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The influence of Lean thinking on organisational structure and behaviour in the discrete manufacturing industry

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Abstract

Following a Lean transformation specifically for discrete manufacturing, the organisational structure and behaviour will be profoundly affected. However, how and why this is so has remained unanswered until this research. Lean theory proposes that organisations should restructure along the value stream, however there is no certainty what this implies, and how it can be accomplished. The purpose was to determine new theory that will indicate how and why organisational structures and behaviours will change with Lean transformation. Two discrete manufacturing organisations in South Africa were purposively sampled.

A conceptual framework was utilised at the outset that indicated constructs for the research independent Lean variables and the dependent organisational structure and behaviour variables. Utilising a mixed methodology case study and quantitative multiple linear regression approach, hypotheses and propositions were developed.

The findings confirmed that a flat structure consisting of business units supporting manufacturing cells achieve effective Lean transformations for discrete manufacturing organisations. The components of an effective Lean structure were revealed, as open constructive leadership, an effective Lean champions unit, business units that support linked manufacturing cells led by cell leaders, who cultivate supportive behaviours through cross-functional teamwork and through self-directed work teams who run manufacturing cells or flow support functions.

Key phrases

discrete manufacturing, Lean thinking; organisational behaviour; organisational structure

1. INTRODUCTION

Lean theory development stretches over four decades, from the Japanese organisation Toyota's turnaround (Ōhno 1988:17-44) in the 1970's and the subsequent study of the Toyota Production System (TPS) in 1990 (Womack & Jones 2007:15-47). This was followed by a clarification of the theory in 1996 (Womack & Jones 2003:15-28). Since inception Western organisations have attempted to emulate Toyota's manufacturing processes to transform their organisations. Although remarkable achievements of organisational transformations with marked organisational performance improvements have been cited (Lander 2007:173-184; Womack & Jones 2003:103-246), the success rates of Lean implementations remain in contention (Cooper 2011:164).

Approaches for Lean success comprise implementation frameworks (Quarterman 2007:14-19), Lean applications such as ***Heijunka*** (Jones 2006:29-35), value stream mapping (Lander 2007:528; Rother & Shook 2003:3-105), organisational behavioural issues (Pinheiro 2010:28; Sawhney & Chason 2005:77), management and leadership issues (Johnson 2009:10) and organisational culture (Gander 2009:105).

An extensive literature review spanning the period 2003 to 2015 revealed only two studies dealing directly with Lean implementation and organisational structure (Haug 2008; O'Carroll 2004) and 14 studies dealing directly with Lean implementation and organisational behaviour.

In this context, the following sections discuss the literature reviewed followed by a discussion of the research problem, concept, questions, and methodology. The findings are discussed and future work suggestions conclude the article.

1.1 Literature review

The literature review considers the extent of literature of how a Lean transformation, covering the Lean principles identified by Womack and Jones (2003:15-28) of specifying value, identifying the value stream, creating continuous flow, establishing pull and working to achieve perfection, will affect discrete manufacturing organisational structure and behaviour. For effective Lean transformations twenty Lean techniques have been identified for implementation, based on definitions (Ōhno 1988:1-44; 121-130; Quarterman 2007:14-19; Womack & Jones 2003:347-353). These techniques are defined in Table 1.

TABLE 1: Twenty Lean techniques and their definitions

Technique	Definition
Hoshin Kanri	Policy deployment with strategy formulation shared with employees (Womack & Jones 2003:347-353).
Kaizen	Continuous improvement with employee involvement (Womack & Jones 2003:347-353).
Problem solving	A formal and consistent approach adopted by an organisation to resolve organisational problems (Womack & Jones 2003:347-353).
Seven wastes	Guidelines to eliminate all wastes from the organisation namely: transportation; inventory; over-production; waiting; and queuing; over-processing and unnecessary motion or movement (Ōhno 1988:1-44).
Defining value from customer viewpoint	Work content that the customer is willing to pay for (Womack & Jones 2003:347-353).
Five-S	Clean-up programme for the organisation designated five S, meaning to sort, set in order, shine, standardise and sustain (Womack & Jones 2003:347-353).
Standard work	Standard operating practices or procedures or SOPs that define the key processes of the organisation (Womack & Jones 2003:347-353).
Teamwork with total employee involvement	Employees working together in teams in a consistent manner applying Lean techniques to continuously improve the organisation (Ōhno 1988:1-44).
Total productive maintenance (TPM)	A management planning and control system that has as its purpose the overall care of plant, equipment and services, with the main objective being zero downtime with total employee involvement (Womack & Jones 2003:347-353).
Visibility	Visual management as an effective means of controlling and communicating results and progress made on the shop floor (Womack & Jones 2003:347-353).
Cycle time reduction	An ongoing approach to reduce the times that activities and tasks take in the organisation (Ōhno 1988:1-44).
Single piece flow	An ongoing approach to reduce batch production on the basis of customer orders one then make only one (Ōhno 1988:1-44).
Single minute exchange of die (SMED)	An ongoing approach to reduce the time it takes to set a machine for a production run with objective to reduce the set up time to less than 10

Technique	Definition
	minutes (Ōhno 1988:1-44).
Kanban	Cards issued or areas designated to control work flow from inception to finalisation with down stream operations signaling upstream operations to provide the work to be processed (Ōhno 1988:1-44).
Designing for quality per Taguchi	An ongoing process to design quality into the product before and during manufacture (Todd 1995:310-312).
Poka Joke	Japanese word that means mistake proofing, meaning that operations are designed not to go wrong (Ōhno 1988:1-44).
Jidoka	Japanese word meaning that Inspection is built into the process. The machine inspects the work automatically (Ōhno 1988:1-44).
Heijunka	Japanese word meaning that the workload is level scheduled to a manufacturing cell, paced to average customer demand (Womack & Jones 2003:347-353).
Policy deployment	Organisation's policy, objectives, and goals are shared with all employees, cascaded downwards through the organisation (Womack & Jones 2003:347-353).
Value stream mapping (VSM)	Value stream mapping – a process of mapping the flow on paper, identifying the value and non-value adding activities (Womack & Jones 2003:347-353).

Source: Compiled from literature as indicated

These techniques are utilised as independent variables in this research.

1.2 Lean thinking and organisational structure

Linking Lean with organisational structure, Nahm, Vonderembse and Koufteros (2003:291), identified five constructs for the organisational structure, namely, the number of hierarchical layers; levels of horizontal integration; locus of decision-making; nature of formalisation and level of communication. This is presented in Table 2.

By analysing Haug's (2008:472) work and considering that Lean organisational structures should be developed along the value stream of the organisation, cellular format (in which the structure is aligned to manufacturing cells, being formally recognised as part of the

organisational structure) is added to the constructs (defined characteristics that are measurable in quantitative research)

Organisational functionality is highlighted, characterised by disconnected processes that impede Lean (highly formal departmentalised structures by function that discourage cross functional interaction amongst employees) (Jones, Medlen, Merlo, Robertson & Shepherdson 1999:16; Nahm ***et al.*** 2003:287; 301; O'Carroll 2004:76; Brown, Collins & McCombs 2006:3; Worley & Doolen 2006:243; Haug 2008:471; Hettler 2008:106), however limited literature may be available regarding a solution on how to restructure a discrete manufacturing organisation during Lean implementation.

Restructuring along the value stream appears to be the best option (Jones ***et al***. 1999:16; Nahm ***et al***. 2003:288; Brown ***et al***. 2006:4; Worley & Doolen 2006:243; Hettler 2008:106; Haug 2008:472). However, how and why this should be done remains unanswered.

TABLE 2: The organisational structure constructs

Construct	Definition
Number of hierarchical layers	The degree to which an organisation has many versus few levels of management
Levels of horizontal integration	The degree to which departments and workers are functionally specialised versus integrated in their works, skills, and training
Locus of decision-making	The degree to which decisions are made high versus low in the organisational hierarchy
Nature of formalisation	The degree to which workers are provided with rules and procedures that deprive versus encourage creative, autonomous work and learning
Level of communication	The degree to which vertical and horizontal communications are slow, difficult, and limited versus fast, easy, and abundant versus

Source: Nahm *et al.* 2003:291

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1.3 Organisational behaviour and Lean thinking

Some specific organisational behaviours with Lean point to open, free flowing communications (direct involvement and engagement of employees) and affective commitment (i.e. employees becoming so motivated that they contribute actively with own ideas and actions to continuously improve the organisation) (Angelis, Conti, Cooper & Gill 2011: 572; Bhasin 2011:17; 997; Boyle, Scherrer-Rathje & Stuart 2011:587-283; Cameron-Strother 2009:67; Cooper 2011:113; Gagnon 2004:123; Harris 2007:8; Losonci, Demeter & Jenei 2011:31; Pinheiro 2010:37; Poppendieck 2002:7; Sawhney & Chason 2005:77; Shetty 2011:23; 27; Testani & Ramakrishnan 2011:3; Tress & Espinoza 2012:1-5; Worley & Doolen 2006:231) which feature prominently.

Empowerment is highlighted as a success factor of Lean by Poppendieck (2002:7) and Pinheiro (2010:11). Organisational culture was considered an aspect with Lean transformation by Jones ***et al***. (1999:15); Sawhney and Chason (2005:92); and Gander (2009:105) indicated that the organisational culture will change with Lean resulting in management and employees becoming more team oriented and committed.

Cooper (2011:39) identified the following aspects as key to successful Lean implementations: highly capable leadership; communication channels with effective feedback; the development of collaborative relationships between management and

employees who are well versed in the practice of change management; and understanding how to effect change of culture. He provides reasons for failure as the dismissive relationships between production and industrial engineering employees, and the senior manufacturing engineer undermining the director of operations and the lack of top management support.

Constructive leadership (i.e. a transformational leadership style which include "Humanistic and Encouraging" behaviours, where the leader is sensitive to the needs of others, and help others learn from their mistakes) features strongly in research by Worley and Doolen (2006:228), Johnson (2009:41) and Testani and Ramakrishnan (2011:3). Tress and Espinoza (2012:3) identified that attitudes change positively as Lean is implemented.

Analysis of the literature revealed eight possible constructs as dependent organisational behaviour variables, namely: awareness of a Lean vision, mission values, and organisational goals (Bhasin 2011:17, 997) communication of Lean methodology (Cooper 2011:39); acknowledge of process (Cooper 2011:39); commitment (Angelis ***et al.*** 2011:572; attitude (Tress & Espinoza 2012:3); and respect (Lander 2007:42).

2. RESEARCH PROBLEM

Major uncertainties exist surrounding the question of how discrete manufacturing organisations will be affected once a Lean transformational strategy has been adopted by such organisations. These organisations may be affected in terms of its organisational structure and behaviour; however, a gap exists in the theory.

2.1 Research concept

The research concept as illustrated in Figure 1 where derived from the problem area, the influencing factors, and variables identified from the literature. Figure 1 shows that Lean principles and techniques impact corporate strategy, the organisational transformation, and organisational structure and behaviour. The concept provides for hypotheses and propositions generation. Factors of leadership and corporate culture are accounted.

2.2 Research questions

The research sub-questions are discussed in terms of the proposition generation in Table 3.

The main research questions pertaining specifically to discrete manufacturing organisations were: how and why are the organisational structure and behaviour significantly influenced by Lean implementation?

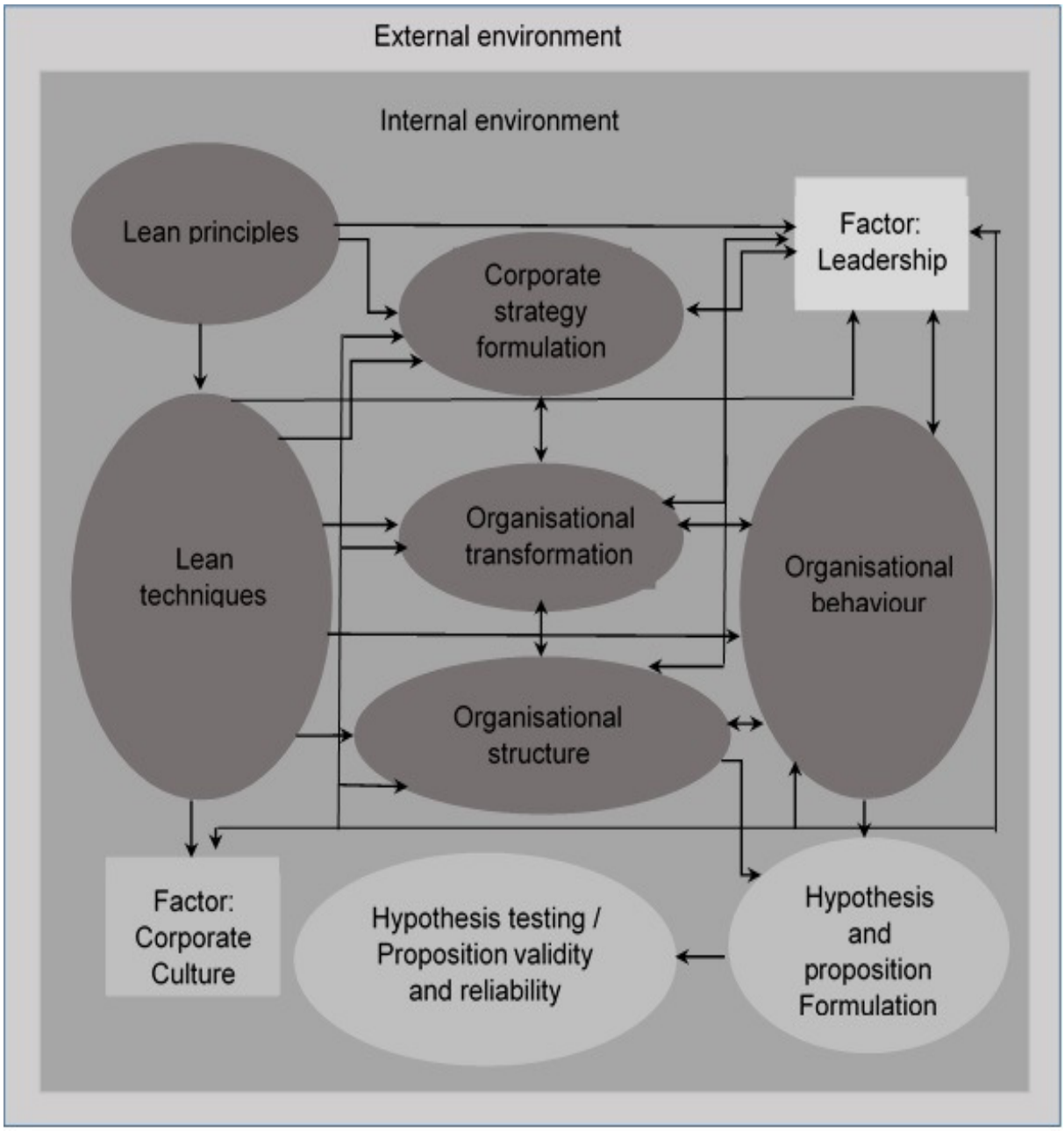

FIGURE 1: Research concept

Source: Developed by authors

TABLE 3: Constructs and Lean techniques coded as dependent and independent variables

Organisational structure variable	Abbreviation and code	Organisational behaviour variable	Abbreviation and code
Constructs utilised as the dependent variables			
Number of hierarchical levels	NOHL	Awareness of a Lean vision, mission values and organisational goals	ALVMG
Level of horizontal integration	LHINT	Perception of leadership	PERCL
Locus of decision-making	LOCDM	Participation and involvement	PARTINV
Level of communication	LCOM	Roles and responsibilities	RLSRESP
Nature of formalisation	NOF	Knowledge of Lean process	KNOWLP
Cellular format	CELFM	Commitment	COMM
		Respect	RESP
		Attitude	ATT
		Communication	COM
Lean techniques utilised as the independent variables			
Teamwork	TW	Cycle time reduction	CTR
Taguchi	TAG	Total productive maintenance	TPM
Five-S	5S	Visibility	VIS
Kanban pull	KAN	Hoshin Kanri	HOSHK
Kaizen	KAIZ	Problem solving	PROB
Seven wastes	7W	One piece flow	SPF
Standard work	STAND	Heijunka	HEIJ
Cellular manufacturing	CM	Value stream mapping	VSM
Value per customer	DISTVAL	One digit exchange of die	SMED
Mistake proofing	POKJID	Policy deployment	POLDEP

Source: Authors' synthesis of study's dependent and independent variables

2.3 Research methodology

A purposively sampled, mixed method case study methodology was utilised in this research. Two discrete manufacturing organisations were selected.

One hundred and thirty-six individuals were interviewed from senior, middle, and operational management as well as non-management. Interviewees participated in both the qualitative case study research and the quantitative research. In utilising the mixed method methodology, a quantitative analysis was done along with the case study qualitative approach, as proposed by King, Keohane, and Verba (1994:3).

Three five point Likert-scale questionnaires were used to obtain the quantitative data from the participants. The interrelationships of Lean techniques as the independent variable influencing organisational structure and behaviour as the dependent variables were observed, and multiple linear regression analysis was utilised to determine the pertinent interrelationships.

Structured questionnaires for the same groups of participants based on the same variables were used for the qualitative research. Pattern matching methodology as in Yin (2014:60) was utilised to evaluate the propositions developed for the research.

The quantitative data is relevant only to the two selected cases and is not regarded as generalizable. Preparing for multiple linear regression Table 3 shows the developed dependent and independent variables.

The coding in Table 3 was used with a multiple regression analyses utilising the model per Figure 2.

Figure 2 identifies the expected approach from left to right that organisations will follow with Lean implementation, commencing with goal setting, teamwork and progressing to full flow and pull through cellular manufacturing. Lean will impact the dependent variables such as number of hierarchical levels with other variables to be added in analysis.

The **main hypothesis** states that: The implementation of Lean thinking will transform the organisation and influence the organisational structure and behaviour.

The **null hypothesis** states that: The implementation of Lean thinking will not affect the organisational structure and behaviour.

The following are the sub-hypotheses, codes S for structure and B for behaviour:

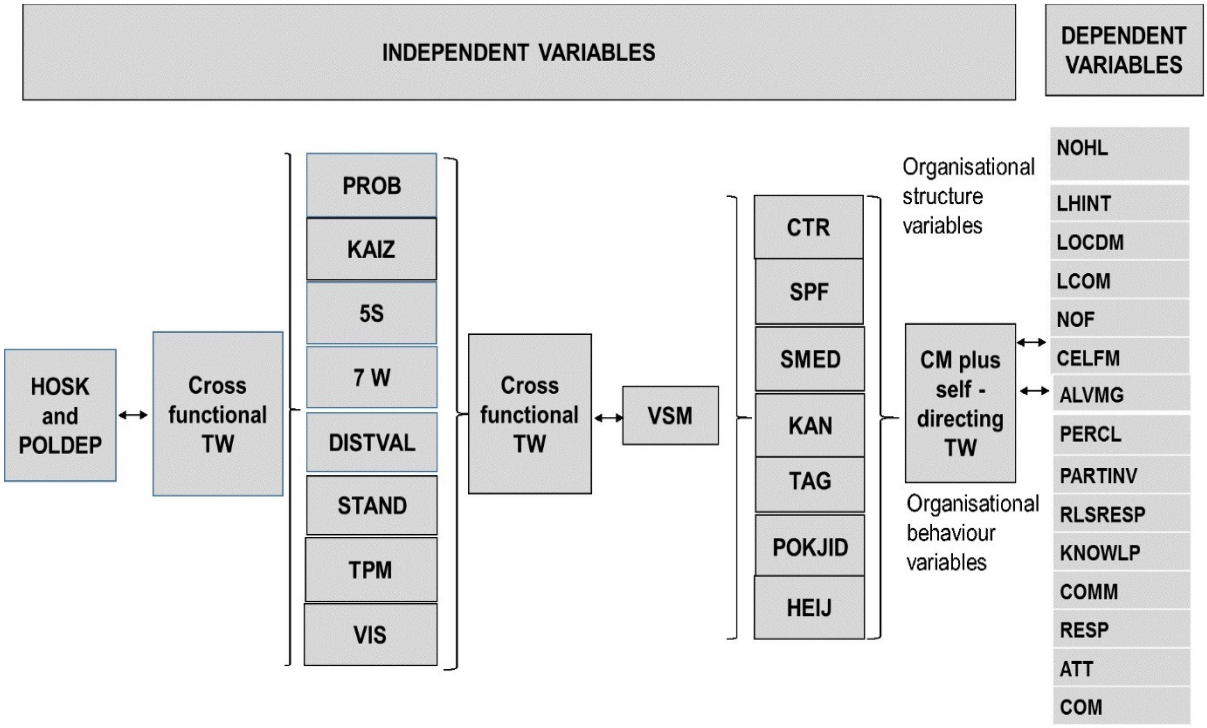

FIGURE 2: Model for Lean techniques as independent variables impacting organisational structure and behaviour variables

Source: Authors' depiction of dependent and independent variables

- **HYPS1** the degree of horizontal integration will increase as progress is made with Lean implementation.
  - o **HYPS1.1** the degree of horizontal integration will improve with more complex Lean technique introductions such as Taguchi, cycle time reduction, value stream mapping, SMED, one piece flow, Kanban, cellular manufacturing, and Heijunka.
  - o **HYPS1.2** the higher the level of horizontal integration, the higher the level of teamwork and employee involvement.
- **HYPS2** the number of organisational levels will decrease as cross-functional teams work more actively and frequently to create a continuous flow into manufacturing cells.

- **HYPS2.1** the number of organisational levels will decrease as employees become more involved, increasing their skills in Lean.

- **HYPS3** the locus of decision-making will decrease as more cross-functional teams achieve effective flow through SMED and cellular manufacturing;
- **HYPS4** the nature of formalisation will be towards detailed work instructions building to effective standard operating procedures but changed, updated and improved by empowered cross-functional teams.
- **HYPS5** the levels of communication will improve in speed and accuracy as Lean implementation progresses towards effective flow through cellular manufacturing.
- **HYPS6** the organisation will achieve a complete transformation to a cellular format with full Lean implementation, which will lead to flatter organisational structures.
- **HYPB1** the awareness of vision, values, mission, goals, and objectives will increase with more awareness and understanding of problem-solving, Kaizen, 5S, Hoshin Kanri, and policy deployment.
- **HYPB2** employee participation will increase with more emphasis on flow creation through cycle time reduction, SMED, value stream mapping, one piece flow, Kanban and Heijunka;
- **HYPB3** communications will improve with frequency and clarity of Lean process.
- **HYPB4** leadership will be challenged as more Lean techniques are introduced.
- **HYPB5** roles and responsibilities will be clarified with the Lean implementations of standard work, waste elimination, 5S, Kaizen, problem-solving and even more with flow creation.
- **HYPB6** employees will feel more respected with team work and the participation in finding solutions to implement flow.
- **HYPB7** knowledge of Lean will improve with experience, training, and development of employees.
- **HYPB8** motivations measured in terms of attitudes will be challenged with Lean implementation but will improve with Lean successes.

- **HYPB9** Commitments will be challenged with Lean implementation but will improve with employee involvement, teamwork and Lean successes.

Utilising regression analysis yielded the R, R^2 and the F statistic. The b coefficients of the independent variables provided the nature of the relationships.

The qualitative dimension of the research methods followed Yin's (2014) model as explained in Figure 3.

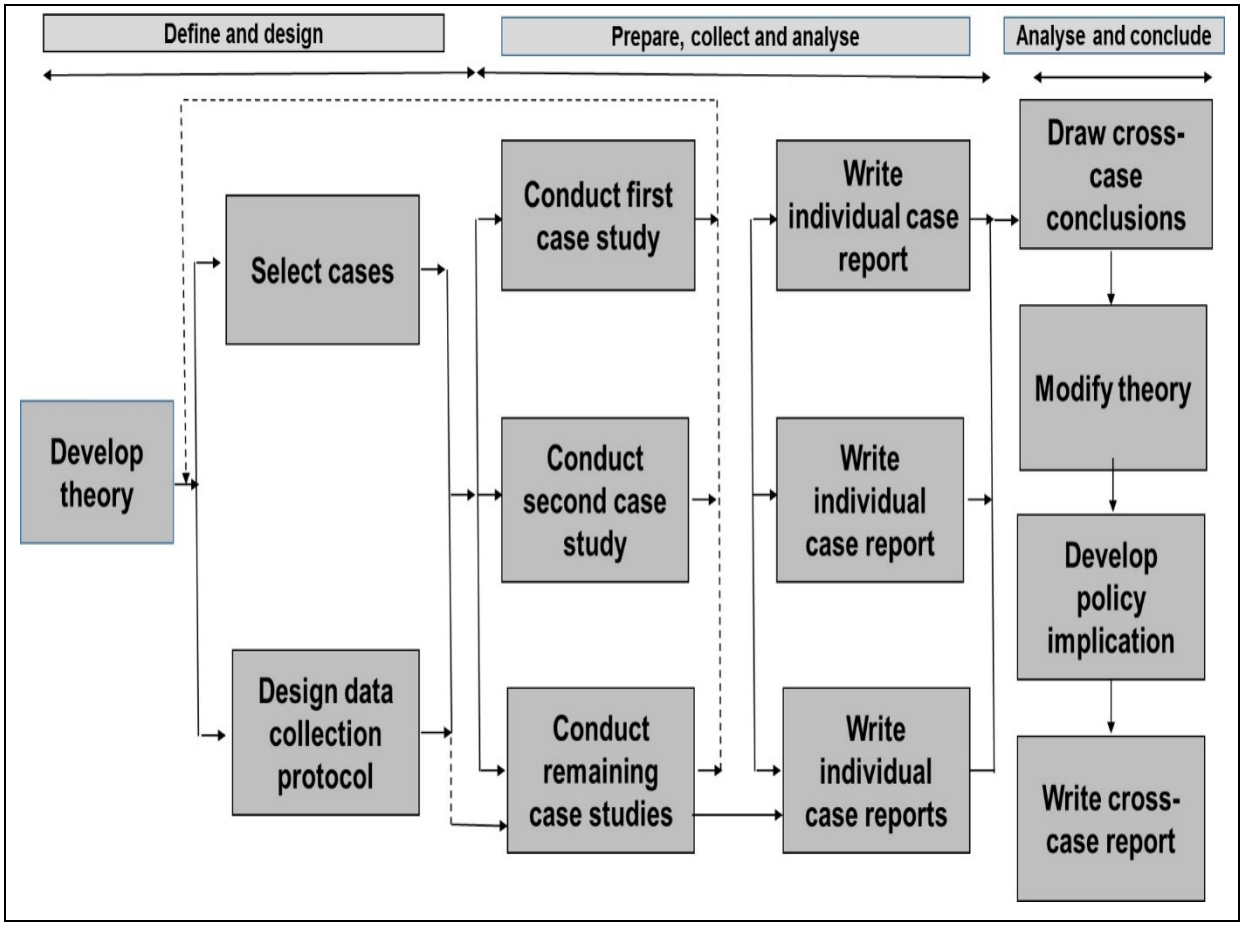

FIGURE 3: Multiple case study methodology approach

Source: Yin 2014:60

Figure 3 shows the steps followed for multiple case study research, commencing with a pilot study, expanding into the second and third case study, and concluding with a cross-case report. Two cases were analysed in this research.

Based on the literature review and the model (Figure 2), the research propositions were developed in terms of the research questions (Table 4).

Table 4 provides the research propositions utilised to develop patterns from the qualitative case study.

TABLE 4: Research propositions in terms of how and why questions

Research questions and propositions (M signifies main propositions, and S sub-propositions)
Research question 1: How is the organisational structure and behaviour significantly influenced?
MP1 Lean thinking (LT) will significantly influence the organisational structure and behaviour of the organisation – compelling change.
Research question 2: Why is the organisational structure and behaviour significantly influenced?
MP2 LT will significantly influence the organisational structure due to the requirement of total employee involvement.
Sub-research question 1: How will the organisational structure specifically change?
SP1 Cross-functional teams will implement cellular manufacturing to achieve effective flow and pull. Work teams becoming more self-directing will run cells and optimise cells with total organisational support.
Sub-research question 2: Why will specific organisational structure changes be required?
SP2 Organisational changes will be required in order to allow for more cross-functional and self-directing teamwork, reducing functional and leadership impediments. Structural changes will be required in order to support cellular manufacturing.
Sub-research question 3: How will the organisational behaviour change?
SP3.1 Employees will resist Lean implementation at the outset due to uncertainty and fear. **SP3.2** After the whole organisation has learned Lean in context, there will be: more affective commitment due to team processes; more commitment to vision, mission, goals; more understanding of leadership, why Lean is required; more participation and involvement with team *Kaizens* to improve flow and pull: roles and responsibilities will change, with employees taking on more functions; knowledge of Lean process will improve understanding what Lean provides; attitudes will change to more positive support for the organisation,

Research questions and propositions (M signifies main propositions, and S sub-propositions)
becoming more solution focused and more respect for employees for their contributions.
Sub-research question 4: Why will the organisational behaviour change?
SP4 Organisational behavioural changes will occur due to a new Lean awareness and culture brought about by employee teams working cross-functionally, work teams are becoming more self-directing, and leaders are willingly empowering employees.
Sub-research question 5: How can the organisational structure, best be redesigned to optimise the utilisation of all the Lean techniques and disciplines?
SP5.1 Organisational design will be to develop a structure conducive to cross-functional teams supporting self-directed teams with leadership focusing on how best to empower employees and teams. **SP5.2** The best organisational structure will fully accommodate a cellular format, with fully empowered self-directed work teams, well able to implement all the applicable Lean disciplines and techniques.
Sub-research question 6: Why should the organisational structure be redesigned to best accommodate for the utilisation of all the Lean techniques and disciplines?
SP6 The organisational structure should be re-designed to a cellular structure so that employee teams continuously work cross-functionally to support the manufacturing cells and to optimise flow and pull utilising all the Lean disciplines and 20 techniques. The structure should allow free flowing support for cellular teams in order to cultivate organisational behaviours conducive to Lean process.

Source: Authors' own developed propositions

2.4 Validity and reliability

Yin's (2014) validity method was extensively utilised as summarised in Table 5. The table shows that validity for case studies consist of construct, internal and external validity testing. Reliability testing involves consistency in protocol which was detailed for this research.

TABLE 5: Validity analysis

Tests	Case study tactic	Phase of research in which the tactic occurs
Construct validity	▪ Use multiple sources of evidence ▪ Establish chain of evidence ▪ Have key informants review draft case study reports	▪ When data is being collected ▪ When data is being collected ▪ When composition of the report is concluded

Tests	Case study tactic	Phase of research in which the tactic occurs
Internal validity	▪ Do pattern matching ▪ Do explanation building ▪ Address rival explanations ▪ Use logic models	▪ When data is being analysed
External validity	▪ Use replication logic for multiple-case- studies	▪ With research design
Reliability	▪ Use case study protocol	▪ When data is being collected ▪ When data is analysed, and generalisations are evident

Source: Yin 2014:45

Table 5 was employed to test the reliability and validity of the results and findings of the research.

3. FINDINGS AND IMPLICATIONS

The findings and implications are discussed in the following sections dealing with the quantitative multiple regression analyses and the qualitative multiple case study.

3.1 Quantitative analysis

A multiple regression analysis was run for each of the dependent organisational structure and behavioural variables. The outcomes are analysed and discussed in terms of the identified hypotheses per Table 6.

TABLE 6: Multiple regression parameters and outcomes for the research hypotheses

Hypothesis number	Description of multiple regression analyses and findings regarding the research hypotheses
HYPS1 and HYPS1.1	**LHINT**: R-squared = 0, 5118, f-statistic= 6, 0285 (analyses significant), critical F= 1.64884 (95% confidence), d-w = 1.62305 positive auto correlation at 95% confidence), standard error= +/- 0.7270.
	HYPS1 – Confirmed: as Lean process progresses the cross-functional interactions improves accordingly.

Hypothesis number	Description of multiple regression analyses and findings regarding the research hypotheses
	HYPS1.1 - Confirmed for: Heijunka, SMED and cellular manufacturing. Not confirmed for: one piece flow; Kanban; Taguchi; cycle time reduction and value stream mapping.
Hyps2 and HYPS2.1	**NOHL**: R-squared = 0, 5723, f-statistic= 7, 65 (analyses significant), critical F= 1.64884 (95% confidence), d-w = 0, 28868 positive auto correlation at 95% confidence), standard error= +/- 17,889.
	HYPS2 - Confirmed for: teamwork; SMED; heijunka; single piece flow. Not explained for cellular manufacturing and value stream mapping but expected because only trained employees worked with these techniques.
	HYPS2.1 - Confirmed by the general results that demonstrate knowledge of Lean process indicating that as levels increase the knowledge of Lean process in general decreases with Lean implementation and vice versa.
HYPS3	**LOCDM:** R-squared = 0.5879, f-statistic= 8.2043 (analyses significant), critical F= 1.64884 (95% confidence), d-w = 0.64259 positive auto correlation at 95% confidence), standard error= +/- 0.7218.
	HYPS3 - Confirmed for SMED and teamwork. Not confirmed for cellular manufacturing. This result, however, was expected due to the low level of knowledge of cellular manufacturing that existed for the case study participants and the complex labour relationships that were observed during the research period.
HYPS4	**NOF:** R-squared = 0.5070, f-statistic= 5.9123 (analyses significant), critical F= 1.64884 (95% confidence), d-w = 1.49331 positive auto correlation at 95% confidence), standard error= +/- 0.7298.
	Confirmed, indicating that the higher the degree of formalisation the less the application of standard work as a technique as well as the utilisation of teamwork as a technique and vice versa.
HYPS5	**LCOM**: R-squared = 0.4041, f-statistic= 3.8997 (analyses significant), critical F= 1.64884 (95% confidence), d-w = 1.49331 positive auto correlation at 95% confidence), standard error= +/- 0.7298.
	Confirmed for cellular manufacturing as a technique and virtually for all the other Lean techniques utilised in the regression analyses and implies that an abundance horizontal vertical and combined free flowing communications will significantly benefit Lean process.
HYPS6	**CELFM:** R-squared = 0.5975, f-statistic= 8.5364 (analyses significant), critical F= 1.64884 (95% confidence), d-w = 0.62475 (positive auto correlation at 95% confidence), standard error= +/- 0.8908**.**
	HYPS6 - was confirmed for most of the Lean techniques, however, not for policy deployment,

Hypothesis number	Description of multiple regression analyses and findings regarding the research hypotheses
	problem-solving and *Kaizen*, visibility, standard work and distinguishing value from a customer viewpoint. Cellular format to cellular manufacturing showed a flat relationship as can be expected.
HYPB1	**ALMVG**: R-squared = 0.4512, f-statistic= 4.72796.3269 (analyses significant), critical F= 1.64884 (95% confidence), d-w = 1.42074 (positive auto **correlation at** 95% confidence), standard error= +/- 0.7603.
	HYPB1 - was confirmed for problem-solving, *Kaizen,* 5s, and policy deployment accept for Hoshin Kanri due to participants understanding policy deployment but not fully the meaning of Hoshin Kanri.
HYPB2	**PARTINV**: R-squared = 0.5239, f-statistic= 6.3269 (analyses significant), critical F= 1.64884 (95% confidence), d-w = 1.320610 (positive auto **correlation at** 99.9% confidence), standard error= +/- 0.7854.
	Confirmed for cycle time reduction and most of the Lean techniques. Not confirmed for: SMED, value stream mapping, one piece flow, Kanban and TPM. This is due to focus by the participants during the research period, when participating in green areas or mini business team meetings. Specialists are involved in more complex Lean techniques.
HYPB3	**COM:** R-squared = 0.5029, f-statistic= 0.6183 (analyses significant), critical F= 1.64884 (95% confidence), d-w =1.30502 (positive auto correlation at 95% confidence), standard error= +/- 0.6183.
	Confirmed with increased communications correlating well with an increased overall understanding of Lean process. Negative b coefficients can be explained as being due the current knowledge of the participants.
HYPB4	**PERCL:** R-squared = 0.4226, f-statistic= 4.2082 (analyses significant), critical F= 1.64884 (95% confidence), d-w =1.67261 (positive auto correlation at 95% confidence), standard error= +/- 0.7139.
	Confirmed for most of the Lean techniques but not for the more complex techniques such as Taguchi, and value stream mapping. This was expected as these techniques are driven by trained specialists.
HYPB5	**RLSRESP:** R-squared = 0.3984, f-statistic= 3.8082 (analyses significant), critical F= 1.64884 (95% confidence), d-w =1.32601 (positive auto correlation at 95% confidence), standard error= +/- 0.6406.
	Confirmed for most of the Lean techniques indicating that workers accept more responsibilities and more role changes as Lean Implementation progresses.
HYPB6	**RESP:** R-squared = 0.2144, f-statistic= 1.5693 (analyses not significant), critical F= 1.64884 (95% confidence), d-w =1.41090 (positive auto correlation at 95% confidence), standard

Hypothesis number	Description of multiple regression analyses and findings regarding the research hypotheses
	error= +/- 0.7295.
	Not totally significant in terms of the f-statistic but this was expected as most of the participants felt that they were well respected in the organisation despite the Lean process.
HYPB7	**KNOWLP:** R-squared = 0.2589, f-statistic= 2.0087 (analyses significant), critical F=1.64884 (95% confidence), d-w =1.88203 (positive auto correlation at 95% confidence), standard error= +/- 0.6039. R-squared = 0.2589, f statistic= 2.0087 (analyses significant), critical F= 1.64884 (95% confidence), d-w= 1.88203 (positive auto correlation at 95% confidence), standard error= +/- 0.6039.
	HYPB7 - was partially confirmed indicating that as more Lean techniques are utilised more learning by employees will be experienced.
HYPB8	**ATT:** R-squared = 0, 3313, f-statistic= 2.0087 (analyses significant), critical F=1.64884 (95% confidence), d-w =1.88203 (positive auto correlation at 95% confidence), standard error= +/- 0.6039. R squared = 0.2589, f statistic= 2.8492 (analyses significant), critical F=1.64884 (95% confidence), d-w = 1.12673 (positive auto correlation at 95% confidence), standard error= +/- 0.5880.
	Confirmed for policy deployment; distinguishing value; waste reduction; *Kaizen*; problem solving; five-S; value-stream mapping and to a lesser extent from cellular manufacturing and single-piece flow, confirming that employees are achieving a positive attitude by participating in the techniques highlighted.
HYPB9	**COMM**: R-squared =, 0.396.1 f-statistic= 3.7721 (analyses significant), critical F=1.64884 (95% confidence), d-w = 1.77450(positive auto correlation at 95% confidence), standard error= +/- 0.6680.
	Outcome confirmed for increased commitment being found in the utilisation of techniques such as : Hoshin Kanri; policy deployment; problem solving; value-stream mapping; cellular manufacturing; single-piece flow; Kanban; Heijunka; visibility; standard work; and teamwork.

Source: Authors' own hypothesis development

The above analyses indicate significance for the hypotheses with explainable exceptions. The constructs were also utilised for the qualitative research and provided support for multiple case study construct validity required for the qualitative analyses.

3.2 Qualitative analysis

The two purposively selected cases are discussed next, followed by the qualitative process and analyses.

3.2.1 Case study F01

F01 is a pump engineering US listed organisation with 2,700 employees worldwide and about 150 in South Africa. Up to 2006, the company acted as traders of electric motors, pumps and spares in South Africa, but has since become a manufacturing organisation through purchasing a going concern that belonged to the South African engineering group.

The current facility on the East Rand consists of three factories: a machine shop, rubber and chroming plants. Under the influence of the US management (parent company) (Plant manager F01 2014) F01) adopted a Lean transformational strategy, replacing the current managing director; plant, engineering, and export managers some two years ago with individuals whom have an appreciation for Lean thinking Since September 2012, the plant manager fulfilled a key role for driving the Lean initiative. The F01 organisation utilises a matrix structure for the worldwide organisation (Figure 4) with the detailed operations structure (Figure 5).

The above figures show the reporting relationships for F01 with dotted lines indicating matrix organisational structure relationships. After a substantial five-S campaign, the organisation is focused on establishing manufacturing cells for the total facility including warehouse and distribution. Substantial progress has been made with a rubber, rotor, and assembly cell.

Currently, employees have received training in Lean thinking up to supervisor level. Some employees from sales, export, engineering, warehouse and distribution, received Lean exposure by participating in cross-functional Kaizen teams, facilitated by the US ***Kaizen*** team consisting of Lean specialists from the parent organisation.

Figures 4 and 5 show the reporting relationships for F01 with dotted lines indicating matrix organisational structure relationships. After a substantial five-S campaign, the organisation is focused on establishing manufacturing cells for the total facility including warehouse and distribution. Substantial progress has been made with a rubber, rotor, and assembly cell.

Currently, employees have received training in Lean thinking up to supervisor level. Some employees from sales, export, engineering, warehouse and distribution, received Lean exposure by participating in cross-functional Kaizen teams, facilitated by the US ***Kaizen*** team consisting of Lean specialists from the parent organisation.

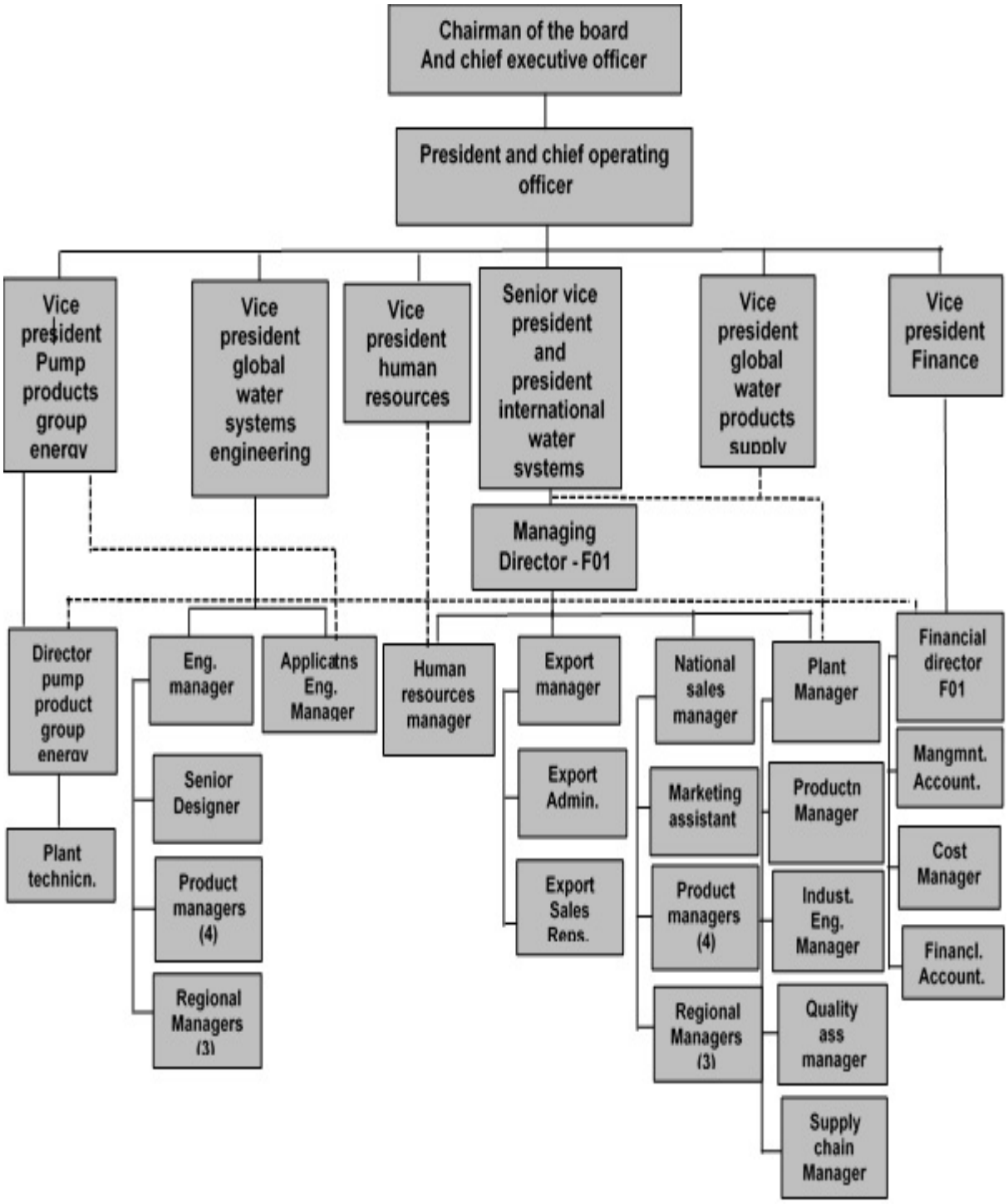

FIGURE 4: F01 organisational structure

Source: Authors' own depiction of F01's organisational structure

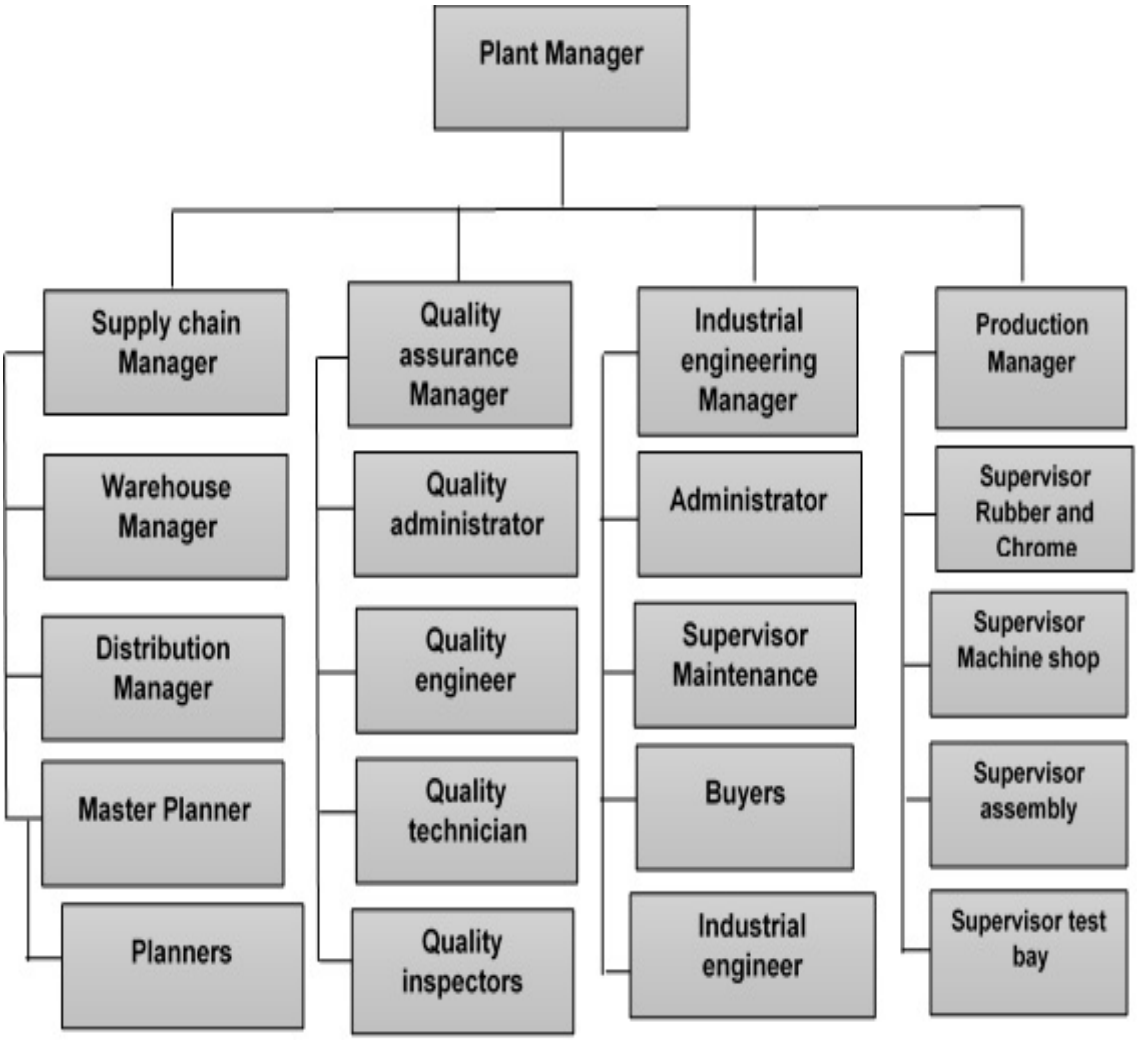

FIGURE 5: F01 operations structure

Source: Authors' own depiction of F01's operations structure

3.2.2 Case study W01

W01 is the largest aluminium extrusion organisation in Africa, owned by a large investment organisation listed on the JSE. The organisation has a large East Rand facility employing 1,100 and comprises an Aluminium extrusion, scrap, and binning plant; re-melt plant; powder coating plant and an anodising plant. Following major restructuring in 1998, the organisation adopted a Lean initiative in 2002 in the form of the 20 keys process (Kobayashi

1995: 213). Five-S was utilised to clean up the organisation, and all the employees were involved in the exercise.

The total organisation has been set up as a continuous flow line: the binning operation supplies the re-melt manufacturing cell which in turn supplies the extrusion manufacturing cells of four press extrusion lines. The extrusion operation supplies the anodising and powder coating manufacturing cells.

The finished products are despatched to the Gauteng stockist organisation that acquired two distribution organisations, one in 2007 and the other in 2011. The current W01 organisational structure is shown as the top management organisational structure (Figure 6) and operations structure (Figure 7).

Figure 7 demonstrates an effective Lean structure of first-line managers running mini business teams within a business unit with support functions of die correctors and maintenance specialists allocated directly to a particular cell. Support teams collect from the cell and move materials to downstream units' ***kanbans***.

One hundred and thirty six detailed structured interviews provided the qualitative data, and two responses were obtained from focus group sessions with top managers.

Table 7 shows the pattern matching for the two organisations in terms of the relevant responses from the individual and focus group questionnaires as well as data gathered from plant visits, studying value stream maps and Lean story boards.

Table 7 indicates patterns supporting the propositions to a major degree and could be cross-linked for both the cases researched. The validity and reliability of the qualitative finding are discussed next.

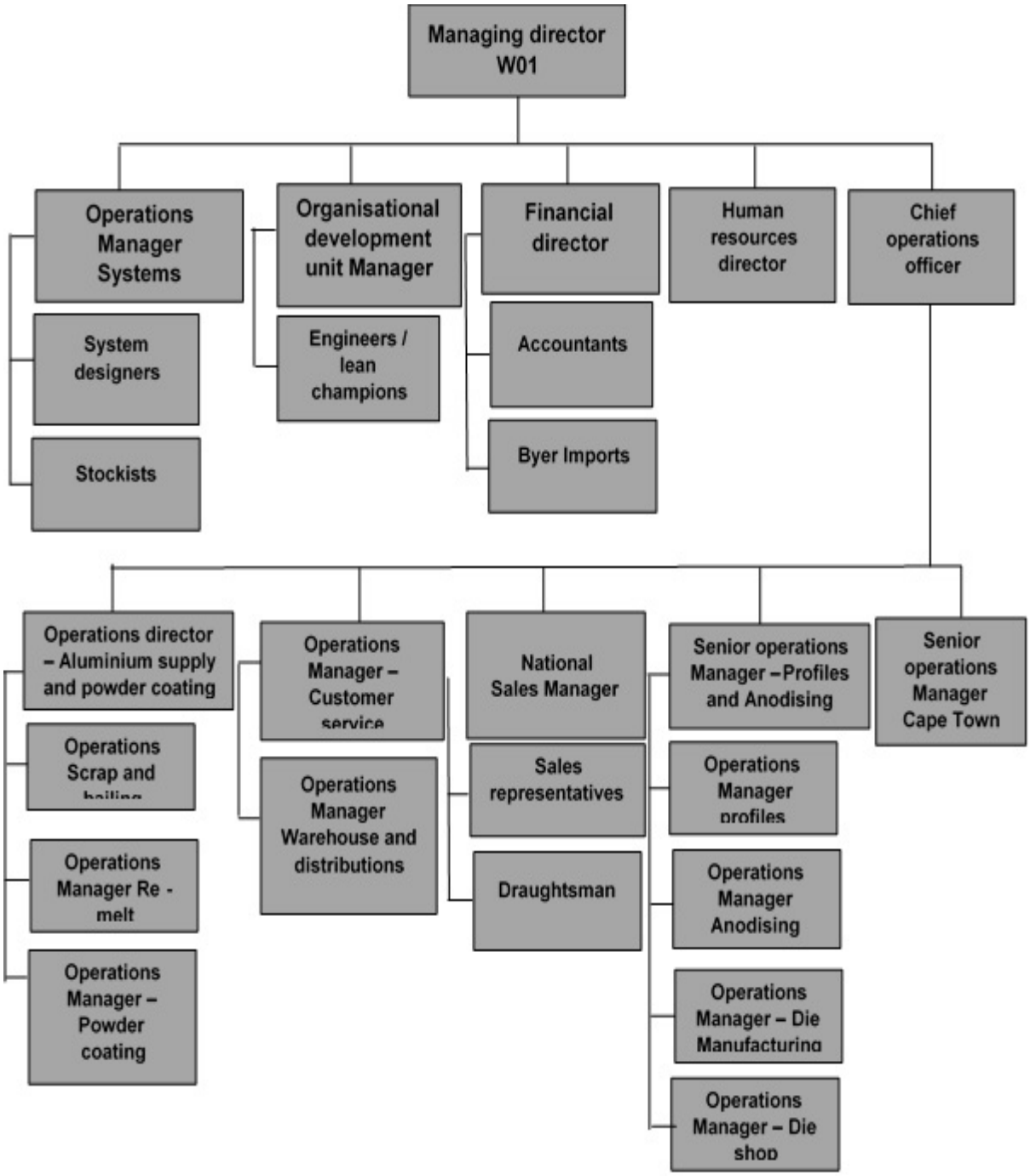

FIGURE 6: W01 organisational structure

Source: Authors' own depiction of W01's organisational structure

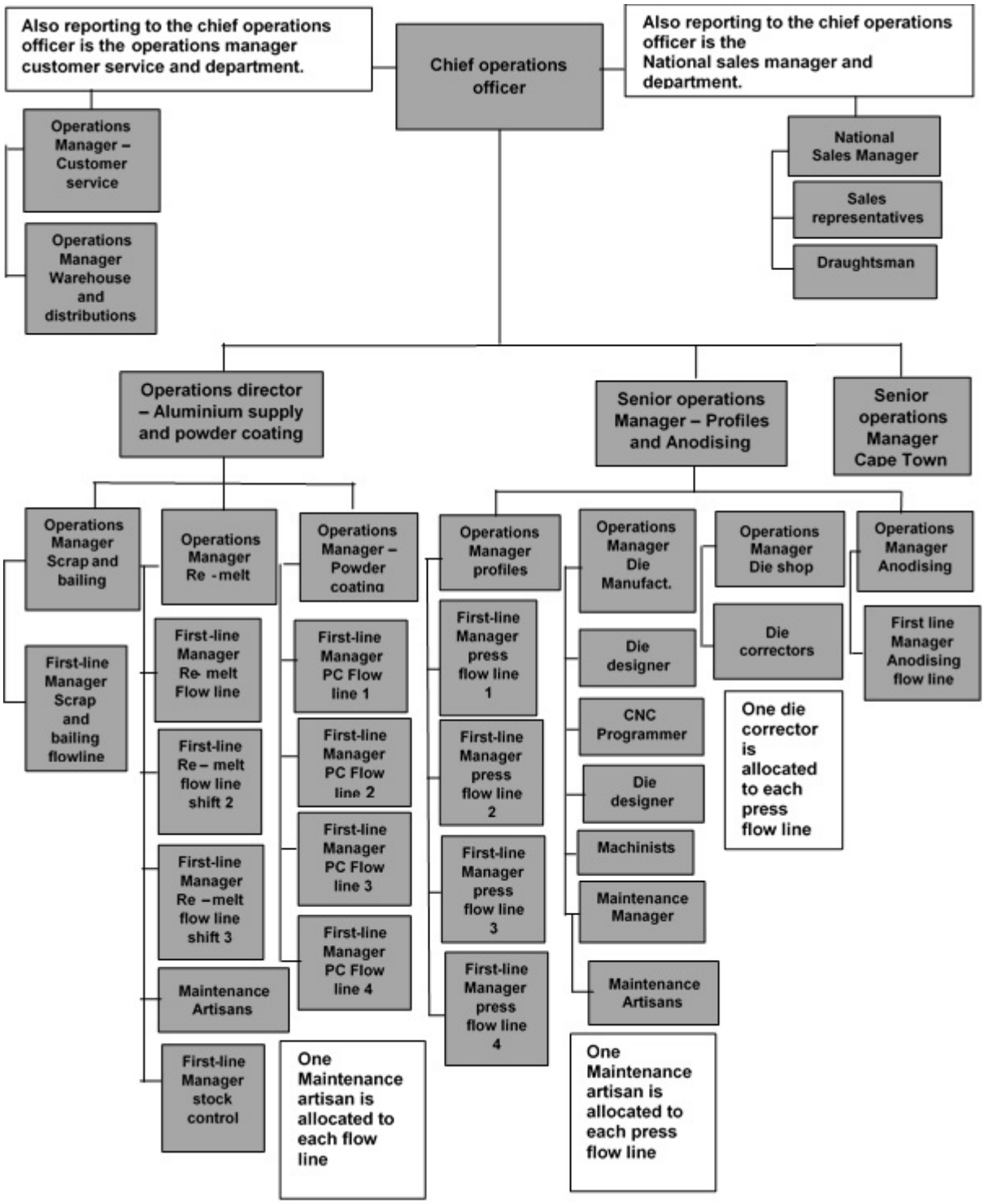

FIGURE 7: Organisational structure for W01 operations

Source: Authors' own depiction of W01's operations structure

TABLE 7: Pattern matching with propositions for F01 and W01 organisations

Proposition number	Matched pattern with proposition for F01	Matched pattern with proposition for W01
MP1	FMP1PS1 - Appointment of managing director, plant manager, and engineering manager in 2012. FMP1PS2 - Top management team wishes to restructure as Lean progresses, indicated their concerns with the current matrix creating silos. Three year plan to be developed. Cross functional team activity considered key. FMP1PS3 - Supervisors are working at cell implementation with industrial engineering and plant manager. FMP1PS3 - Plant manager and supervisors appreciating self-directed initiatives from workers. FMP1PS4 -Green areas established and work teams are developed. FMP1PS5 - Corporate support SA operation with Kaizen team working cross-functionally with F01 employees. FMP1PS6 - Managing director contemplating appointment of Lean champion to speed up Lean implementation.	WMP1PS1 - New managing director in 1998 brought significant changes: hierarchical levels reduced from eight to four; Lean in the form of 20 keys introduced 2002; production, profit, and attendance bonuses introduced and 25% of organisational gains shared with employees. WMP1PS2 - Restructuring involved: total organisation supporting the manufacturing cells; unit and operations managers meet twice weekly to deal with cross-functional issues; mini business teams have meeting places; each mini business team runs a manufacturing cell and is led by a first-line manager. WMP1PS3 - Appointment of a business development manager (2003), championing the 20 keys process; Lean champions empowered to set organisational goals by unit.
MP2	FMP2PPS1 - Plant manager implemented green areas (where people normally as a team, meet in a clean designated area), involving all the manufacturing, distribution, and warehouse employees. FMP2SP2 - Green areas teamwork is occurring with discussions involving production output and quality. FMP2PS3 - Quarterly talk with all the employees of the organisation by managing director welcoming employee feedback. FMP2PS4 - Lean awareness due to five-S.	WMP2S1 - Managing director (1998) initiated the mini business team concept with teams meeting daily in mini business areas from 2002 onwards. WMP2S2 - Organisational development unit worked at developing first-line managers to understand Lean 20 keys fully. WMP2S3 - First-line managers are facilitating mini-business team meetings and do training in 20 keys. WMP2S4 - Workers are empowered through multi-skilling and to run cells self-directed.

Proposition number	Matched pattern with proposition for F01	Matched pattern with proposition for W01
	FMP2PS5 - Plant manager working to create self-directed teams. Export team virtually fully self-directed. FMP2PS6 - Employees and managers are working in a cross-functional team to create cellular manufacturing. FMP2PB1 - workers see the benefits of finding things quicker in a clean workplace and are working to achieve self-direction.	WMP2S5 - Managing director (1998) initiated joint leadership meeting: employees invited; organisational performance discussed; feedback from workers responded to. WMP2B1 - Workers are providing ideas for *Kaizen* activity, example of a remarkable die design idea by a die corrector. WMP2B2 – Cross functional team of unit and operations managers: ensure complete downwards communication to first-line managers and upwards communications from the first-line managers twice weekly.
SP1	FSP1PS1 - Cross-functional teams developing in the organisation: planning, sales, and manufacturing supervisors meet daily to schedule orders; cross-functional interaction between engineering, sales and planning to configure assembly orders; cross-functional teams have successfully implemented cells for distribution and a NPD cell. FSP1PS2 - F01 has developed a rotor, rubber, and assembly cell; focused on developing more cells in other areas.	WSP1PS1 - Manufacturing cell first-line managers' report to operations manager reporting to unit managers; sales totally integrated into manufacturing and is part of operations; die correctors and maintenance artisans are allocated to cells and work closely with first-line manager; customers link directly with cells; all customer orders are made to order within three days of placement and planning link directly with first-line managers regarding customer orders. With a major change in 1998, hierarchical layers were reduced from eight to four. WSP1PS2 - Highly successful with single-minute exchange of die (SMED) implementations, achieving less than three minutes for extrusions, less than 18 minutes for powder coating and seconds for anodising changeovers.
SP2	FSP2PS1 - Since Lean implementation, productivity has improved from 40% to 76% and on-time delivery from 40% to 62%. FSP2PS2 - Cross-functional teams have implemented cells for the rotor, rubber, assembly, and NPD cell. Green areas are promoting teamwork at shop level. People in cells starting to act as teams, most notably the assembly cell.	WSP2PS1 - W01 a world-class organisation; won the national productivity award twice in a row; achieved world class levels of performance achieving 19, 5% PBIT to sales, and 3 day deliveries all made to order; achieving 40 die changes per day compared to a similar Italian organisation achieving, only 3 to 4 per day. WSP2PS2 - Mini business teams run manufacturing cells with virtually, full self-

Proposition number	Matched pattern with proposition for F01	Matched pattern with proposition for W01
	FSP2PS3 - Teams operating cells are becoming more self-directing with four out of 17 employees in the assembly cell working without supervision.	directed teams. WSP2PS3 – Fist-line managers work virtually independently from operations manager, taking all the relevant decisions to run a small business.
SP3.1 and SP3.2	FSP3.1B1 - When Lean was introduced after September 2012, employee felt threatened, not consulted, concerned for job losses, speculated, felt that it would result in doing more without rewards. Dismissals are due to discipline occurred. FSP3.2B1 - Affective commitment: improving; workers are participating more and giving ideas in green areas or at point Kaizens; workers want to contribute more, example of a forklift driver reporting on the making of excess stock and shop stewards providing researcher with ideas how to improve F01; found most employees not aware of the vision and mission but well aware of the goals of F01. FSP3.2B2 - 23 out of 66 participants interviewed felt confident about the new leadership, active since 2012 and recognised the improvements due to Lean process. FSP3.2B3 - More participation than before in Lean process from workers as indicated by 29 out of 66 participants attributed to green areas and awareness of benefits and results; workers are more involved in the development of sops and kaizen activities. FSP3.2B4 - the Production manager, confirmed that workers are participating more in the derivation of sops facilitated by supervisor. FSP3.2B5 - knowledge of Lean process mainly up to supervisor level. Workers involved in five-S, ideas and Kaizen. FSP3.2B6 - Attitudes are improving as more awareness is gained of Lean process as	WSP3.1B1 - When Lean was introduced (2002), employees felt threatened, not consulted, concerned for job losses, speculated, felt that it would result in doing more without rewards. WSP3.2B1 - Currently, high level of affective commitment, evident from worker participation in mini business team meetings, *Kaizen* events, and ideas presented by the participants during interviews. High level of awareness of the vision mission and goals of W01. WSP3.2B2 - High level of trust and confidence in current leadership from 60 out of 70 participants. WSP3.2B3 - High level of participation in Lean process, confirmed by 62 out of the 70 participants. WSP3.2B4 - Managing director confirmed that sops are established, updated, and changed by the mini business teams facilitated by first-line managers. WSP3.2B5 - Worker knowledge of Lean is: five-S; workers participating more in maintenance check sheets; cycle time reduction; teamwork in mini business areas; visibility; Kaizen; problem solving; SMED; goal alignment; waste reduction; and value stream mapping for expansion. WSP3.2B6 - Improved attitudes due to: participating in mini business team activities; cleaning and organising, five-S activities; employees feeling the togetherness in mini business teamwork; workers feeling that they are contributing towards the Lean 20 keys process; a tidy workplace making employees

Proposition number	Matched pattern with proposition for F01	Matched pattern with proposition for W01
	observed from researchers experience with shop stewards and positive responses from 21 participants. FSP3.2B6 - More respectful management due to: leaders having an open door policy; recognition by leaders; recognition through reward ceremony; more teaching and coaching; having a more open participative and non-autocratic leadership style; employees being able to share ideas in team forums; respectful leadership; employees being able to participate in green area meetings; workers realising the benefits gained from Lean process;	feel good; incentive bonuses maintaining a positive attitude; employees gauging W01 success in terms of bonus pay-outs; worker supporting overtime; management's open door approach; business growth and performance with employees benefiting; prompt grievance handling; effective mini-business teamwork; consultative management; automating processes; better disciplines; clear sops ; workers achieving targets; employing family; empowered first-line managers; humble leadership; affirmative action; recognition in team session; leaders visiting mini business team areas; effective team-competitions; multi-skilling and up-skilling of employees; workers cleaning achieving earned-respect; improved discipline through procedure; respectful leadership; transparent leadership; leaders making an effort to greet employees; employees able to provide input at the joint leadership meeting; management listening with care; effective grievance handling; non-harassment of employees; non-emotional behaviour from leaders.
SP4	FSP4PB1 - Behaviour has changed due to: more Lean awareness; five-S awareness; the remarkable change around since Lean implementation; more visibility; more cross-functional team work; more shop-floor teamwork; green areas; more open door communications; changes in leadership style to less autocratic; more recognition; more idea sharing; more focus on self-directed teamwork and more awareness of results due to Lean. FSP4B2 - Positive culture: more awareness; participative; impact and urgency; standards and discipline; structured; accommodating; strong in adaptation and growth; output focussed; solution focused; teamwork; cooperation; Lean; and service first.	WSP4PB1 - Behaviour changed due to: Lean awareness; a cleaner workplace; teamwork; togetherness; discipline; caring attentive managers; decisive leadership; results; bonuses; mini business areas; visibility; grievance handling; well-mannered leaders; greeting of employees; empowerment; self-directing teams; multi-skilling; up-skilling; idea sharing; respect-culture; transparency; consultations; working easier; clear-cut sop's; and follow through. WSP4B2 - Organisational culture: trustful; entrepreneurial; "we are family"; open; happy; stand together; like a chain; clean and green; tight and effective; teamwork; make a plan; do it right; customer focused; Lean; goal aligned and vision focused.
SP5.1 and	FSP5.1 and 5.2.PS1 - Senior team focussed	WSP5.1 and 5.2.PS1 - effective organisational

Proposition number	Matched pattern with proposition for F01	Matched pattern with proposition for W01
SP5.2	on restructuring within the matrix; contemplating appointment of a Lean champion to accelerate Lean process; focussed on developing work teams; supervisors and plant manager focused on teamwork and developing self-directed teams.	structure: manufacturing cells report to leaders who report to operations managers who report to unit managers; Lean champions cross-functionally focused, setting priorities and goals; manufacturing cells are cross-functionally linked, one factory to the next; sales and manufacturing cross-linked; finance cross-functionally focused; permanent support in manufacturing cells from maintenance and die correctors; continues flow virtually achieved.
SP6	FSP6P1 - Working to Lean achieved in most areas with good progress being made.	WSP6P1 - Working to Lean, well achieved in all areas: Cellular or flow structures are well evolved. World-class performance levels achieved.

Source: Pattern matching with propositions based on research results and findings

3.2.3 Validity and reliability of the case study findings

As indicated in the research methodology section, the validity and reliability of the case study findings (Yin 2014: 45) are discussed in Table 8.

TABLE 8: Case study findings: validity and reliability tests

Tests	Case study tactic	Phase of research in which the tactic occurred
Construct validity	▪ Use multiple sources of evidence. ▪ establish chain of evidence ▪ have key informants review draft case study reports	The constructs that were used in both the quantitative and qualitative research proved relevant in terms of hypothesis significance, proposition pattern matching and other sources of evidence such as value stream mapping and Lean story boards; a chain of evidence was established in terms of structural and behavioural patterns indicating consistency between the two cases; key informants from both organisations reviewed draft reports from group questionnaires, before committing to final comment.
Internal validity	▪ Do pattern matching ▪ Do explanation building	Table 7 shows the detailed replicated pattern matching and identifies similar results for both cases, supporting the propositions of the research;

Tests	Case study tactic	Phase of research in which the tactic occurred
	▪ Address rival explanations ▪ Use logic models	Explanation building was used for the hypotheses, propositions and the patterns; rival explanations were considered, from the theory by Womack and Jones (2003) in terms of matrix type structures versus the propositions from this research and findings from the F01 case study countering their proposal; the logic models utilised throughout this research were the concept, Figure 1, and the constructs model per Table 2 and these proved decisive for this study.
External validity	▪ Use replication logic for multiple case studies	Replication was established for both cases in terms of considerations regarding organisational structure based on thought processes and trends from case study F01 and confirmation of fact in case study W01. Virtually perfect replication was found for both case studies regarding commitment, attitudinal and communication behaviour.
Reliability	▪ Use case study protocol	The case study protocol was consistent in terms of the ethical process; the researcher dealing with each participant in a consistent manner asking the same structured questions; consistently evaluating the units of the research; consistently considering value stream mapping and Lean story boards and the analyses of data that indicated clear generalisations in matched patterns.

Source: Authors' own presentation of the case study findings' validity and reliability tests

Table 8 provides validity and reliability for generalizable results in terms of the quantitative outcomes supporting the qualitative outcomes. New theory is established in the replication for discrete manufacturing structures and is summarised in the next section in the form of recommendations for Lean transformations. The next section concludes the article.

4. RECOMMENDATIONS AND FUTURE WORK

From this research future directions for optimised Lean structures have emerged for discrete manufacturing organisations. From these the following recommendations are that:

- self-directed teams be established who would man manufacturing cells reporting to a unit manager who in turn would report to the chief executive;

- sales, finance, maintenance, human resources and any other required service functions be permanently linked to a particular manufacturing cell to ensure a continuous flow of information and material to and from the cell;
- a business unit, of lean specialists, be established, who would cross-functionally support manufacturing cell development through the setting of goals, priorities and facilitating action plans;
- manufacturing cells be enabled to receive customer and supply orders directly processed through effective ***kanban*** and scheduling processes;
- manufacturing cells feeding manufacturing cells be cross-functionally linked through effective cross-functional teamwork.

It is further recommended that:

- The cultivation of Lean behaviours be stimulated through a Lean champion providing, education, training, coaching and learning of Lean practise to the lowest levels of the organisation utilising the system of first-line manufacturing cell managers that are thoroughly Lean skilled;
- Behavioural changes be achieved through cross-functional teamwork, leading to the design of effective manufacturing cells by employees facilitated by team leaders;
- Behavioural change continue with employees becoming more empowered and self-directing, continuously encouraged by open, and supportive and constructive leadership frequently visiting teams on the shop floor or in meeting areas;
- Affective commitment be cultivated through effective daily green area type, team processes, inviting active participation and idea sharing;
- Gain sharing be implemented with growth to enable the gauging by employees of organisational performance.

For future research literacy and language issues should be addressed and it is recommended that management embrace the adage “a picture paints a thousand words” for the development of employees in Lean transformations.

5. CONCLUSION

A new theory was developed that indicate how and why organisational structures and behaviours will change with Lean transformation. Major uncertainties existed surrounding the question of how discrete manufacturing organisations will be influenced once a Lean transformational strategy has been adopted by such organisations. The change will be realised through the establishment of self-directed teams; the permanent linking of service functions to a particular manufacturing cell to ensure a continuous flow of information and material to and from the cell; the establishment of a business unit of lean specialists; the enablement of manufacturing cells to receive customer and supply orders directly processed; and lastly cross-functionally linking manufacturing cells feeding manufacturing cells. Lean transformation implemented in discrete manufacturing organisations will change the way manufacturing takes place as well as the behaviour and the organisational structure which will lead to more profitable organisations.

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