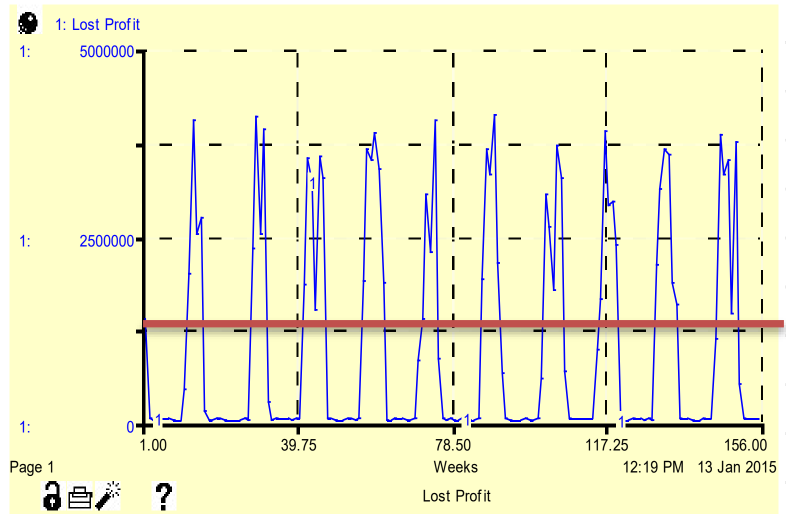
Note that the Y axis between the above base and scenario graphs are not equal

Scenario 5: Lost profit graphs

Base Model



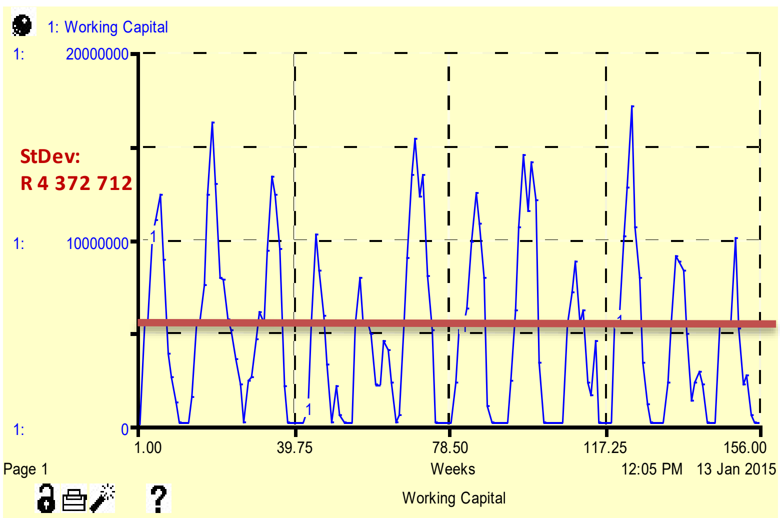
Scenario 5



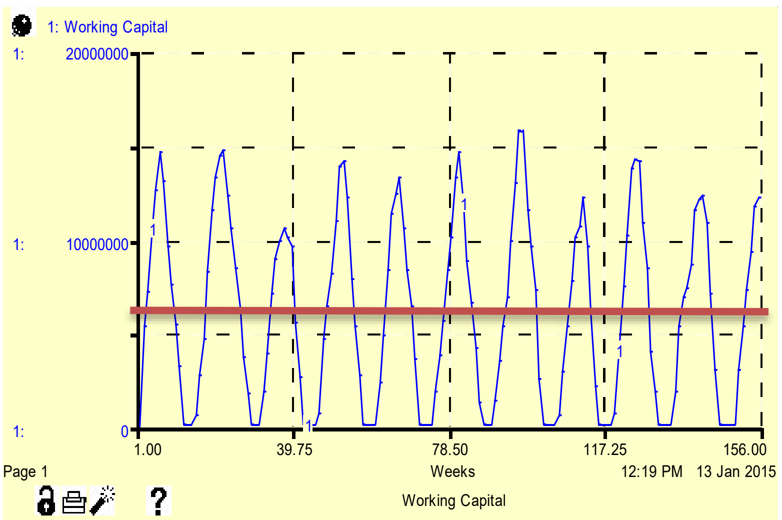
Note that the Y axis between the above base and scenario graphs are not equal

Scenario 5: Working capital graphs

Base Model

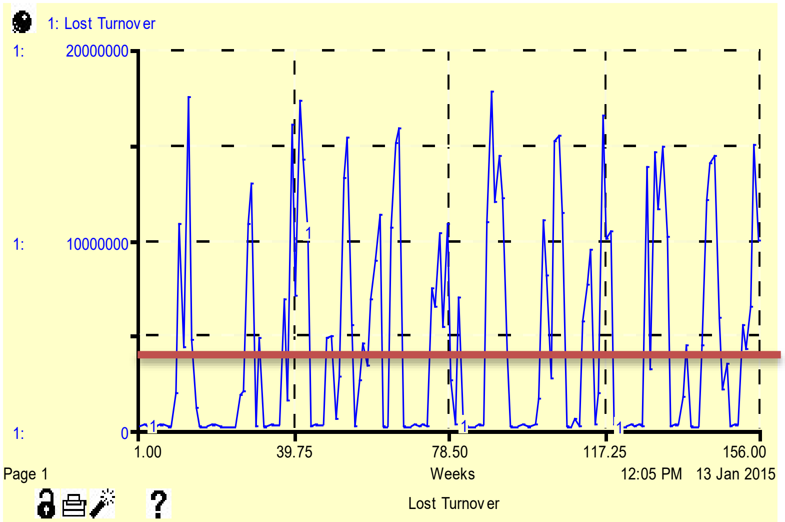


Scenario 5

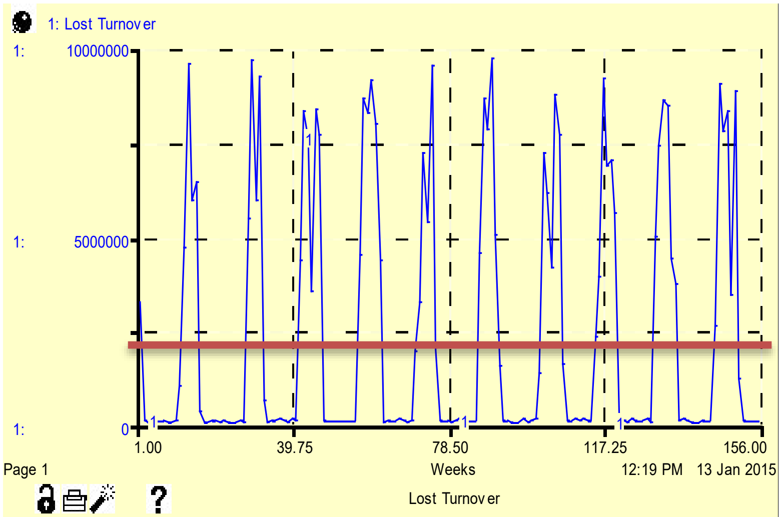


Scenario 5: Lost turnover graphs

Base Model



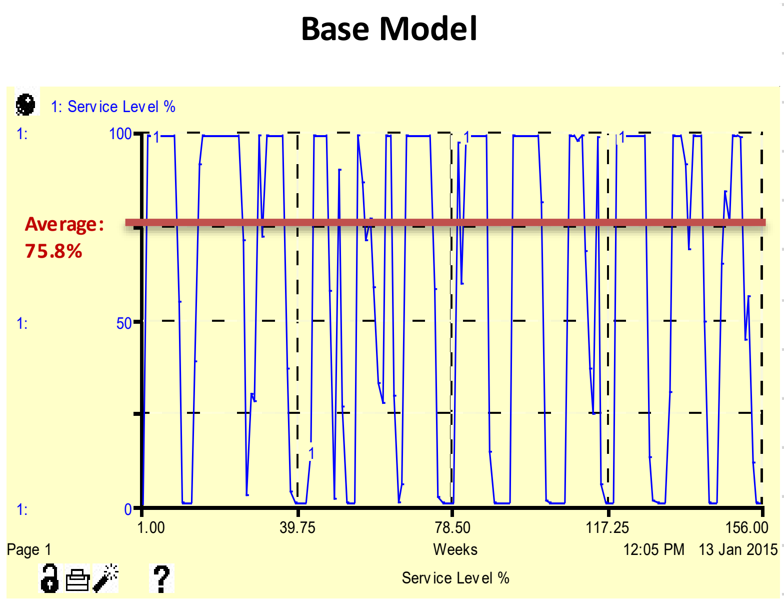
Scenario 5

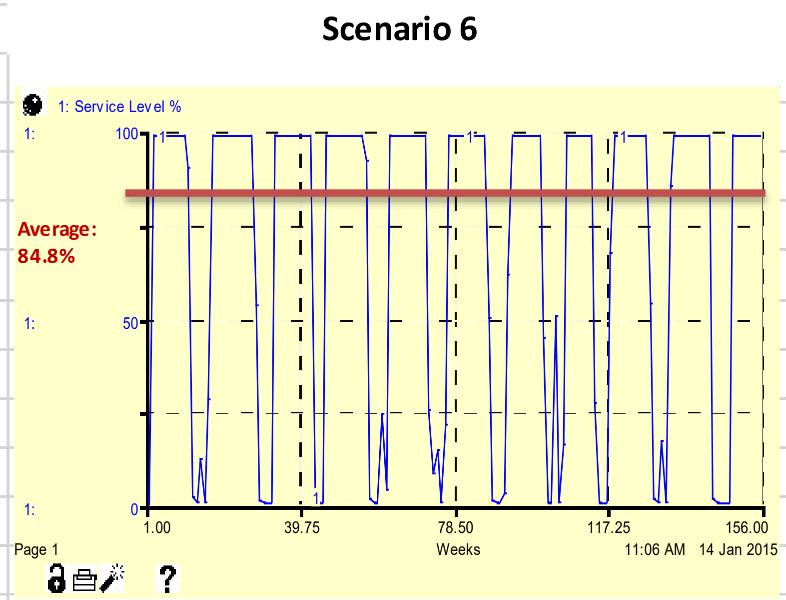


Note that the Y axis between the above base and scenario graphs are not equal

APPENDIX 11: SCENARIO 6 – BEHAVIOUR OVER TIME GRAPHS

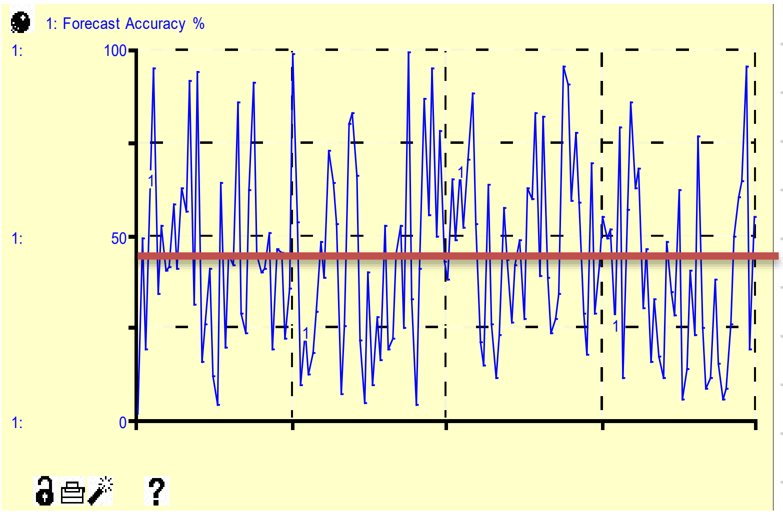
Scenario 6: Service level graphs



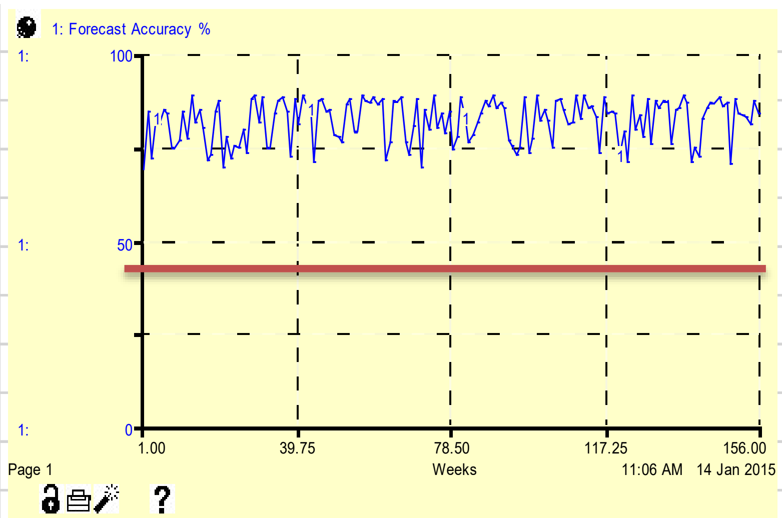


Scenario 6: Forecast accuracy graphs

Base Model

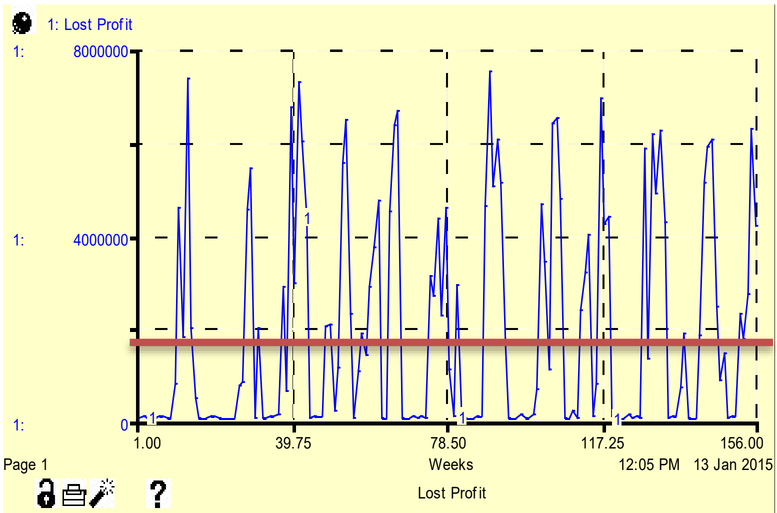


Scenario 6

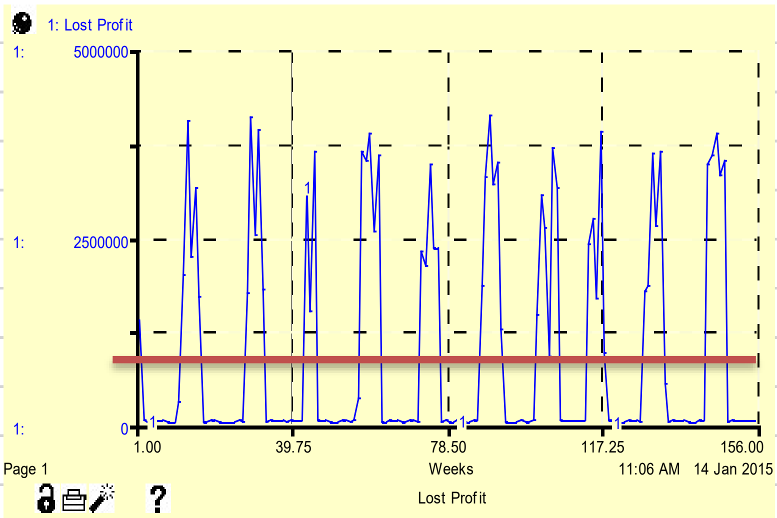


Scenario 6: Lost profit graphs

Base Model



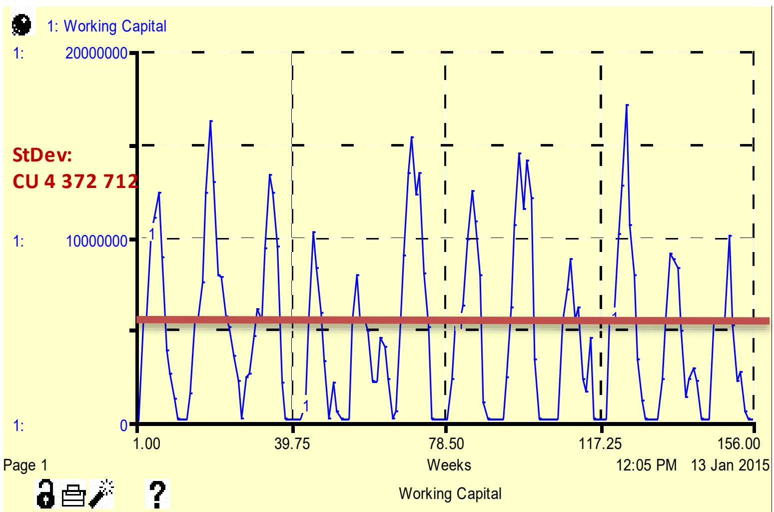
Scenario 6



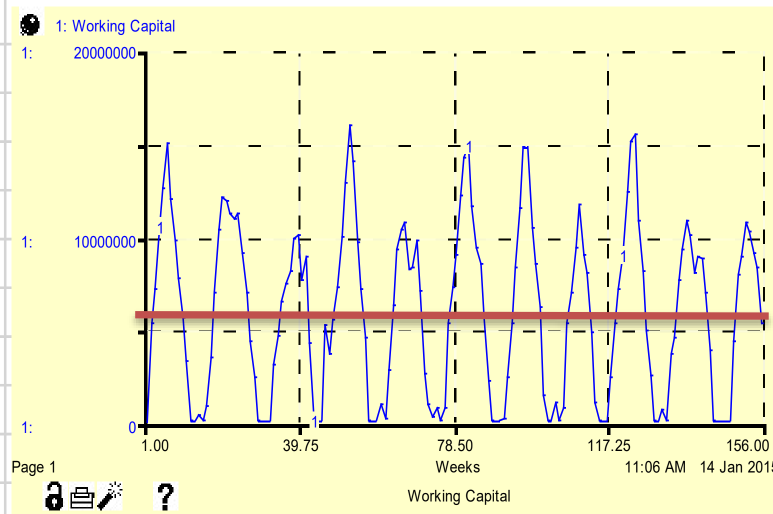
Note that the Y axis between the above base and scenario graphs are not equal

Scenario 6: Working capital graphs

Base Model

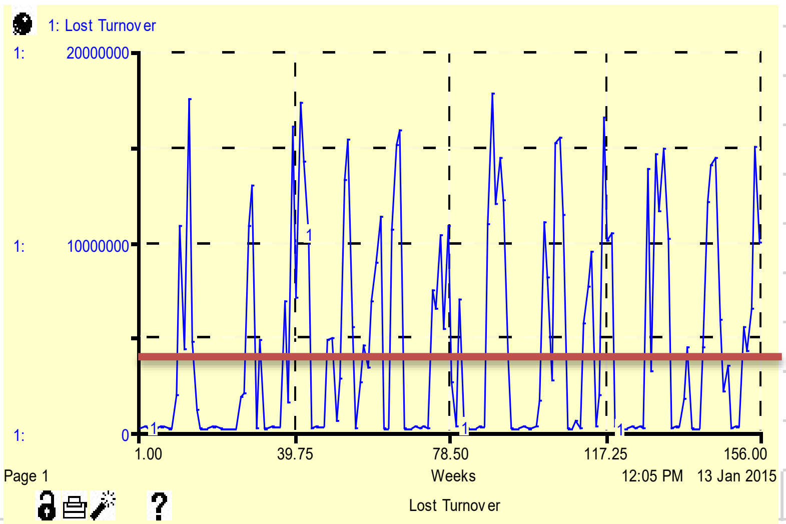


Scenario 6

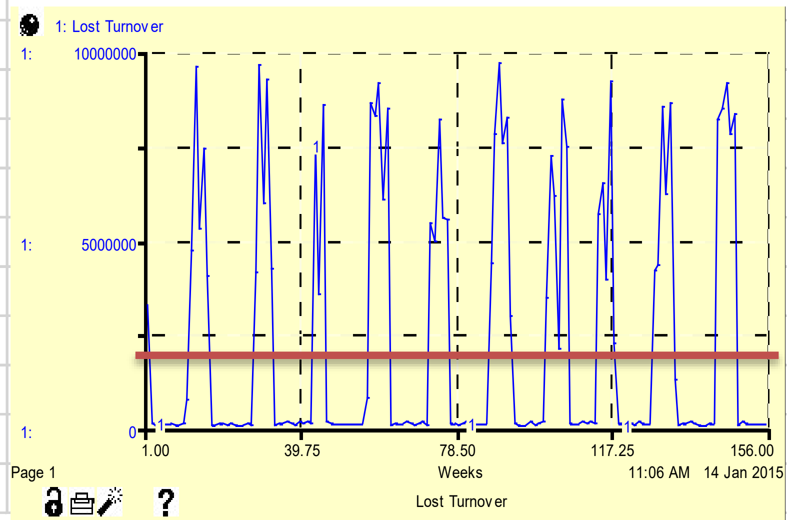


Scenario 6: Lost turnover graphs

Base Model



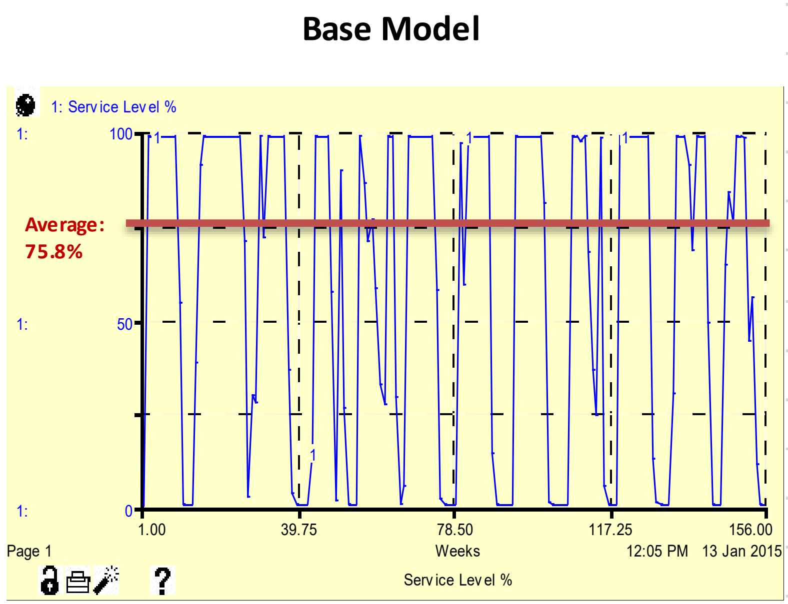
Scenario 6

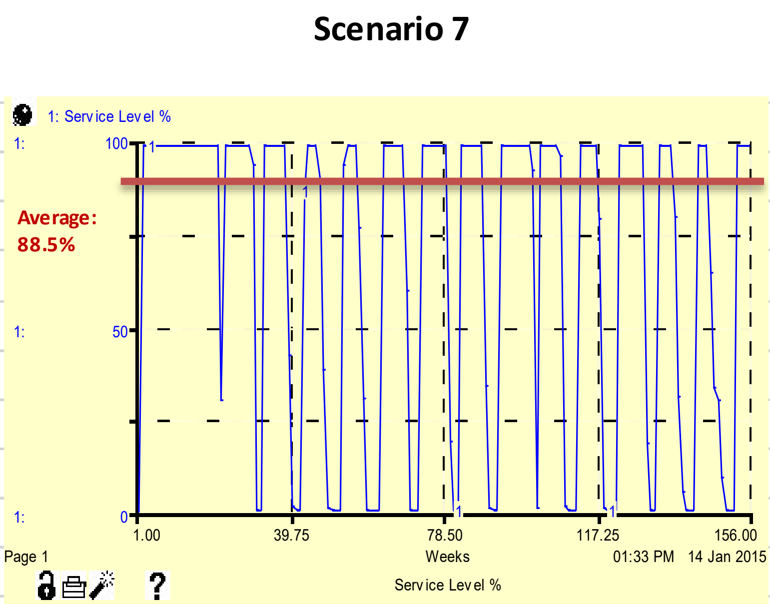


Note that the Y axis between the above base and scenario graphs are not equal

APPENDIX 12: SCENARIO 7 – BEHAVIOUR OVER TIME GRAPHS

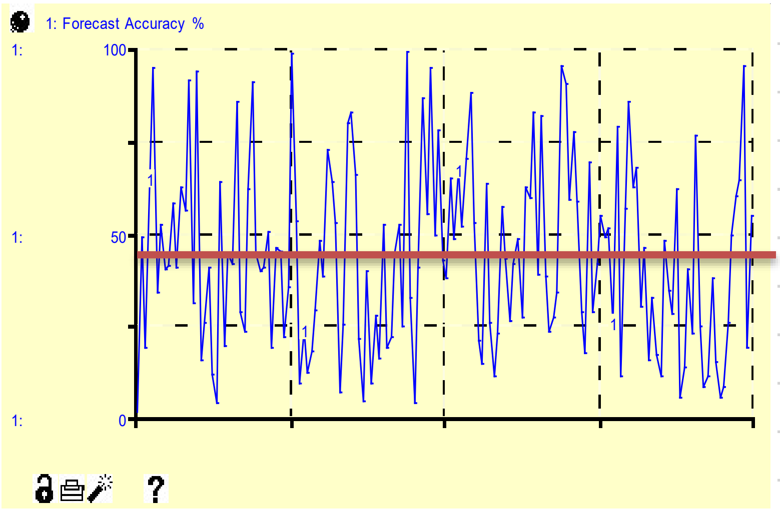
Scenario 7: Service level graphs



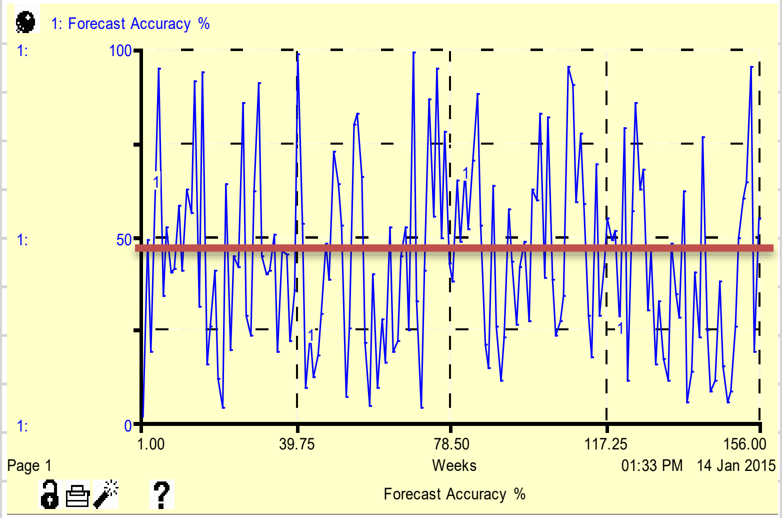


Scenario 7: Forecast accuracy graphs

Base Model

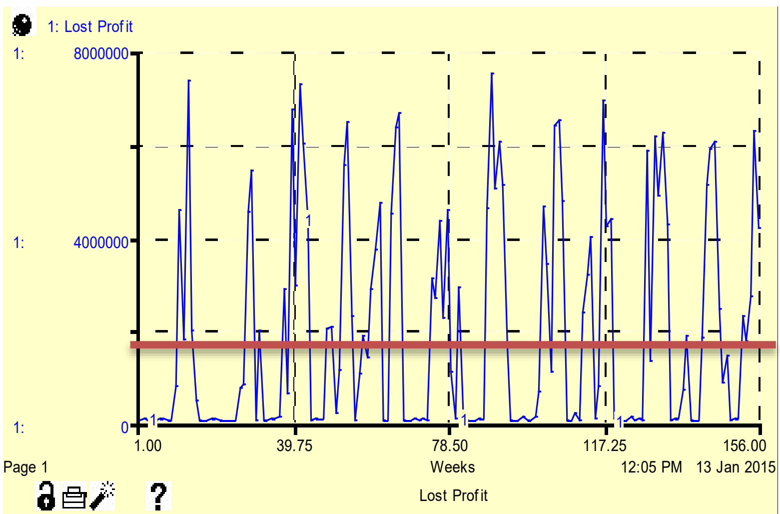


Scenario 7

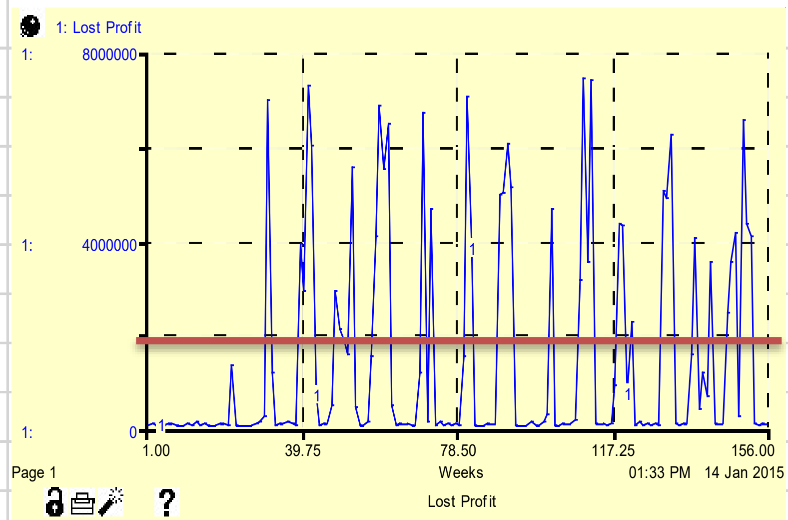


Scenario 7: Lost profit graphs

Base Model

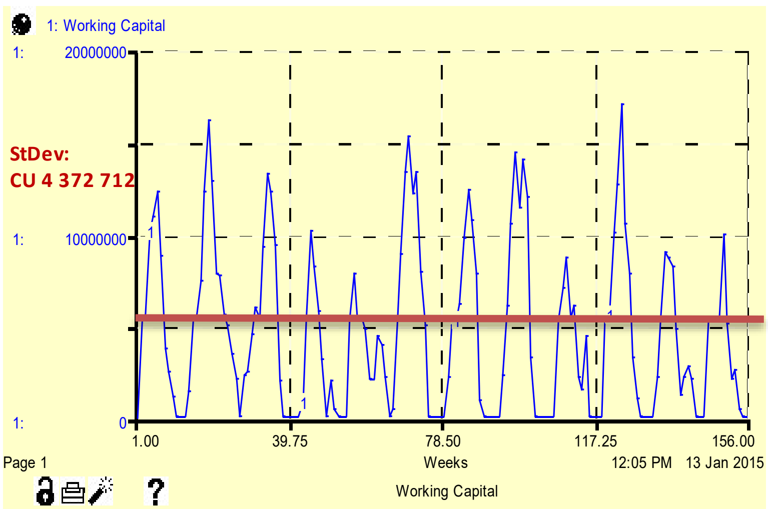


Scenario 7

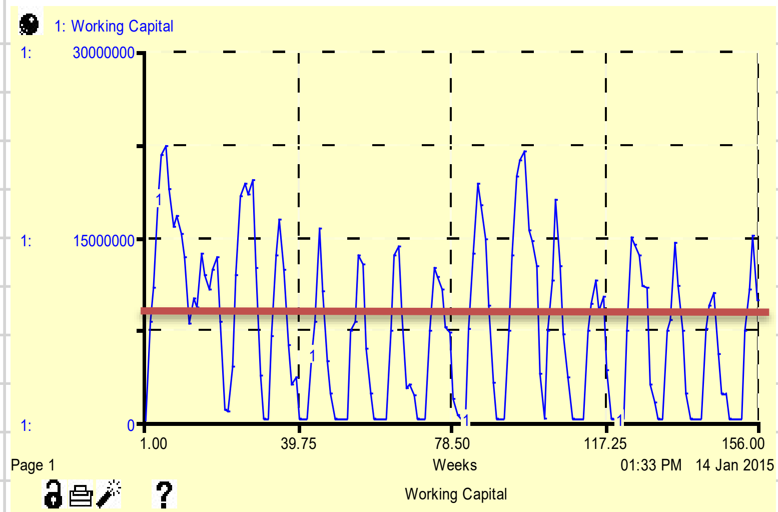


Scenario 7: Working capital graphs

Base Model

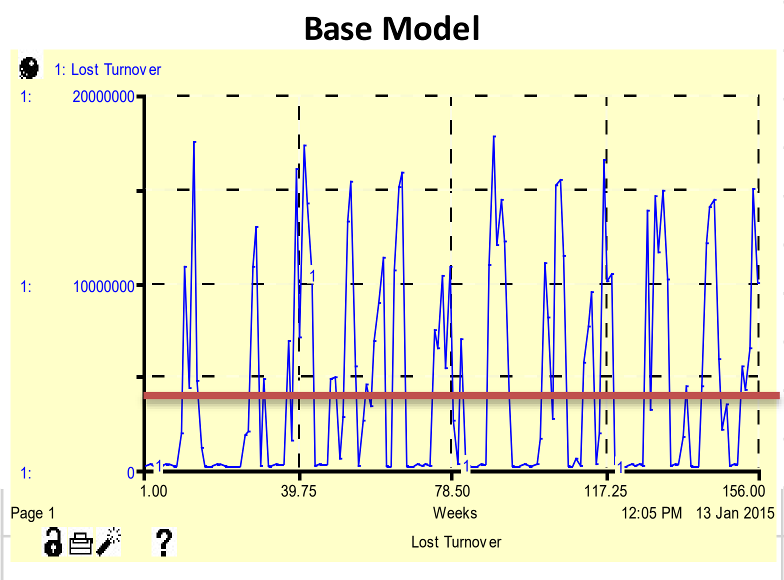


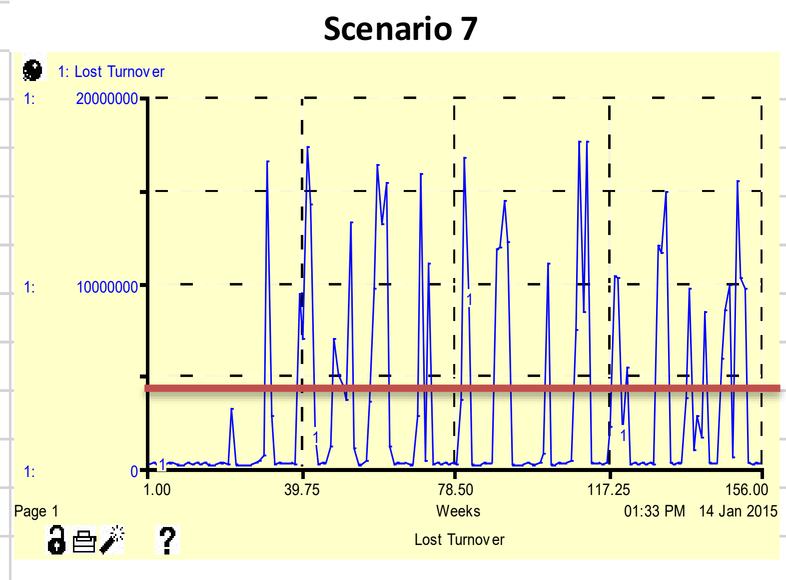
Scenario 7



Note that the Y axis between the above base and scenario graphs are not equal

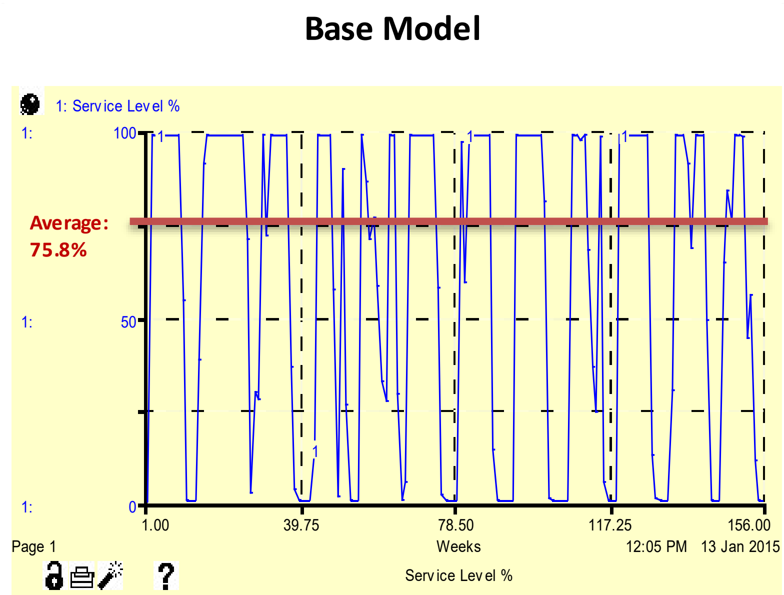
Scenario 7: Lost turnover graphs

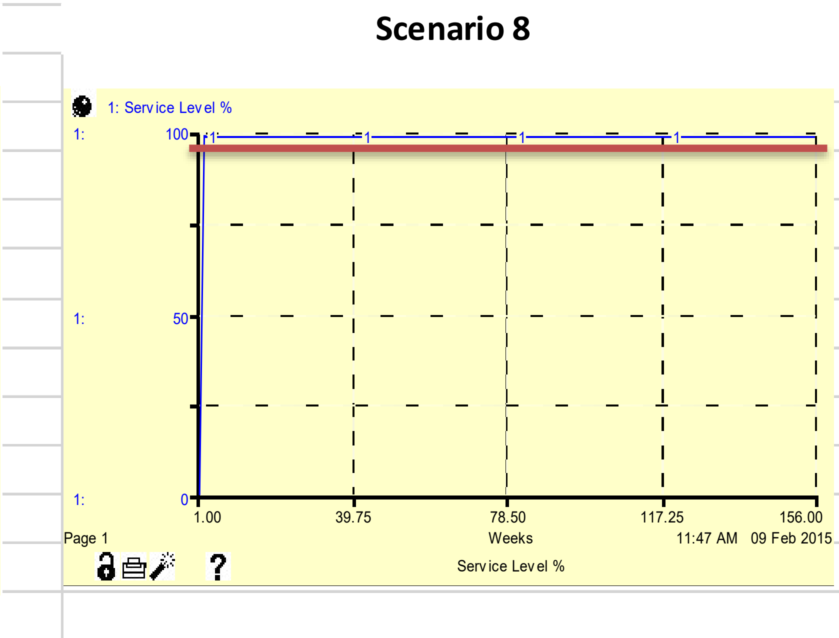




APPENDIX 13: SCENARIO 8 – BEHAVIOUR OVER TIME GRAPHS

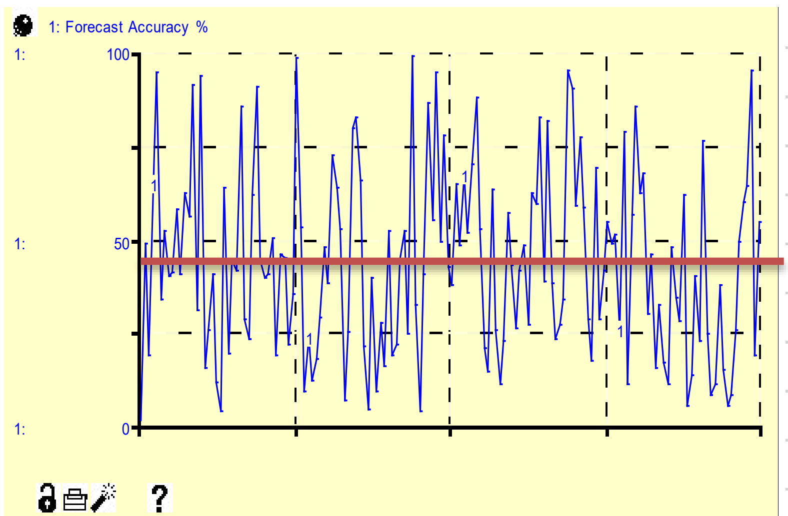
Scenario 8: Service level graphs



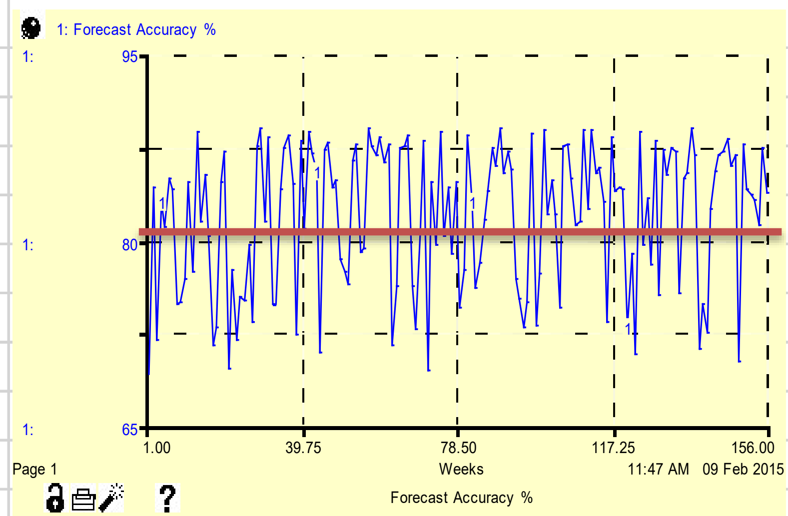


Scenario 8: Forecast accuracy graphs

Base Model



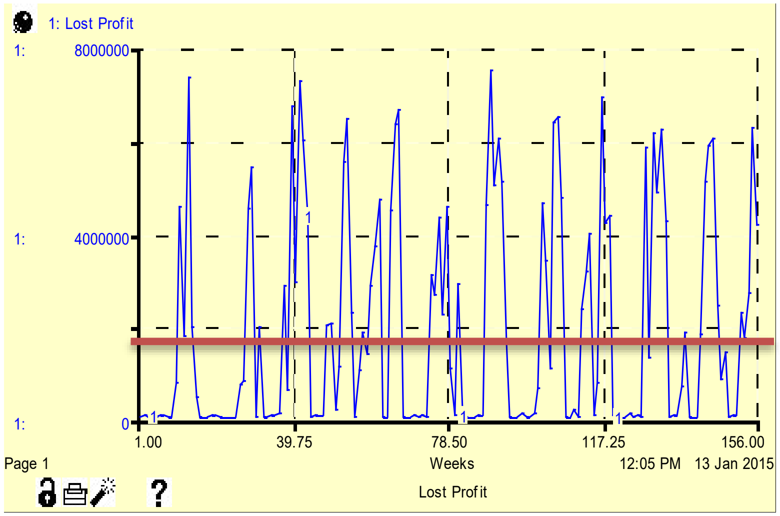
Scenario 8



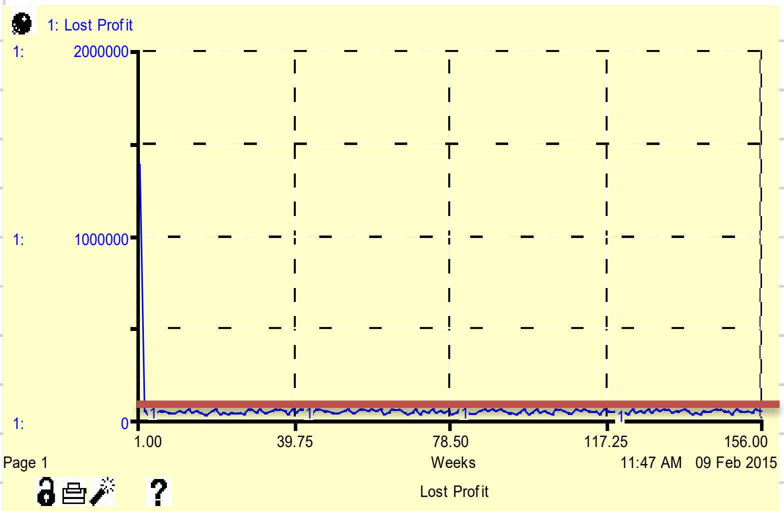
Note that the Y axis between the above base and scenario graphs are not equal

Scenario 8: Lost profit graphs

Base Model

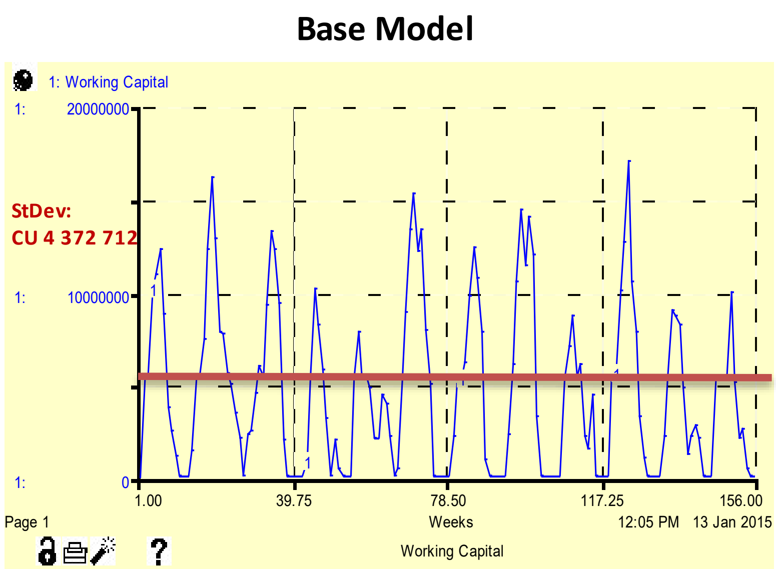


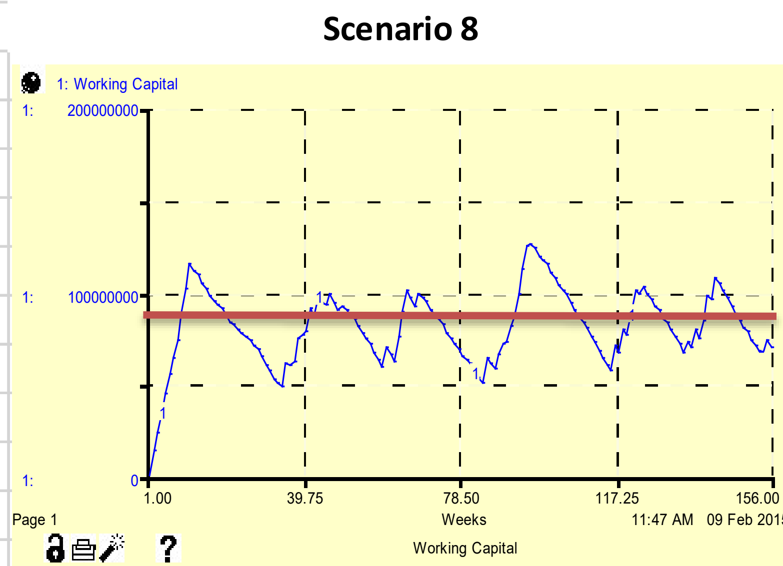
Scenario 8



Note that the Y axis between the above base and scenario graphs are not equal

Scenario 8: Working capital graphs

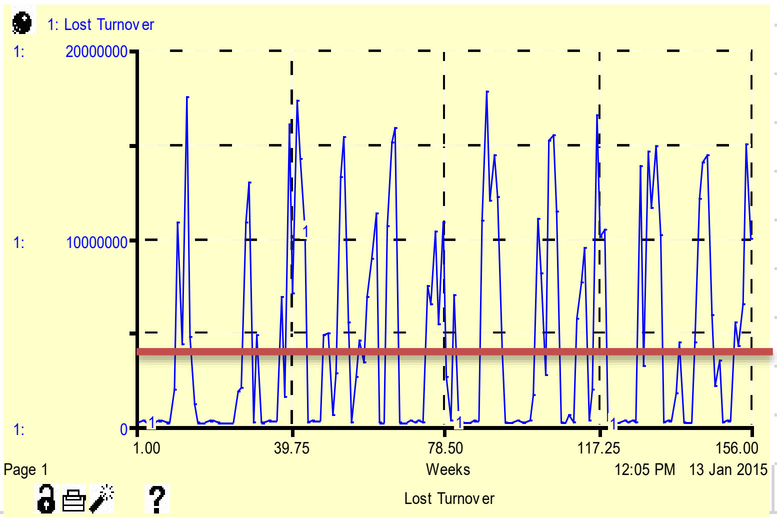




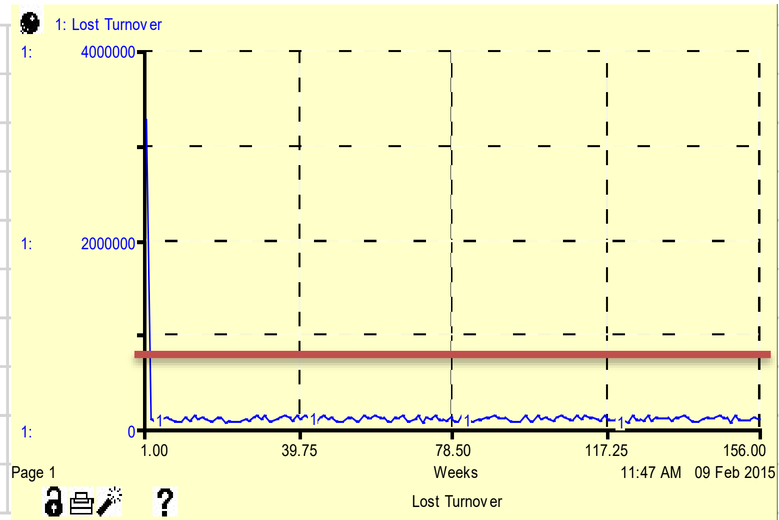
Note that the Y axis between the above base and scenario graphs are not equal

Scenario 8: Lost turnover graphs

Base Model



Scenario 8



Note that the Y axis between the above base and scenario graphs are not equal

APPENDIX 14: SYSTEM DYNAMICS MODEL

APPENDIX 15: SYSTEM DYNAMICS MODEL EQUATIONS

SECTOR: CUSTOMER ORDERING

customer_order_placement = INT(RANDOM(697,229894,12))

inventory_check = INVENTORY_LEVEL-customer_order_placement

order_confirmation = IF(inventory_check>0)THEN customer_order_placement ELSE INVENTORY_LEVEL

SECTOR: DEMAND

base = POISSON(78540,12)

forecast = POISSON(forecast_accumulation,12)

forecast_accumulation = base+innovations+promotions

innovations = POISSON(4363,12)

promotions = POISSON(4363,12)

SECTOR: DISTRIBUTION

customer__deliveries1 = DELAY(order_confirmation*distribution_service_loss*standard_deliveries, lead_time)

customer__deliveries_2 = DELAY(order_confirmation*distribution_service_loss*special_deliveries, lead_time_2)

distribution_service_loss = 0.989

lead_time = loading_and_delivery+transport_planning+warehouse_lead_time

lead_time_2 = loading_and_delivery_2+transport_planning_2+warehouse_lead_time_2

loading_and_delivery = 0.07

loading_and_delivery_2 = 0.07

special_deliveries = 0.05

standard_deliveries = 0.95

transport_planning = 0.14

transport_planning_2 = 0.07

warehouse_lead_time = 0.14

warehouse_lead_time_2 = 0.07

SECTOR: FACTORY

capacity = 140000

output_reliability = 0.97

SECTOR: MANAGEMENT INFORMATION

Absolute_varIance = ABS(variance)

Forecast_accuracy = (forecast-Absolute_varIance)/forecast

Forecast_Accuracy_% = ABS(forecast_accuracy*100)

Lost_Profit = lost_sale_in_units*lost_profit_per_unit

lost_profit_per_unit = 33

lost_sale_in_units = customer_order_placement-Customer_Deliveries lost_sale_in_units_2 = customer_order_placement-Customer_Deliveries

Lost_Turnover = lost_sale_in_units_2*turnover_per_unit

Service_Level_% = (Customer_Deliveries/customer_order_placement)*100

turnover_per_unit = 78

Value_per_unit = 39

variance = forecast-customer_order_placement

Working_Capital = Value_per_unit*INVENTORY_LEVEL

SECTOR: ORGANISATION FOCUS

INVENTORY_LEVEL(t) = INVENTORY_LEVEL(t - dt) + (Producing - Customer_Deliveries) *

dtINIT INVENTORY_LEVEL = 0

INFLOWS:

Producing = DELAY(final_production_plan*output_reliability,3)

OUTFLOWS:

Customer_Deliveries = customer__deliveries1+customer__deliveries_2

SECTOR: PROCUREMENT

SUPPLIER_MATERIAL_INVENTORY(t) =
SUPPLIER_MATERIAL_INVENTORY(t - dt) + (Producing__Material –

Organisational_orders_and_delivery) * dtINIT
SUPPLIER_MATERIAL_INVENTORY = 349067

INFLOWS:

Producing__Material =
DELAY(final_supplier__production_plan*internal__reliability,3)

OUTFLOWS:

Organisational_orders_and_delivery = DELAY(material_despatch,3)

final_supplier__production_plan =
IF(production_plan>supplier_capacity)THEN(production_plan)ELSE (supplier_capacity)

internal__reliability = 0.55

inventory_holding_target = forecast*inventory_target_in__weeks

inventory_target_in__weeks = 4

material_check = SUPPLIER_MATERIAL_INVENTORY-
production_plan_material__calloff

material_despatch = IF(material_check>0)THEN production_plan_material__calloff
ELSE SUPPLIER_MATERIAL_INVENTORY

material_not__supplied = production_plan_material__calloff-
SUPPLIER_MATERIAL_INVENTORY

production_plan = IF (supplier_absolute>0) THEN (supplier_absolute) ELSE 0

production_plan_material__calloff = first_production_plan supplier_absolute = IF(supplier_production_trigger<0) THEN (ABS(supplier_production_trigger)) ELSE 0

supplier_capacity = 100000

supplier_production_trigger = SUPPLIER_MATERIAL_INVENTORY-inventory_holding_target

SECTOR: SUPPLY PLANNING

Absolute = IF(production_plan_trigger<0) THEN (ABS(production_plan_trigger)) ELSE 0

final_production_plan = IF(second_production_plan<capacity)THEN(second_production_plan)ELSE (capacity)

first_production_plan = IF (Absolute>0) THEN (Absolute) ELSE 0

production_plan_trigger = INVENTORY_LEVEL - required_inventory_based_on__target_&_forecast

required_inventory_based_on__target_&_forecast = target_weeks_cover*forecast

second_production_plan =

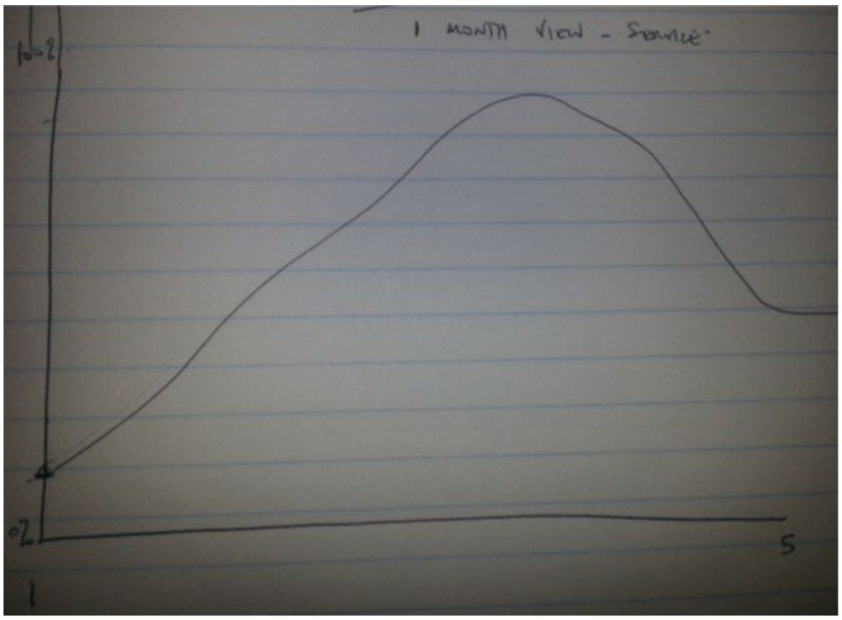
IF(first_production_plan<=Organisational_orders_and_delivery)THEN(first_production_plan)ELSE(Organisational_orders_and_delivery)

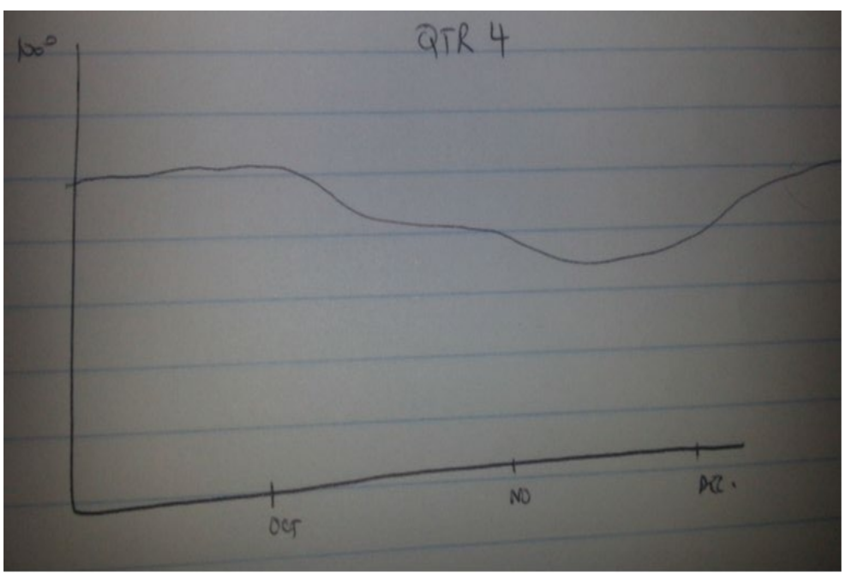
target_weeks_cover = 3

APPENDIX 16: BEHAVIOUR OVER TIME GRAPHS DRAFTED BY INDIVIDUALS

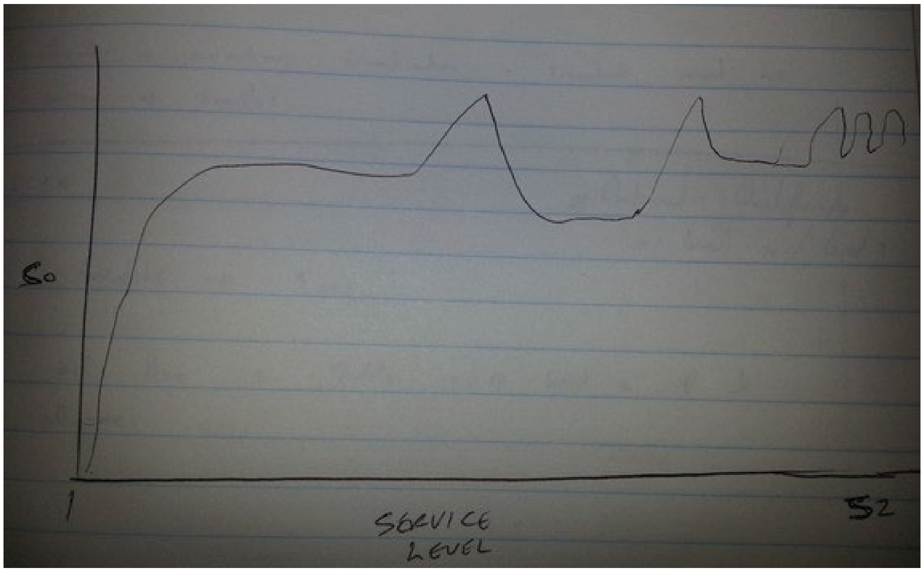
Graphs obtained from certain individuals within the customer service team

Service level:



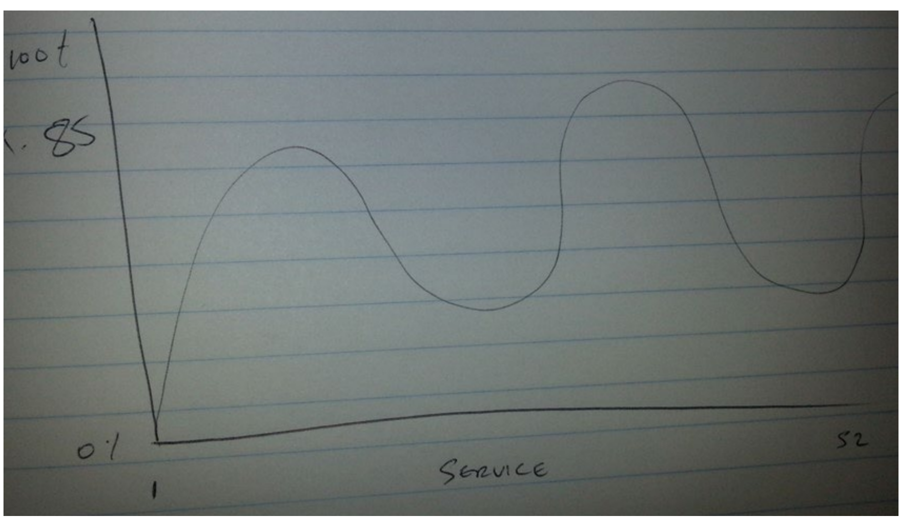


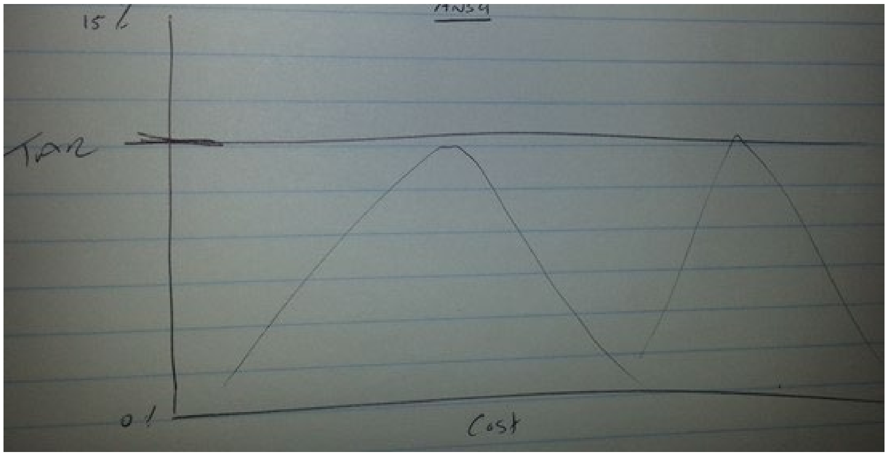
Service level

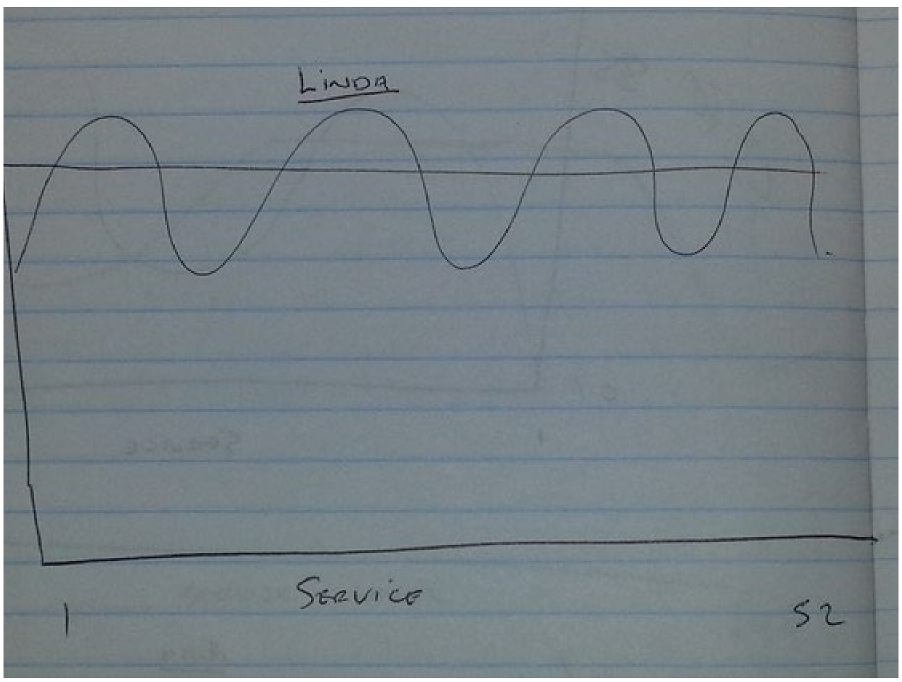


Graphs obtained from certain individuals within the distribution team

Service level:

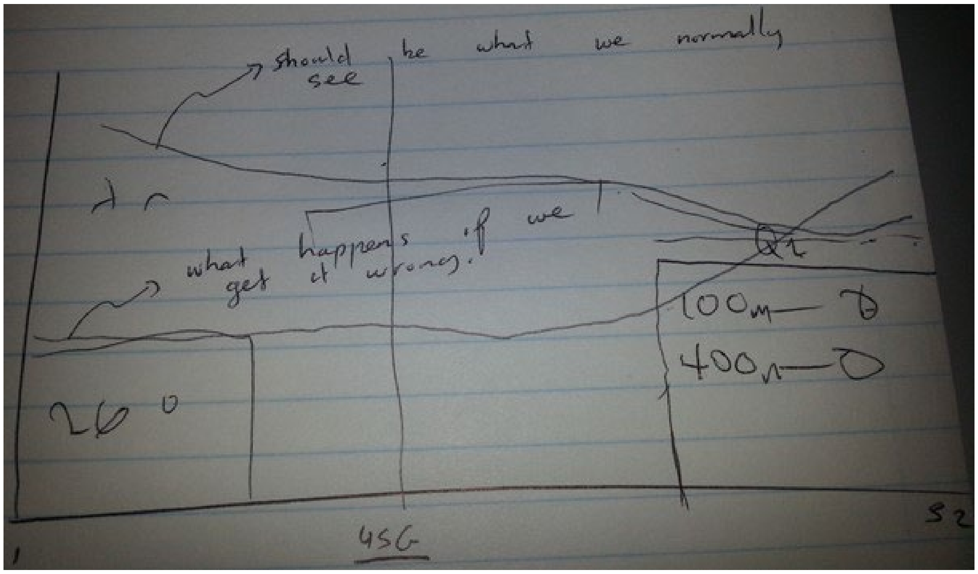



ANSG
15%
TAR
0%
Cost


LINDA
SERVICE
1
52

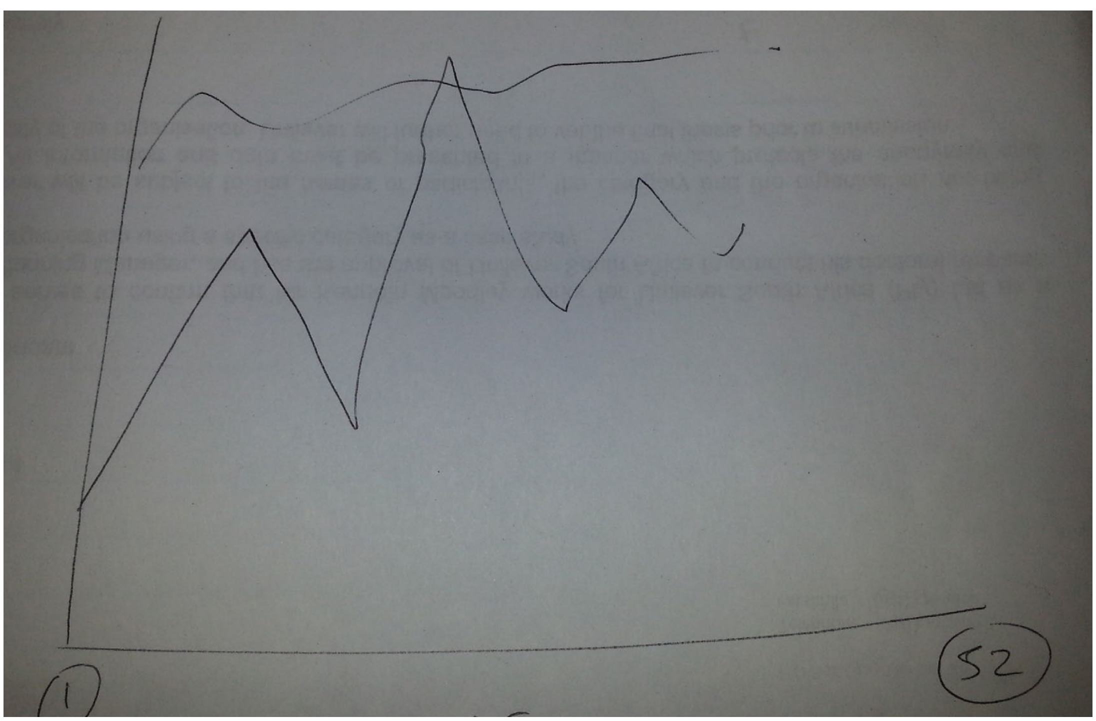
Graphs obtained from certain individuals within the finance team

Sales profile:



Graphs obtained from certain individuals within the procurement team

Service level:



Graphs obtained from certain individuals within the planning team

Service level: