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**THE RELATIONSHIP BETWEEN LEAN MATURITY
AND SUSTAINABLE LEAN TRANSFORMATION GAINS
WITH MEDIATING EFFECTS OF LEADERSHIP AND
CULTURE IN MALAYSIA MANUFACTURING SECTOR**

AZIM AZUAN BIN OSMAN



**DOCTOR OF PHILOSOPHY
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By

AZIM AZUAN BIN OSMAN



UUM
Universiti Utara Malaysia

**Thesis Submitted to
College of Business
Universiti Utara Malaysia,
in Fulfilment of the Requirement for the Degree of Doctor Philosophy**

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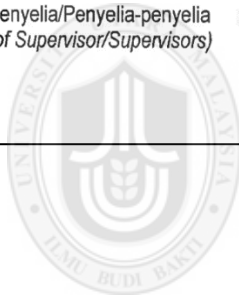
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ABSTRACT

Toyota Motor's survival during the 1973 global oil crisis, has inspired US manufacturers to transform from the mass production system to the lean production system. However, lean transformation attempted by most manufacturers around the globe has produced mixed results. Nearly two-thirds of the lean transformation ended in failure, while only a small percentage of those transformed have successfully sustained its gains. Therefore, this study empirically investigated the factors that contribute to Malaysian manufacturers' ability to achieve sustainable gains as a result of their lean transformation initiatives. Based on extensive literature review, a multiple mediator's research model was proposed to explain the relationship between lean transformation and sustainable gains. To address several gaps in the current knowledge, sustainable gains were operationalised from tangible and intangible gain facets. Besides that, maturity criteria (completeness, extensiveness and experience) in applying lean tools were used as proxies to measure the lean transformation level which served as the independent variable. Meanwhile, lean leadership and lean culture were proposed as mediators. The research model was underpinned by the integration of Theory E and Theory O, as well as the sustainable organisational concept. For testing the research model, a survey on 92 lean manufacturing organisations was conducted. The collected data was then analysed using the PLS-SEM technique running on SmartPLS 3.3.3 software. The results revealed that both lean leadership and lean culture fully mediated the relationship between lean tools adoption maturity and sustainable gains at $\beta = 0.176$, $t = 2.397$, $p = 0.017$ and $\beta = 0.120$, $t = 2.016$, $p = 0.044$ respectively. Thus, this study contributed to the lean management body of knowledge by providing tangible statistical evidence on previously unexplained relationship between lean maturity, lean leadership and lean culture with sustainable gains.

Keywords: lean transformation sustainability, lean maturity, lean leadership, lean culture, manufacturing sector.

ABSTRAK

Kelangsungan hayat Toyota Motor semasa krisis minyak global pada tahun 1973 telah memberi inspirasi kepada pengilang-pengilang Amerika Syarikat untuk melakukan transformasi daripada sistem pengeluaran besar-besaran kepada sistem pengeluaran kejut. Namun begitu, percubaan transformasi kejut yang dilakukan kebanyakan pengilang dari serata dunia telah menghasilkan keputusan yang tidak menentu. Hampir dua pertiga transformasi kejut berakhir dengan kegagalan, manakala hanya peratusan kecil daripada mereka yang berjaya mengekalkan perolehan. Oleh yang demikian, kajian ini telah menjalankan siasatan empirikal tentang faktor-faktor yang menyumbang kepada kemampuan pengilang-pengilang Malaysia untuk mencapai perolehan yang mampan hasil daripada inisiatif transformasi kejut yang mereka jalankan. Berdasarkan tinjauan kepustakaan yang meluas, sebuah model penyelidikan berbilang pencilah telah dicadangkan untuk menjelaskan hubungan antara transformasi kejut dan perolehan yang mampan. Untuk menangani beberapa jurang dalam pengetahuan semasa, perolehan yang mampan dioperasikan dari segi perolehan ketara dan perolehan tidak ketara. Selain itu, ciri-ciri kematangan (kesempurnaan, keluasan dan pengalaman) dalam mengaplikasikan alatan-alatan kejut digunakan sebagai proksi untuk mengukur tahap transformasi kejut yang juga berfungsi sebagai pemboleh ubah bebas. Sementara itu, kepemimpinan kejut dan budaya kejut dicadangkan sebagai pemboleh ubah-pemboleh ubah pencilah. Model penyelidikan ini diampu oleh integrasi Teori E dan Teori O, serta konsep perubahan organisasi yang mampan. Untuk menguji model penyelidikan ini, sebuah tinjauan ke atas 92 organisasi pembuatan kejut telah dilakukan. Data yang dikumpul kemudiannya dianalisis menggunakan teknik PLS-SEM. Hasil kajian menunjukkan bahawa kepemimpinan kejut dan budaya kejut sepenuhnya mencelah hubungan antara kematangan penggunaan alatan kejut dan perolehan mampan masing-masing pada $\beta = 0.176$, $t = 2.397$, $p = 0.017$ dan $\beta = 0.120$, $t = 2.016$, $p = 0.044$. Demikian, kajian ini menyumbang kepada bidang pengetahuan berkenaan pengurusan kejut dengan memberikan bukti statistik yang nyata mengenai hubungan antara kematangan pelaksanaan alatan kejut, kepemimpinan kejut dan budaya kejut dengan perolehan mampan yang tidak dapat dijelaskan dalam kajian sebelumnya.

Kata kunci: kemampanan transformasi kejut, kematangan kejut, kepimpinan kejut, budaya kejut, sektor pembuatan.

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TABLE OF CONTENT

Content	Page
CERTIFICATION OF THESIS WORK	ii
PERMISSION TO USE	iv
ABSTRACT	v
ABSTRAK	vi
LIST OF PUBLICATIONS	vii
ACKNOWLEDGEMENTS	viii
TABLE OF CONTENT	ix
LIST OF TABLES	xii
LIST OF FIGURES	xv
LIST OF ABBREVIATIONS	xvi
 CHAPTER ONE INTRODUCTION	 1
1.1 Research Background	1
1.1.1 Significance and Issues in Malaysian Manufacturing Sector	4
1.2 Research Problem	7
1.3 Research Questions	10
1.4 Research Objectives	10
1.5 Research Significance	11
1.6 Research Scope	12
1.7 Definition of Key Terms	14
1.8 Organisation of the Thesis	16
 CHAPTER TWO LITERATURE REVIEW	 19
2.1 Introduction	19
2.2 History and Development of Lean Production System	19
2.2.1 Global Trends of Lean Transformation Studies	21
2.2.2 Lean Transformation Studies in Malaysia Manufacturing Settings	24
2.3 The Lean Transformation Sustainability Concept	30
2.4 Existing Studies on Lean Transformation Sustainability	35
2.4.1 Lean Transformation Sustainability Models and Frameworks	39
2.4.2 Lean Transformation Sustainability Contributing Factors	42
2.4.3 Relationships among Lean Transformation Sustainability Variables	45
2.4.4 Lean Transformation Sustainability Assessments	47
2.5 Sustainable Gains	51
2.6 Lean Tools Adoption Maturity	53
2.7 Lean Leadership	57
2.8 Lean Culture	65
2.9 Hypotheses Development	68
2.9.1 Relationship between Lean Tools Adoption Maturity and Sustainable Gains	69
2.9.2 Relationship between Lean Leadership and Sustainable Gains	71
2.9.3 Relationship between Lean Culture and Sustainable Gains	77

2.9.4	Mediating Effects of Lean Leadership and Lean Culture	79
2.10	Summary of the Chapter	83
CHAPTER THREE RESEARCH METHODOLOGY		84
3.1	Introduction	84
3.2	Underpinning Theories	84
3.3	Research Framework and Operational Definitions	91
3.4	Research Design	94
3.4.1	Research Philosophy	95
3.4.2	Approach to Theory Development and Methodological Choice	96
3.4.3	Research Strategy	100
3.4.4	Time Horizon	101
3.5	Sampling Process	103
3.5.1	Population, Target Population and Sampling Frame	104
3.5.2	Unit of Analysis and Eligible Respondents	107
3.5.3	Sampling Technique	109
3.5.4	Sample Size	112
3.6	Instrumentation	114
3.6.1	Questionnaire Development	115
3.6.2	Questionnaire Pre-Test	120
3.6.3	Data Collection Procedures	128
3.7	Data Analysis Techniques	129
3.7.1	Descriptive Statistics	130
3.7.2	PLS-SEM	130
3.8	Summary of the Chapter	135
CHAPTER FOUR ANALYSIS & FINDINGS		136
4.1	Introduction	136
4.2	Response Rate	136
4.2.1	Post-Hoc Power Analysis	138
4.2.2	Non-Response Bias Test	140
4.3	Data Screening	141
4.3.1	Missing Data	142
4.3.2	Suspicious Response	143
4.3.3	Outlier Cases	143
4.3.4	Normality of Data Distribution	145
4.4	Demographic Information	146
4.5	Descriptive Statistics	154
4.6	Common Method Bias	157
4.7	Measurement Model Analysis	158
4.7.1	Measurement Model Specification	159
4.7.2	Internal Consistency Reliability and Convergent Validity Assessment	162
4.7.3	Discriminant Validity Assessment	166
4.7.4	CTA-PLS Robustness Test	168
4.8	Structural Model Analysis	169
4.8.1	Collinearity Assessment	170
4.8.2	Model's Explanatory Power and Predictor's Effect Size	171
4.8.3	Model's Predictive Accuracy	174
4.8.4	Model's Predictive Power	175

4.8.5	Significance of Path Relationships	176
4.8.6	Importance-Performance Matrix Analysis	182
4.9	Robustness Tests	184
4.9.1	Nonlinear Effects Assessment	185
4.9.2	Unobserved Heterogeneity Assessment	186
4.10	Summary of the Chapter	188
CHAPTER FIVE DISCUSSIONS & CONCLUSION		190
5.1	Introduction	190
5.2	Recapitulation of the Study	190
5.3	Discussion of the Research Findings	195
5.3.1	Answers for Research Question 1	195
5.3.2	Answers for Research Question 2	198
5.3.3	Answers for Research Question 3	200
5.4	Research Implications and Contributions	203
5.4.1	Theoretical Contributions	203
5.4.2	Practical Contributions	207
5.4.3	Methodological Contributions	210
5.5	Limitations and Recommendations for Future Research	213
5.6	Summary of the Chapter	217
REFERENCES		221
APPENDICES		265
Appendix A: Lean Transformation Sustainability publications		265
Appendix B: Content Validation Rubric		269
Appendix C: Ratings of Questionnaire Items by Panel of Experts		282
Appendix D: Survey Questionnaire		285
Appendix E: Chi-square Test Output for Non-Response Bias Assessment		301
Appendix F: EM and MCAR Test Output for Missing Data Replacement		303
Appendix G: Chi-square Table for Multivariate Outliers Detection		304
Appendix H: WebPower Output for Multivariate Data Normality Test		305
Appendix I: Frequency Analysis Output for Demographic Information		306
Appendix J: Descriptive Analysis Output		310
Appendix K: Full Collinearity Test Output for CMB		311
Appendix L: PLS Algorithm Output for Construct Reliability and Validity Tests		312
Appendix M: CTA-PLS Output for Measurement Model Robustness Test		318
Appendix N: Blindfolding and PLSpredict Output for Model Predictive Power		319
Appendix O: Bootstrapping Output for Significance Testing		320
Appendix P: IPMA Output		322
Appendix Q: Output Quadratic Effects for Nonlinearity Robustness Test		323
Appendix R: Output Ramsey's RESET for Nonlinearity Robustness Test		324
Appendix S: Output FIMIX-PLS for Unobserved Heterogeneity Robustness Test		325

LIST OF TABLES

Table	Page
Table 2.1 <i>Lean lexicon</i>	20
Table 2.2 <i>Lean transformation sustainability definitions</i>	32
Table 2.3 <i>Coherence between the concept of sustainable organisational change, LTS definitions and synonym terms used in previous studies</i>	35
Table 2.4 <i>Lean transformation sustainability studies</i>	37
Table 2.5 <i>Lean transformation sustainability models validation modes</i>	40
Table 2.6 <i>Lean transformation sustainability contributing factors</i>	42
Table 2.7 <i>Compatibility between lean leadership principles and factors contribute to lean transformation sustainability</i>	43
Table 2.8 <i>Compatibility between lean culture dimensions and factors contribute to lean transformation sustainability</i>	44
Table 2.9 <i>Research designs of lean transformation sustainability studies</i>	46
Table 2.10 <i>Statistical analysis of relationships among LTS variables</i>	47
Table 2.11 <i>Assessed variables in previous lean transformation sustainability studies</i>	48
Table 2.12 <i>Compatibility of sustainable lean gains with operational performance and business performance</i>	50
Table 2.13 <i>Compatibility of lean transformation sustainability contributing factors with lean leadership and lean culture</i>	50
Table 2.14 <i>Definitions and dimensions of lean leadership construct</i>	58
Table 2.15 <i>Synthesisation of lean leadership measurements</i>	63
Table 3.1 <i>Compatibility of studied constructs with Theories E and O</i>	87

Table 3.2 <i>Constructs' operations definitions</i>	93
Table 3.3 <i>Development of lean transformation sustainability SAQ</i>	118
Table 3.4 <i>Profile of lean experts</i>	122
Table 3.5 <i>CVI and IRA for Lean Building Blocks and Lean Tools Adoption Maturity constructs</i>	124
Table 3.6 <i>CVI and IRA for Sustainable Gains constructs</i>	125
Table 3.7 <i>CVI and IRA for Lean Leadership constructs</i>	125
Table 3.8 <i>CVI and IRA for Lean Culture constructs</i>	126
Table 4.1 <i>Survey information</i>	137
Table 4.2 <i>Non-response bias results</i>	141
Table 4.3 <i>List of missing data</i>	142
Table 4.4 <i>Summary of outliers' detections</i>	144
Table 4.5 <i>Demographic information: Organisations' profile</i>	147
Table 4.6 <i>Demographic information: Respondents' profile</i>	151
Table 4.7 <i>Range of cutting points and levels of categories</i>	155
Table 4.8 <i>Mean and standard deviation of latent variables</i>	156
Table 4.9 <i>Full collinearity test results</i>	158
Table 4.10 <i>Internal consistency and convergent validity results</i>	163
Table 4.11 <i>Discriminant validity results (HTMT Ratio)</i>	167
Table 4.12 <i>CTA-PLS results</i>	169
Table 4.13 <i>Collinearity assessment results</i>	171
Table 4.14 <i>Results of explanatory power (R^2) and effect sizes (f^2)</i>	173
Table 4.15 <i>Results of predictive accuracy (Q^2)</i>	175
Table 4.16 <i>Results of PLSpredict</i>	175
Table 4.17 <i>Results of significance testing (direct relationships)</i>	178

Table 4.18 <i>Results of significance testing (indirect relationships)</i>	180
Table 4.19 <i>Summary of mediation types</i>	182
Table 4.20 <i>Result of IPMA</i>	183
Table 4.21 <i>Nonlinear effects assessment</i>	186
Table 4.22 <i>Fit indices for the one- to three-segment solutions</i>	187
Table 4.23 <i>Relative segment sizes</i>	188
Table 5.1 <i>Alignment of research objectives with statistical analyses and research hypotheses</i>	194
Table 5.2 <i>Summary of research findings</i>	218
Table 5.3 <i>Summary of research implications</i>	219
Table 5.4 <i>Summary of limitations and future research opportunities</i>	220



LIST OF FIGURES

Figure	Page
Figure 2.1 <i>Phases of lean transformation studies</i>	21
Figure 2.2 <i>Lean transformation sustainability research trend</i>	23
Figure 2.3 <i>Lean building blocks</i>	45
Figure 3.1 <i>Lean Transformation Sustainability Model</i>	92
Figure 3.2 <i>Adopted research design inquiries according to Research Onion</i>	95
Figure 3.3 <i>Flow chart of overall research process</i>	98
Figure 3.4 <i>Methodological choices</i>	99
Figure 3.5 <i>Sample size calculation using G*Power</i>	113
Figure 4.1 <i>Post-hoc power analysis using G*Power</i>	139
Figure 4.2 <i>Measurement model stage one</i>	161
Figure 4.3 <i>Measurement model stage two</i>	162
Figure 4.4 <i>Main effect model</i>	173
Figure 4.5 <i>Structural model</i>	177
Figure 4.6 <i>Types of mediation</i>	181
Figure 4.7 <i>Importance-performance map</i>	183

LIST OF ABBREVIATIONS

AVE	Average variance extracted
C&P	Chemicals and petrochemicals
CB-SEM	Covariance-based Structural Equation Modelling
CCA	Confirmatory composite analysis
CI	Continuous improvement
CMB	Common method bias
CMV	Common method variance
CoE	Centre of Excellence
COVID-19	Coronavirus disease 2019
CREANOVA	Creativity and innovation
CTA	Confirmatory tetrad analysis
CVI	Content validity index
DOSM	Department of Statistics Malaysia
E&E	Electrical and electronics
EM	Expectation maximisation
EPU	Economic Planning Unit
FMM	Federation of Malaysian Manufacturers
FIMIX-PLS	Finite mixture PLS
F&B	Food and beverages
FPS	Ford Production System
GLOBE	Global Leadership and Organizational Behaviour Effectiveness
GDP	Gross domestic product
HCM	Hierarchical component model
HOC	Higher order construct

HTMT	Hetereotrait-monotrait
I&S	Iron and steel
IMVP	International Motor Vehicle Program
IPMA	Importance-performance matrix analysis
IRA	Inter-rater agreement
JIT	Just-in-time
LBB	Lean tools building blocks
LC	Lean culture
LEI	Lean Enterprise Institute
LL	Lean leadership
LM	Lean tools adoption maturity
LOC	Lower order construct
LPS	Lean production system
LTS	Lean transformation sustainability
M&E	Machinery and equipment
MAJAICO	Malaysia Japan Automotive Industries Cooperation
MARii	Malaysia Automotive, Robotics and IoT Institute
MCAR	Missing completely at random
MCO	Movement control order
MPC	Malaysia Productivity Corporation
MIDA	Malaysian Investment Development Authority
MIT	Massachusetts Institute of Technology
MITI	Ministry of International Trade and Industry
MLR	Multiple linear regressions
MYR	Malaysia ringgit

NUMMI	New United Motor Manufacturing Inc.
NZTE	New Zealand Trade and Enterprise
PLS-SEM	Partial Least Square Structural Equation Modelling
RESET	Regression equation specification error test
RMSE	Root mean square error
RO	Research objective
RQ	Research question
RCA	Revealed comparative advantage
SAQ	Self-administered questionnaire
SG	Sustainable gains
SLR	Systematic literature review
SME	Small and medium-sized enterprise
SMM	Small and medium-sized manufacturing
SPSS	Statistical Package for Social Science
TFP	Total factor productivity
Theory E	Theory of economic value
Theory O	Theory of organisational capability
TMM	Toyota Motor Manufacturing
TPM	Total productive maintenance
TPS	Toyota Production System
TQM	Total quality management
VIF	Variance inflation factor
WWII	World War II

CHAPTER ONE

INTRODUCTION

1.1 Research Background

Lean production system (LPS) is a term introduced and used by John Krafcik (1988) to represent Toyota Production System (TPS). TPS was founded to help Toyota Motor Manufacturing (TMM) rebuild and survive in the environment of limited resources after the Second World War (WWII). Its main objective is to reduce waste in every section and step across the production timeline (Womack, Jones, & Roos, 1990).

Waste in this context refers to non-value-added activities which exist in a production system and can be classified into eight types. The eight wastes include; 1. overproduction, 2. over processing, 3. defect, 4. excessive inventory, 5. unnecessary motions, 6. unnecessary transportation, 7. waiting time, and 8. underutilised labours. These wastes increase production cost while adding no value from the customer's perspective (Kilpatrick, 2003; Ohno, 1988).

As a result of Toyota's success in sustaining its prosperity during 1973 global oil crisis, US manufacturers began to convert from the traditional mass production system to the LPS (Shah & Ward, 2007). This conversion is shortly called as the lean transformation (Mann, 2015; Murti, 2009; Roth, 2011). The term "lean transformation" describes necessary changes to achieve the gains associated with LPS adoption. The term "transformation" suggests a magnitude, wholeness, and depth of change needed in organisations to fully adopt LPS and achieve associated gains (Roth, 2011). Now, LPS is widely acknowledged as the world class manufacturing strategy across the globe.

However, most abroad manufacturers attempted lean transformation with mixed results (Burch, 2008; Schonberger, 2007). Jadhav, Mantha, and Rane (2014) denoted that nearly two-thirds of lean transformation ended with failure while only 16.67% of those transformed had successfully sustained gains. In 2005, over 50% of US manufacturers failed in their lean transformation (Kallage, 2006). In 2007, Industry Week had reported over 70% of US manufacturers did not make well progress in lean transformation while only 2% were fully accomplished their objectives (Tenescu & Teodorescu, 2014). The following year, survey responses of over 300 American lean manufacturers revealed that only 20% were categorised as top performers (Aberdeen, 2008). Also, there were less than 10% of British manufacturers that successfully adopted LPS (Bhasin & Burcher, 2006).

These statistics are indicating that many manufacturers have attempted lean transformation but the success rate is low. This low success rate is largely attributed to the failure in sustaining its gains in the long-run (Nooraei Ashtiani, 2016; Pentlicki, 2014). Lean practices and tools might sound simple, but in reality, most organisations fail to sustain the gains over time. This inability to sustain the gains highlight an important gap in the current lean literatures (Jadhav et al., 2014; Marshall, 2014; Vance, 2017). Apparently, sustaining the whole gains made through lean operations is the key piece of successful lean transformation (Connell, 2008).

In many cases, manufacturers have performed well during the early stage of the transformation, but later realised improvement activities started to stagnate and the gains made became subtle (Dombrowski & Mielke, 2014; Lean Learning Center, 2008; Mohd-Zainal, Goodyer, & Grigg, 2011). According to Veech (2004), improvement

made as the results of lean transformation projects often dissipated after six months of its initiation. This statement is further supported by Connell (2008) who reported production workers of an automotive components manufacturers began reverting back to pre-project operating procedures after a month or two. The newly-improved operating procedures were totally forgotten and abandoned, post six months. In fact, reverting to the old ways of working is charted as the top rank obstacle that retarded lean transformation progress among abroad countries (Lean Enterprise Institute, 2004; Simões, 2012).

Unfortunately, alike setback was also reported in dominant local manufacturing industries (Mohd Rose, Ab Rashid, Nik Mohamed, & Ahmad, 2017; Nordin, Md Deros, & Abd Wahab, 2010b; Sahwan, Ab Rahman, & Md Deros, 2012; Y. C. Wong, Wong, & Ali, 2009). This setback was implying that lean transformation among local manufacturers also vulnerable to sustainability issues. In the context of this study, “sustainability” refers to the ability to be maintained at a certain rate or level over time (Madsen et al., 2019). Roslin, Muhammad Shahadat, Md Dawal, and Tamri (2012) asserted that local manufacturers were having problems adapting and sustaining the lean principles, despite their serious intention to implement LPS.

These issues therefore, have triggered researcher’s interest to empirically investigate what are the factors critical to guarantee the sustainability of lean transformation among Malaysian manufacturers. As per the growing interest, available local publications on lean transformation sustainability (LTS) are still limited (Osman, Othman, & Abdul Rahim, 2020b), while existing international publications on LTS are short of

quantitative evidence, since most publications are case studies (Osman, Che Mamat, & Mat Ali, 2020).

1.1.1 Significance and Issues in Malaysian Manufacturing Sector

This study which focuses on Malaysian manufacturing sector is deemed crucial due to the its magnitude of significance upon Malaysia economy. The significance of local manufacturing sector is proved by its contribution to the national gross domestic product (GDP), employment opportunities and external trade (Hooi, 2016). Malaysia's manufacturing sector have recorded GDP growth at RM1.1 trillion in 2016, compare to year 2013 with RM193.2 billion. This sector remains the second largest sector in the Malaysian economy, contributing 23% to national GDP in 2016 (Malaysia Productivity Corporation, 2014c, 2016).

The manufacturing sector employed 2.39 million persons in 2016 making up 16.9% of the total Malaysian workforce (Malaysia Productivity Corporation, 2016). Approved manufacturing projects in 2016 also have offered employment opportunities for another 64,120 individuals in addition to the existing workforce (Malaysian Investment Development Authority, 2017). This sector also have recorded the highest number of employment opportunities in 2014 with 259, 831 from 757, 031 of total vacancies (Hooi, 2016).

From the external trade viewpoint, electrical and electronics (E&E), machinery and equipment and chemicals industries are labelled as the catalytic sub-sectors for exporting selected manufactured goods. Meanwhile, aerospace components and medical devices manufacturers are identified as the growing sub-sectors which also

spur the manufacturing sector growth through export activities (Malaysian Investment Development Authority, 2017). As the response, Malaysian Investment Development Authority (MIDA) are focusing on these sub-sectors to manufacture and export niche and more complex products as a part of Eleventh Malaysia Plan (11MP).

The E&E industry is the country's largest export earner in 2016. Exports of E&E products totalled RM287.7 billion and accounted for 44.6% of the total value of manufacturing goods exported in 2016. This record was followed by chemicals industry (9.1%), petroleum-based products (8.4%), machinery and equipment (5.8%), metal fabrications (5.2%) while the rest of the contributions were from other sub-sectors such as transport equipment (i.e. automotive, aerospace and shipbuilding), medical devices, rubber products, wood-based products etc. (Malaysia Productivity Corporation, 2016).

Despite of manufacturing sector's great contribution on national economy and its heavy reliance on trading activities, the share of Malaysia's manufacturing exports in the world market is declining. This is proven by the deteriorating number of exports that had revealed comparative advantage (RCA) greater than 1 (Economic Planning Unit, 2016). Economic Planning Unit (EPU) (2016) highlighted that this downturn situation were mainly caused by low productivity, lack of innovation and weak competitiveness of local manufacturing sector compare to the competitor countries like Vietnam and China.

On the contrary, 2009 National Productivity Report revealed that between the year 2005 to 2009, Malaysia manufacturing sector recorded an increase of 0.5% in total factor productivity (TFP) thanks to various improvement strategies implemented by local

manufacturers including lean manufacturing (Mohamed Ismail & Che Razak, 2010a). This report is further supported by many past studies which indicate local manufacturers perceived lean manufacturing as a good strategy in assisting them to improve productivity (Che Mamat, Md Deros, Ab Rahman, & Ahmad Jami, 2014; Mohd Rose et al., 2017; Mohd Rose, Md Deros, & Ab Rahman, 2013; Y. C. Wong et al., 2009).

Unfortunately, local manufacturing sector is now suffering from low productivity which have negatively affected its competitiveness in the global market. Is lean manufacturing adoption no longer offers productivity improvement to local manufacturers? Do these contradict circumstances are implying that local manufacturers are incapable to sustain gains made from lean transformation?

Recent studies in Malaysia context are focusing on how lean manufacturing can be integrated with new manufacturing paradigms such as green model (Cheong, Ng, Saw, Fathi, & Tan, 2019), cleaner production (Yusup, Wan Mahmood, Salleh, & Mohd Yusof, 2014) and sustainable manufacturing practices (Habidin, Mohd Zubir, Mohd Fuzi, & Salleh, 2020; Yusup, Wan Mahmood, Salleh, & Mohd Yusof, 2015) to achieve sustainable manufacturing performance. In contrast, the researcher believes it is more important to study on how to sustain the lean transformation in detail before proceeding to integrate lean manufacturing with these new manufacturing paradigms.

Contrariwise, lean manufacturing has proven its contribution towards competitive advantage (L. G. Jones, 2013; Lewis, 2000; Nicholas, 2011), manufacturer's survival (Lee-Mortimer, 2006) and even encourage innovation process (Ková, 2013; Schultz &

Strømme, 2015) in some other countries. Thus, local manufacturers should be able to overcome the issue of competitiveness and lack of innovation if they manage to preserve gains from lean transformation. Therefore, there is a strong need to study factors that determine manufacturers' sustainable success in lean transformation in the context of Malaysian manufacturing sector.

1.2 Research Problem

Most manufacturers that attempted lean transformation experienced a common problem of its sustainability throughout the years (Association for Manufacturing Excellence, 2009). Failure statistics (Ahmed Soliman, 2013; Costa et al., 2019; Jadhav et al., 2014; Madsen et al., 2019; Pearce & Pons, 2019; Sisson & Elshennawy, 2015; Van Landeghem, Bauters, & Limère, 2013) as well as qualitative evidence on lean transformation downturn (Grigg, Goodyer, & Frater, 2018; Murti, 2009; Pentlicki, 2014; Turesky & Connell, 2010) were repeatedly reported. Yet, most existing studies overlooked the importance of long-term success of lean transformation, especially in Malaysia (Osman, Othman, et al., 2020b). Hence, there is a missing piece in LPS literature from the local perspective.

Majority of prior studies measured lean transformation gains based on tangible indicators such as persistent performance level in terms of operational excellence (Sahoo & Yadav, 2018; Santos Bento & Tontini, 2018), financial advantages (Galeazzo, 2019; L. G. Jones, 2013), and ongoing business growth (Hines, Found, Griffiths, & Harrison, 2008; Roth, 2011). However, manufacturers should also consider intangible indicator such as continuous improvement capability to properly assess whether gains made from lean transformation are truly sustainable or not (Burch, 2008; Murti, 2009;

Schlichting, 2009). In the same vein, Buchanan et al. (2005) characterised that a sustainable organisational change not only recognised by its stability of work methods and persistent achievement of performance goals (tangible indicators), but also its consistent trajectory of improvement (intangible indicator). A credible LTS assessment tool should be able to measure the relative balance between the two gains and the possible synergy created by focusing attention on both types of gains (tangible and intangible) simultaneously (Jørgensen, Matthiesen, Nielsen, & Johansen, 2007). Thus, this study intended to validate the measurement of sustainable lean transformation gains based on both tangible and intangible indicators.

Moreover, most conducted studies on LTS were case studies (Osman, Che Mamat, et al., 2020). Hence, quantitative evidence regarding this phenomenon of interest is still lacking. Quantitative evidence is important to provide generalisability of findings and complement qualitative evidence reported in existing studies (Creswell & Creswell, 2018; Zikmund, Babin, Carr, & Griffin, 2013). Quantitative evidence is also needed to verify and strengthen existing literature and especially confirm the critical factors for lean transformation success (Pearce & Pons, 2019). Such evidence may advance industry practice, giving the tangible statistics required to convince and consult lean practitioners. On that account, this study attempted to add quantitative evidence and establish new statistical findings on this phenomenon of interest.

Also, most existing studies evaluate the magnitude to which an organisation utilised lean tools and techniques as a proxy to measure lean transformation level (Ahmed Soliman & Gadalla, 2014; Iris & Cebeci, 2014; Santos Bento & Tontini, 2018; Setianto & Haddud, 2016). However, focussing on narrow criteria in measuring organisation's

lean transformation level may lead to false assessment (Galeazzo, 2019). Apparently, academic studies reported lean transformation has positive impact on various performance gains (Onofrei, Prester, Fynes, Humphreys, & Wiengarten, 2019; Sahoo, 2019; Shashi, Centobelli, Cerchione, & Singh, 2019), but statistics based on real scenarios in industry recorded high failure rates (Costa et al., 2019; Madsen et al., 2019; Pearce & Pons, 2019). Hence, this study intended to measure lean transformation level beyond the magnitude of utilising lean tools and techniques to avoid false assessment. On that account, “lean maturity” criteria that include magnitude, extensiveness, and experience of organisations in lean tools adoption (Mousavi, Jazani, Cudney, & Trucco, 2020; Roth, 2011) are utilised to assess lean transformation impact on sustainable lean transformation gains.

Besides false assessment of lean transformation level, this study believes that contradiction between academic findings and statistics from industries may be explained by certain intervening variables that often neglected in academic studies. Among the intervening variables that had been tested in recent quantitative studies were including formal training (Ramlee, 2017), quality practices (Onofrei & Fynes, 2019), organisational cultural practices (Cadden, Millar, Treacy, & Humphreys, 2020) and agile manufacturing practices (Khalfallah & Lakhal, 2021). However, none of these variables specifically mediated the effect of lean transformation on sustainable gains.

On the other hand, existing qualitative evidences suggested that lean leadership (Gregory, 2012; Holmemo & Ingvaldsen, 2016; Mann, 2009; Orr, 2005) and formation of lean culture (Liker, 2004; Mann, 2003) are the missing links that supposed to bridge a critical gap between adoption of lean tools and techniques and its sustainable gains.

Therefore, this study also aimed to investigate the mediating effect of lean leadership and lean culture on the relationship between lean tools adoption maturity and sustainable lean transformation gains.

1.3 Research Questions

From the formulated problems in previous section, the following research questions were derived:

1. RQ1: Is there a positive relationship between lean tools adoption maturity and sustainable lean transformation gains?
2. RQ2: Does lean leadership mediate the relationship between lean tools adoption maturity and sustainable lean transformation gains?
3. RQ3: Does lean culture mediate the relationship between lean tools adoption maturity and sustainable lean transformation gains?

1.4 Research Objectives

Referring to the posited research questions, these following objectives were proposed:

1. RO1: To analyse the relationship between lean tools adoption maturity and sustainable lean transformation gains.
2. RO2: To investigate the mediating effect of lean leadership on the relationship between lean tools adoption maturity and sustainable lean transformation gains.
3. RO3: To investigate the mediating effect of lean culture on the relationship between lean tools adoption maturity and sustainable lean transformation gains.

1.5 Research Significance

The significance of this study lies in its ability to contribute to the development of knowledge in the area of lean transformation studies. The present study is regarded as theoretically significant since it attempted to explain relationships between sustainable lean transformation gains and its contributing factors which remain unclear in previous studies. It also tried to investigate the role of human interventions (i.e., lean leadership and lean culture) in lean transformation efforts that are often overlooked in previous studies. Moreover, this study would contribute to the literature on lean transformation sustainability by providing Malaysia's perspective on this phenomenon of interest.

The significance of this study also concerns on the survival of local manufacturing sector and national economy. Department of Statistics Malaysia have charted manufacturing sector as the second largest contributor to national gross domestic product (GDP) since the 80s. Malaysia government through Malaysia Productivity Corporation (MPC) have acknowledged LPS as one of the manufacturing strategy which facilitate manufacturers in increasing total factor productivity (TFP) (Mohamed Ismail & Che Razak, 2010a). The present study is expected to provide local manufacturers with useful insights and best practices on how to sustain lean transformation. The successful and sustainable lean transformation will support the survival of manufacturing sector, and indirectly preserve the economic success (Pentlicki, 2014).

This study would also alert managers and practitioners that it requires more than just complete implementation of lean tools and techniques to acquire continuous and sustainable gains from lean transformation. They should consider other contributing

factors to stay lean and keep harvesting its benefits. Such information is practically useful for both current practitioners and manufacturers who have yet to attempt lean transformation. No organisation will dare to initiate lean transformation if it is unsustainable and prone to failure. Hence, by providing detail insight on set of factors which determine sustainable gains, this study might promote LPS adoption (lean transformation) further among local manufacturing organisations.

1.6 Research Scope

In recent years, the applications of lean principles are increasingly linked to the term sustainability. However, the present study only focused on lean transformation sustainability (LTS) in manufacturing settings. Studies presenting LTS in other settings such as healthcare (Kaltenbrunner, Mathiassen, Bengtsson, & Engström, 2019), construction (Mellado & Lou, 2020), and service in general (Leite, Bateman, & Radnor, 2016; Wuestman & Casey, 2015) were not reviewed or discussed in the present study.

Moreover, only publications that perceived “sustainability” from the context of ability to maintain lean transformation over time or in the long-run (Benkarim & Imbeau, 2021; Jørgensen et al., 2007; Madsen et al., 2019) were referred and critically discussed. On the contrary, studies that viewed “sustainability” from the context of triple bottom line (i.e., environment, social, and economy sustainability) were not seriously considered or discussed in detail. For instance, studies done by Kumar, Mathiyazhagan, and Mathivathanan (2020), Habidin et al. (2020), Tiwari, Sadeghi, and Eseonu (2020) as well as Iranmanesh, Zailani, Hyun, Ali, and Kim (2019) were omitted.

Also, this study focussed on lean transformation sustainability within the operations system in manufacturing organisations. An operations system includes; 1. inputs (e.g., expertise, best practices, funding, equipment, facilities and technologies), 2. processes (e.g., capacity planning, production, inventory, and quality control), 3. outputs (e.g., high quality products), and 4. outcomes (e.g., satisfied customers) (McNamara, n.d.). The present study did not cover the larger setting (i.e., production system) because major lean transformation activities do not involve matters beyond manufacturing operations such as distribution, sales, and advertising (Bicheno & Holweg, 2009; Nightingale & Srinivasan, 2011; Ruffa, 2011; Swamidass, 2000).

This study also limits the research scope to manufacturing organisations that are currently pursuing lean transformation for at least two years following previous studies (Galeazzo, 2019; Madsen et al., 2019; Murti, 2009; Van Landeghem et al., 2013). Madsen et al. (2019) suggesting that the diffusion and use of the lean principles stand a good chance of keeping its current level and momentum after two years of its deployment. Two-year delay after lean transformation initiation is long enough for organisations to learn to be lean and develop necessary capabilities to capitalise on its potential benefits. Another criterion to consider for drawing eligible samples for this study is the position of individual that would represent the selected manufacturing organisations. Only managerial level staffs (top, middle or first-line managers) are regarded as qualified individuals to provide answers regarding lean transformation inquiries in their respective organisations (Netland, Powell, & Hines, 2020; van der Merwe, 2016).

Further, this study adopted survey research design since it is considered as an appropriate strategy to collect quantitative data for answering causal research questions (Chua, 2014; Creswell, 2014; Sekaran & Bougie, 2016). All three research questions posited in the present study were causal research questions i.e., to test whether or not one variable causes another variable to change. Since the research model was established based on soft theories, the causal relationships between variables being studied were hypothesised based on predictions. Therefore, partial least square structural equation model (PLS-SEM) was employed to analyse the research data. Hence, no model fit assessment (goodness-of-fit indices) was involved in the data analysis procedures. Instead, it was compensate with model's predictive accuracy, Q^2 and model's predictive power, Q^2_{predict} assessments to indicate the statistical model goodness.

1.7 Definition of Key Terms

The following lists are the definitions of terms that are repeatedly mentioned throughout this thesis:

Lean Tools Building Blocks

A set of lean tools and techniques which can be used by practitioners to introduce, improve and sustain the Lean System in their organisation (Alukal, 2006a).

Lean Culture

An ideal organisational (corporate) culture that foster the success and sustainability of lean transformation in business organisations (Jenei, Toarniczky, Losonci, & Imre, 2014; Urban, 2015).

Lean Elements

Refer to lean tools, techniques, practices, procedures and principles (Gurumurthy & Kodali, 2009).

Lean Leadership

Organisation leaders' necessary roles, values, competencies, skills, attributes or characteristics for effective lean transformation (Gundes de Almeida, Tortorella, & van Dun, 2018).

Lean Tools Adoption Maturity

Refers to how complete, how widely, and how long lean tools and techniques are adopted in an organisation (Mousavi et al., 2020).

Lean Pilot Project

The process of installing basic lean elements into the organisational system.

Lean Thinking

Recognising lean as an operational philosophy that centres on reducing waste and adding value (R. Othman, 2016).

Lean Transformation

The conversion from traditional production system to lean production system (Mann, 2015; Murti, 2009). It is also referring to necessary changes to achieve the gains associated with lean practices (Roth, 2011).

Lean Transformation Sustainability

Maintaining the momentum of lean transformation in organisation's operations system to achieve persistent performance goals while having consistent direction towards continuous improvement.

Sustainable Gains

The ability to persistently acquire benefits and improvements from lean transformation efforts that include both tangible and intangible gains.

Sustainability

The ability to be maintained at a certain rate or level over time (Madsen et al., 2019).

Waste

Any non-value added activities or resources identified in a production system which mainly categories into eight types including overproduction, over processing, inventory, defect, motion, transportation, waiting time and underutilised labour (Kilpatrick, 2003; Ohno, 1988).

1.8 Organisation of the Thesis

This thesis consists of five main chapters namely, Introduction, Literature Review, Research Methodology, Analysis and Findings, as well as Discussion, Conclusion and Recommendations. The first chapter which is the Introduction presented background of the research, statements of the problem along with posited research questions, proposed objectives, research scope, significance of the research and definition of key terms used in this thesis.

The second chapter encompassed review of lean transformation studies at both global and local settings. Furthermore, this chapter included discussion of previous researches related to sustainable organisational change, sustainable lean transformation in particular, and factors that contribute to its sustainability. This chapter ended with the proposition of several hypotheses to be tested later in Chapter Four.

The third chapter first introduced underpinning theories that support the newly established research framework, named as Lean Transformation Sustainability model. Besides that, this chapter operationally defined variables included in the research framework. Chapter Three also explained how the research was designed, what instruments and analyses had been used, conducted data collection procedures along with sampling justification. Furthermore, the procedures and results of the survey questionnaires pre-test were also presented in this chapter. Selection of appropriate data analysis techniques to test proposed hypotheses and answer the related research questions were also discussed as the closing for this chapter.

The fourth chapter presented step-by-step analysis procedures performed to test all of the hypotheses proposed in the second chapter. Besides hypotheses testing, this chapter also reported the detail about the samples gathered. Findings from the hypotheses testing were also explained and aligned with the research objectives proposed in the first chapter.

Finally, the last chapter concluded the findings and confirmed the research objectives accomplishment. In addition, this chapter highlighted the implications of the study,

discussed several limitations and further recommend directions and opportunities for future research.



CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter presented review of Lean Production System (LPS) history and its development in both global and local settings. Various definitions, terminologies, and nomenclatures on LPS were also discussed. Furthermore, this chapter included discussion of previous studies related to ambiguous issues on Lean Transformation Sustainability and its potential determinants.

2.2 History and Development of Lean Production System

Lean production system (LPS) was inspired from Toyota Production System (TPS) founded by Taiichi Ohno. Ohno was an engineer from Toyota Motor Manufacturing (TMM) who studied Ford Production System (FPS) to help TMM rebuild after the Second World War (WWII). On that time, TMM realised that they could not afford to invest much due to lack of resources. Therefore, TPS was developed with its main objective to produce more with less resources (Ohno, 1988).

Then, the term “lean” was first introduced and used by John F. Krafcik to describe a waste-free production system (Hallam & Keating, 2014). Krafcik was a manufacturing engineer at New United Motor Manufacturing Inc. (NUMMI) and also one of the member of International Motor Vehicle Program (IMVP) research team organised by Massachusetts Institute of Technology (MIT) (Krafcik, 1988). The term “lean” is an analogy to a lean body mass which means a body consisted of no or minimum fat. The fat is interpreted as the waste in the context of a production system (K. B. Stone, 2012a).

Due to Toyota's success in sustaining its prosperity during 1973 global oil crisis, US manufacturers began to convert from the traditional mass production system to the LPS (Shah & Ward, 2007). This conversion is shortly called as lean transformation (Mann, 2015; Murti, 2009; Roth, 2011). The term "lean transformation" describes necessary changes to achieve the gains associated with LPS adoption. The term "transformation" suggests a magnitude, wholeness, and depth of change needed in organisations to fully adopt lean thinking and sustain the resulting gains (Roth, 2011). Now, LPS is widely acknowledged as the world class manufacturing strategy across the globe.

As lean transformation endeavours continue to expand across the globe, numerous jargons such as "lean philosophy", "lean thinking", "lean principles", "lean production", "lean manufacturing", and "lean enterprise" began to make appearance in the literature. To avoid terminological confusion in the present study, definitions of all related terms are therefore provided (see Table 2.1).

Table 2.1
Lean lexicon

Terms	Definitions
1. Lean philosophy	The definition of lean, its principles and main concepts (Gupta & Jain, 2013).
2. Lean thinking	Recognizing lean as an operational philosophy that centres on reducing waste and adding value (R. Othman, 2016).
3. Lean principles	A set of beliefs based on lean thinking that guide operational strategy and decision (Nicholas, 2018). Five lean principles introduced by Womack and Jones (1996) are including; value, value stream, flow, pull, and perfection.
4. Lean practices	The tangible mechanisms used to operationalised and implement lean principles (Mirdad & Eseonu, 2015).
5. Lean elements	Refers to lean practices, tools, and techniques (Gurumurthy & Kodali, 2009).
6. Lean operations	Operations that supply customers with exactly what they want, when the customer wants it without waste through continuous improvement (Heizer, Render, & Munson, 2017).
7. Lean manufacturing	Lean transformation activities which occur at the manufacturing area within a production system (Abdul Wahab, Mukhtar, & Sulaiman, 2017).
8. Lean production	Lean transformation activities which cover a larger scope, beyond manufacturing operations that may include supply chain operations, distribution, and sales (Abdul Wahab et al., 2017; Swamidass, 2000).

Table 2.1 (continue)

Terms	Definitions
9. Lean process	An idea that expands beyond lean manufacturing or lean production which encompass all organisational functions (Pakdil & Leonard, 2015).
10. Lean enterprise	An ongoing agreement among all the organisations sharing the value stream for a product family to correctly specify value from the end customers' perspectives, eliminate wasteful activities from the value stream, and make actions that actually create value occur in continuous flow as pulled by the customers (Lean Enterprise Institute, 2014).

2.2.1 Global Trends of Lean Transformation Studies

K. B. Stone (2012a) categorised the trend of lean transformation studies into five phases along four decades (1970-2009) as illustrated in Figure 2.1.

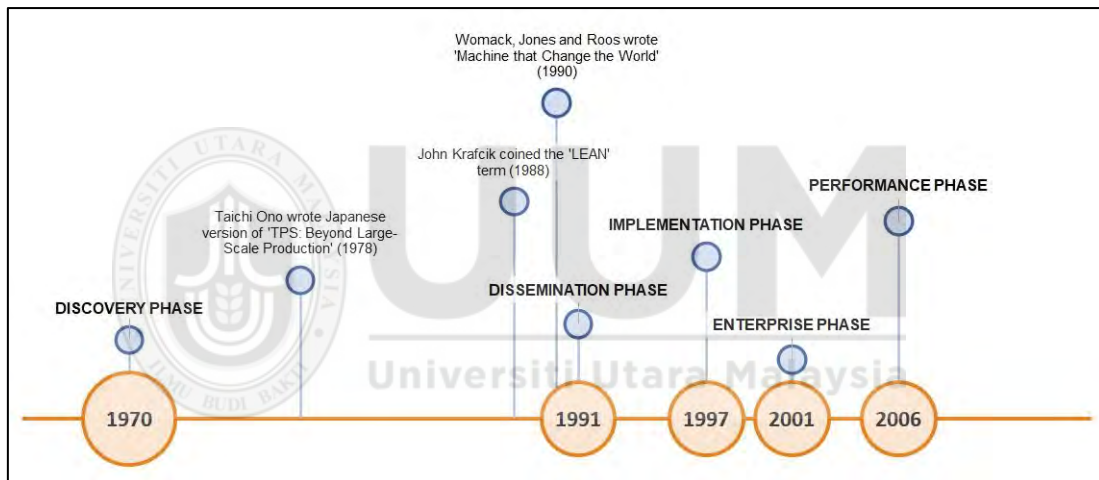


Figure 2.1
Phases of lean transformation studies

The earliest is the Discovery Phase (1970-1990), when books and articles introducing and promoting lean transformation were written. The Machine that Change the World (Womack et al., 1990), the classic best-selling book about LPS was published in 1990. The book introduced three then expanded to five lean core principles (Womack & Jones, 1996) namely identify value, optimize the value stream, create continuous flow, pull the resources and aim for perfection.

Then, during the Dissemination Phase (1991-1996), Karlsson and Åhlström (1996) developed an operationalised model based on these core principles. The model was established for assessing the transformation of a manufacturing firm from traditional production system into LPS. This model has been widely adapted during Enterprise Phase (2001-2005) and Performance Phase (2006-2009) as in studies by Sánchez and Pérez (2001), Soriano - Meier and Forrester (2002) and Puvanasvaran et al. (2009).

During the Implementation Phase (1997-2000), empirical studies utilising qualitative (Bamber & Dale, 2000; Panizzolo, 1998) and quantitative (Pérez & Sánchez, 2000) research designs started to make appearances. The implementation of LPS includes its feasibility and critics, level of implementation, drivers and barriers. Nevertheless, the number of lean empirical research was considered very few at that time. More empirical studies and lean models were published during Enterprise Phase (2001-2005) and Performance Phase (2006-2009).

Shah and Ward (2003) included human resource management (HRM) in their research model called Lean Bundles in addition to TQM, TPM and JIT introduced by Cua, McKone, and Schroeder (2001). Shah and Ward (2007) then added external factors such as suppliers' relations and customers' involvement to establish a more holistic model. The evolution of this model shows that lean transformation has expanded beyond production lines and shop floor applications, covering broader organisational structure and finally reached the enterprise level.

In order to provide the evidence of gains acquired from the lean transformation, researchers began to assess the effect lean practices, tools or techniques on

organisations' performance. Throughout the Performance Phase (2006-2009), studies regarding the effect of LPS adoption on various performance measures were published. For instance, financial performance (Jayaram, Vickery, & Droge, 2008), operational performance (Dal Pont, Furlan, & Vinelli, 2008) and both financial plus operational performance (Fullerton & Wempe, 2009). However, Stone's systematic literature review (SLR) only covered the development of lean transformation studies until 2009, leaving post Performance Phase (i.e., 2010 onwards) unlabelled.

In more recent SLRs on lean transformation studies, Danese, Manfè, and Romano (2018) and Psomas and Antony (2019) highlighted the problem of sustaining lean transformation and its outcomes over the years as one of the future research directions. This notion was also supported by the consistent publication of studies on this topic over the years and the expansion of its research coverage (setting) (see Appendix A). Based on Appendix A, a line chart was plotted to reveal the research trend over the years (see Figure 2.2).

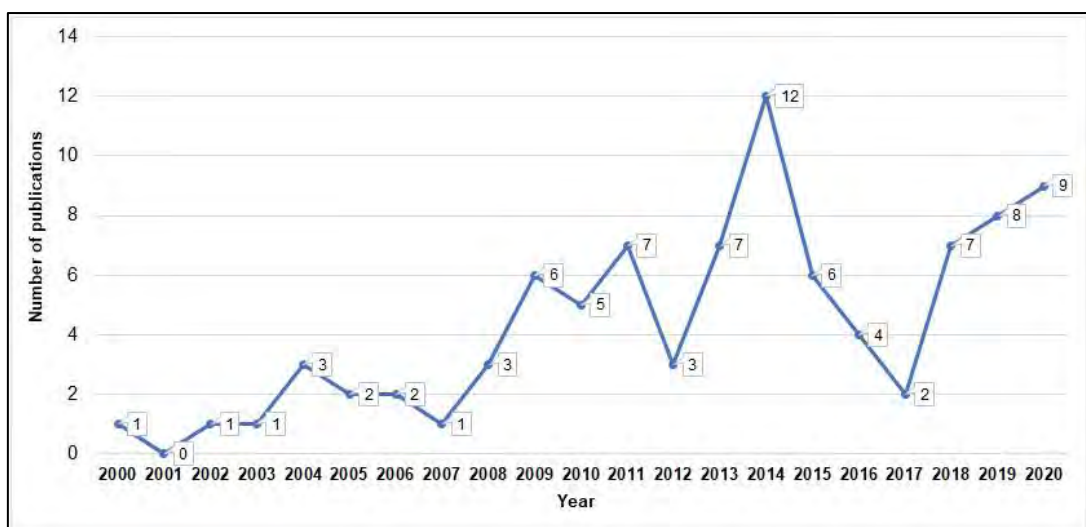


Figure 2.2
Lean transformation sustainability research trend

Figure 2.2 revealed that studies on sustaining lean transformation started to make appearance in year 2000, and there was at least one publication published every year except in 2001. This continuous publication trend is implying that lean scholars are actively researching the ways to sustain lean transformation and its associated gains until recently. Therefore, the post-Performance Phase can be labelled as the “Sustaining Phase”.

2.2.2 Lean Transformation Studies in Malaysia Manufacturing Settings

The first formal lean transformation in Malaysia manufacturing setting was reported in year 2006. This transformation involved local automotive industries through the initiation of Malaysia Japan Automotive Industries Cooperation (MAJAICO) program to develop and mould local automotive industry into competitive industry players globally (Abdul Wahab et al., 2017; Muslimen, Mohd Yusof, & Zainal Abidin, 2011). However, the earliest academic journal published on lean transformation studies in local manufacturing setting was involving aerospace composite industry (Mohamad, Abdullah, & Wan Mahmood, 2008; Puvanasvaran et al., 2008). This was followed by electrical and electronics (E&E) industry (Y. C. Wong et al., 2009) before reaching to food (Abdul Rashid, Shaari, Mohamad Zakuan, & Hasan Basri, 2010) and automotive itself (Nordin, Md Deros, & Abd Wahab, 2010a). Pioneer studies in local manufacturing settings reported the level of lean adoption by the manufacturers was moderate (Mohamad et al., 2008; Nordin et al., 2010b; Puvanasvaran et al., 2008; Y. C. Wong et al., 2009). Further, Malaysian manufacturers continued to show high tendency of adopting lean tools and techniques to pursue improvement in terms of product quality and durability (Yusup et al., 2014).

From the global view, local lean publications began to make appearance during Performance Phase (2006-2009) of Stone's (2012a) lean evolution timeline. Hence, many local researchers had published articles related to lean adoption and its impact on operational performance (Mohamad et al., 2008; Mohamed Ismail & Che Razak, 2010b), business performance (Agus & Hajinoor, 2012; Agus & Iteng, 2013), environmental performance (Bandehnezhad, Zailani, & Fernando, 2012; Hibadullah, Mohd Fuzi, Chiek Desa, Mohd Zamri, & Habidin, 2013) and sustainable performance (Habidin, Mohd Zubir, Conding, Jaya, & Hashim, 2013; Wan Mahmood, Yusup, Salleh, & Mohd Yusof, 2015).

Besides impact of lean adoption on various performance measures, there were also many studies conducted to fill in other literature gaps in Malaysia manufacturing context. A recent systematic literature review (SLR) by Osman, Othman, et al. (2020b) classified these gaps into nine unique themes which include; 1. sustaining lean system implementation, 2. clarifying lean definitions, 3. motivations to implement lean system, 4. benefits from lean system implementation, 5. barriers to successfully implement lean system, 6. factors influencing successful lean system implementation, 7. integration of lean system with other management practices, 8. lean system models development, and 9. results from lean system implementation. Studies on the impact of lean system implementation on performance measures were a part of results acquired from lean system implementation research theme.

Based on a content analysis of 163 lean system studies in Malaysia, this SLR revealed that majority were focussing on results acquired from lean system implementation (91 studies). Then, the trend was followed by the development of lean system

implementation frameworks and models (76 studies). On the contrary, the bottom two research themes that received less attention were; 1. clarifying lean definitions (four studies), and 2. sustaining lean system implementation (three studies). Hence, it was evident that studies on lean transformation sustainability (LTS) are still lacking. In fact, most existing studies did not centre on how to measure LTS and predictors that determine LTS in manufacturing organisations (W. P. Wong, Ignatius, & Soh, 2012; W. P. Wong & Wong, 2014).

The limited number of studies on LTS did not mean this topic was irrelevant or insignificant. According to prior researchers, there were several difficulties and complexity to carry out studies related to LTS. Assessment of sustainability is difficult to conduct due to the high degree of subjectivity (Burch, 2008; L. G. Jones, 2013). Besides, the time dimension to assess the duration of sustainable state of lean transformation could not be captured easily as the implementation level might change over time. Lean transformation might be benefitted to manufacturers during the early stage, but could dissipate over time (Pearce, 2014). Moreover, there was also a considerable confusion on when does the sustaining phase begin after the lean transformation has been initiated (Osman, Othman, & Abdul Rahim, 2020a). Another difficulty stems from the data collection process where collecting data via a large-scale survey of diverse organisations could be quite challenging (Marshall, 2014).

Despite some difficulties and complexity to carry out a study on this topic, it was deemed critical and valuable to be conducted for some reasons. Since lean transformation had been officially introduced to Malaysian manufacturers for over a decade (Abdul Wahab et al., 2017; Muslimen et al., 2011), its adoption in local

manufacturing settings once contributed for 0.5% increment in Malaysia's total factor productivity between the year 2005 to 2009 (Mohamed Ismail & Che Razak, 2010a). Thus, it is critical to identify what are the possible predictors that determine the sustainability of lean transformation among local manufacturers.

This study was also expected to fill the current gap in the literature of lean transformation studies locally. From the international view, there were at least one published study every year that addressed this research theme since 2004 (see Appendix A). This publish trend is implying that sustaining lean transformation has become the major concern among lean scholars and practitioners worldwide (Bhasin & Burcher, 2006; Jadhav et al., 2014; Kallage, 2006; Tenescu & Teodorescu, 2014). This is due to the fact that very few abroad manufacturers succeeded in lean transformation, with published success rates ranging from a merely 2% to 30% (Van Landeghem, Claeys, & Van Landeghem, 2018). A 2016 study of 85 manufacturing organisations involved in lean system for at least eight years reported that only 12% obtained complete success, and overall the level reached was 1.3 on a scale from 0 to 3 (Glass, Seifermann, & Metternich, 2016).

As per the growing interest, federal government through Malaysia Productivity Corporation (MPC) also had shown interest and demonstrated commitment on lean transformation since 2011. MPC's lean journey was initiated as part of improving the operations of the small and medium enterprises (SMEs) in Malaysia. The journey started off with a capacity building module for MPC's officers in collaboration with experts from various industries. This was done to ensure that MPC officers are well-trained before assisting the local SMEs and other government agencies. In 2012, MPC

further improved its lean journey by setting up the LEAN Centre of Excellence (CoE) at MPC's East Coast branch in Kuantan, Pahang. Several kick-start projects followed suit, such as Perbadanan Kemajuan Negeri Pahang (PKNP), Majlis Perbandaran Kuantan (MPK), Pejabat Daerah dan Tanah Kuantan (PDT), Universiti Teknologi Mara (UiTM) and Kuantan Specialist Hospital (Malaysia Productivity Corporation, 2013). A Lean Summit was held in February 2013 to serve as a platform for sharing sessions and to exchange views and opinions. MPC had been actively promoting lean-related programmes such as public training programmes, overseas study missions, hands-on workshops and seminars (Malaysia Productivity Corporation, 2013). MPC claimed its lean transformation model able to improve productivity and efficiency of processes towards better governance and might help companies save millions in costs. Case in point was at Northport Malaysia Bhd. which had initiated lean transformation for the past three years and managed to save about RM25 million throughout the period. The cost saving gain was resulting from reduced investment on spare parts and cost of avoidance in container and logistics segments (themalaysianreserve.com, 2017).

In 2014, the first CREANOVA Lean was organised by MPC and had attracted participations of 89 organisations from both public and private sector (Malaysia Productivity Corporation, 2014a). CREANOVA Lean is a lean management information and best practices sharing event. This event works as a platform of sharing learning experiences resulting from the implementation of lean and *kaizen* projects. The word CREANOVA is derived from the merging of two words, “creativity” and “innovation”. Additionally, the program aims to strengthen the network of strategic and collaborative collaborations among lean practitioners, experts, industry and scientists in order to continue the practice and culture of lean. CREANOVA Lean is also a stage

where successfully implemented lean and *kaizen* projects in government offices and private companies receive formal lean recognition awarded by MPC (Malaysia Productivity Corporation, 2015).

The first MPC Lean Recognition certificate was endorsed in 2013, whereby the total of nine organisations from manufacturing, service and public sectors were the recipients. Further, the number of the Lean Recognition recipients were increasing to 24 organisations in 2014 and 42 organisations in 2015 (Malaysia Productivity Corporation, 2015, 2017). Overall, there are more than 200 organisations all over the country that have been participated in MPC's LEAN Transformation Program and Assessment with majority of them are qualified as Lean Recognition recipients.

The MPC Lean Recognition certificate has three recognition levels namely "bronze", "silver" and "gold". Organisations are recognised with appropriate level based on their total score in two sections of assessment, namely "lean culture" and "lean projects". Five criteria of lean culture assessment gazetted by MPC include; 1. leadership, 2. capacity on lean transformation, 3. engagement, 4. teamwork, and 5. continual improvement. meanwhile, lean projects assessment is evaluated from the perspective of; 1. status of lean projects, 2. aims of lean projects, 3. team provide project implementation plan, 4. lean tools and techniques used in lean projects, 5. utilisation of supporting partners/stakeholders, 6. achievement of lean project aims, and 7. impact of the lean projects (e.g., time, cost, output, quality and process metrics) (Malaysia Productivity Corporation, 2014b). The minimum score for bronze certificate is 60%, while 70% and 80% are for silver and gold certificates respectively.

Therefore, to keep up with the current positive progress and diffusion of lean thinking in local manufacturing organisations, researchers need to concentrate more on sustaining lean transformation in Malaysian manufacturing settings. It is imperative so that local manufacturers will not suffer the same failure as abroad manufacturers did. Rationally, no more organisation will attempt to initiate lean transformation if it is not sustainable and prone to failure.

2.3 The Lean Transformation Sustainability Concept

In recent years, the applications of LPS are increasingly linked to the term sustainability. As highlighted by Benkarim and Imbeau (2021) as well as Madsen et al. (2019), there are two different perspectives of discussing sustainability in the context of LPS research: 1. studying how LPS adoption can be leveraged to reduce waste of raw materials and energy consumption, or 2. assessing whether LPS adoption in industry settings is sustainable in the long-run. With respect to the former, the focus of the literature is on how lean transformation can contribute to environmental sustainability, such as in a study done by Habidin et al. (2020). On the other hand, the latter perspective concerns on how to maintain the momentum of lean transformation once initial pilots and blitzes are completed (Jørgensen et al., 2007). The present study is focussing on the latter perspective.

There are many varying terms used by previous scholars to express lean transformation sustainability (LTS) such as, sustaining lean gains (Mann, 2003), sustaining lean transition (Lucey, Bateman, & Hines, 2004, 2005), sustaining lean conversion (Mann, 2015), sustaining lean initiatives (Connell, 2008), sustaining lean culture (Hogan, 2009; Nooraei Ashtiani, 2016), sustaining lean improvements (Habidin et al., 2013; Rentes,

Araujo, & Rentes, 2009; Schlichting, 2009), sustaining lean ideology (Bhasin & Found, 2020), lean longevity (Burch, 2008), and lean maturity (Jørgensen et al., 2007; Ruffa, 2011).

Unfortunately, most scholars did not provide clear definitions on these varying terms they were using. The use of varying terms without detail definitions in previous studies leads to considerable confusion and ambiguous interpretations of the LTS concept. Ambiguous interpretations of an abstract concept (latent variable) such as LTS, is jeopardising its content validity. Content validity is imperative to guarantee the measurement of a latent variable is truly represent its full meaning (Boateng, Neilands, Frongillo, Melgar-Quinonez, & Young, 2018; Carpenter, 2018). On that account, this study attempted to provide a clear and all-inclusive definition of LTS.

Some studies on LTS had associated its origin with the sustainable organisational change concept (Osman, Othman, et al., 2020a; Poksinska & Swartling, 2018; Turesky & Connell, 2010). An in-depth review on the sustainable organisational change concept by Buchanan et al. (2005) described a sustainable change as the process through which new working methods, performance goals and improvement trajectories are maintained for a period appropriate to a given context. In other words, a sustainable organisational change is characterised by the following facets; 1. the stability of work methods, 2. the persistent achievement of performance goals, and 3. the consistent trajectory of improvement. Therefore, the present study intended to utilise these three facets as a foundation to formulate an all-inclusive definition of LTS. In addition, few simple definitions of LTS from existing literatures were referred (see Table 2.2).

Table 2.2
Lean transformation sustainability definitions

Authors	Definitions
Alukal (2006b)	Obtaining enduring success with lean transformation.
Jørgensen et al. (2007)	Maintaining the momentum of lean transformation once initial pilots and blitzes are completed.
Murti (2009)	The final stage of the process improvement, focused on how to maintain the momentum of lean transformation within firms.
Ruffa (2011)	Achieving the highest level of lean maturity and advancing at a strong but cautious pace.

Table 2.2 revealed four distinct definitions of LTS. Alukal's definition was focussing on sustaining success in lean transformation. Success in lean transformation journey is often associated to performance goals achieved by the practising organisation (Cadden et al., 2020; Sisson & Elshennawy, 2015; Taylor, Taylor, & McSweeney, 2013). This notion reflects the facet of 'persistent achievement of performance goals' marked by Buchanan et al. (2005). In the same vein, it explains why prior scholars used other synonym terms such as sustaining lean gains (Mann, 2003) and sustaining lean improvements (Habidin et al., 2013; Rentes et al., 2009; Schlichting, 2009) to address the LTS concept from persistent achievement viewpoint.

Meanwhile, both Jørgensen's and Murti's definitions concentrated on maintaining lean transformation momentum over time. Maintaining momentum of an organisational transformation concerns on the stability of work methods as suggested by Buchanan et al. (2005). Thus, in the context of lean transformation, this work method refers to the degree to which an organisation adopts lean tools and techniques. Therefore, maintaining momentum of lean transformation was also in-lined with Ruffa's definition that emphasised on lean maturity level. Lean maturity level portrays organisation's progression related to lean adoption (Santos Bento & Tontini, 2019; Setianto & Haddud, 2016) and number of years it has been implemented in the organisation (Galeazzo, 2019). This definition also unravel why previous scholars used other resembling terms

such as sustaining lean transition (Lucey et al., 2004, 2005), sustaining lean conversion (Mann, 2005), sustaining lean initiatives (Connell, 2008), and sustaining lean ideology (Bhasin & Found, 2020) to address the LTS concept from work method stability viewpoint.

Despite there is no specific LTS definition to directly support Buchanan's notion on the consistent improvement trajectory, studies conducted by Burch (2008), Murti (2009), and Schlichting (2009) did stress on continuous improvement capability as a measure of LTS gains. The missing of consistent improvement trajectory criteria from the existing LTS definitions made most studies left out the measurement of continuous improvement in assessing LTS gains. For instance, studies such as Sahoo and Yadav (2018) as well as Santos Bento and Tontini (2018) measured LTS gains based on operational performance. Meanwhile, Galeazzo (2019) and L. G. Jones (2013) studied financial performance as the LTS gain. Therefore, it is evident that many scholars overlooked the criteria of consistent improvement trajectory in defining and measuring LTS concept as claimed by Jørgensen et al. (2007). Burch (2008) highlighted that, while achievement of performance goals is considered as tangible gains acquired from lean transformation, continuous improvement capabilities represent the intangible gains.

Another concern in defining the LTS concept is the time period (duration) of sustaining phase begins and ends. There is indeed a considerable confusion to determine when does the sustaining phase begins (Dale, 1996). In the TQM context, the sustaining phase started when the pilot phase is completed. The pilot phase involves the process of installing various quality management practices and tools into the organisation system. Once the installation process is done, the pilot phase is over and the sustaining phase

starts to commence (Dale, 1996; Idris & Zairi, 2006). Thus, the same logic can be applied to LPS as both TQM and LPS are regarded as continuous improvement methodologies for improving manufacturing operations (Andersson, Eriksson, & Torstensson, 2006; McLean & Antony, 2014).

From a local literature (Wan Mahmood & Muhamad, 2008) and personal communication with local lean consultants, M. Murad and J. Ismail (personal communication, November 3, 2016), a pilot lean project can be completed and started to show visible improvements within 6 months. In the meantime, Ali, Islam, and Lim (2010) described the period of sustaining phase as undefined duration towards the future. Similarly, Buchanan et al. (2005) portrayed that new working methods, performance goals and improvement trajectories which occur during sustaining phase are expected to last for a period appropriate to a given context. Hence, there is no ending period for sustaining phase as long as the organisation desire and intend to continue such effort.

Therefore, this study conceptually defined Lean Transformation Sustainability (LTS) as maintaining the momentum of lean transformation in organisation's production system to achieve persistent performance goals while having consistent direction towards continuous improvement. The sustaining phase begins once the lean pilot project is completed until a certain period appropriates to the setting. Lean pilot project refers to the process of installing basic lean elements into the manufacturing system of an organisation. Basic lean elements are referring to lean practices, tools or techniques that require less investment and feasible to implement, even for SMEs (Gurumurthy & Kodali, 2009; Mohd Rose, Md Deros, & Ab Rahman, 2010). Overall, definition and

facets of sustainable organisational change served as a solid foundation for the newly propose LTS definition (see Table 2.3).

Table 2.3

Coherence between the concept of sustainable organisational change, LTS definitions and synonym terms used in previous studies

Sustainable Organisational Change	Lean Transformation Sustainability	Synonym Terms
Stability of work methods	Momentum of lean transformation (Jørgensen et al., 2007; Murti, 2009; Ruffa, 2011)	1. Sustaining lean initiatives 2. Sustaining lean transition 3. Sustaining lean conversion
Persistent achievement of performance goals	Enduring success (Alukal, 2006b)	1. Sustaining lean improvements 2. Sustaining lean gains
Consistent improvement trajectory	Continuous improvement capabilities (Burch, 2008; Murti, 2009; Schlichting, 2009)	1. Sustaining lean improvements 2. Sustaining lean gains

Table 2.3 presented the coherence between the concept of sustainable organisational change (Buchanan et al., 2005) and LTS definitions extracted from previous studies (Alukal, 2006b; Jørgensen et al., 2007; Murti, 2009; Ruffa, 2011). It was well supported that the newly proposed definition covers the full meaning of LTS concept as it addressed all characteristics of a sustainable organisational change. Moreover, it justified the diverse terms used in previous studies. Such detail definition demonstrated a better content validity evidence compare to other existing LTS definitions.

2.4 Existing Studies on Lean Transformation Sustainability

There is a vast volume of literature dedicated to LPS, but to meet the aims of this study, only publications on lean transformation sustainability (LTS) in manufacturing settings were considered. Publications presenting LTS in other settings such as healthcare (Kaltenbrunner et al., 2019), construction (Mellado & Lou, 2020), and service in general (Leite et al., 2016; Wuestman & Casey, 2015) were excluded.

Moreover, only publications that perceived “sustainability” from the context of ability to maintain lean transformation over time or in the long-run were included. Publications that refer “sustainability” from the context of triple bottom line (i.e., environment, social, and economy sustainability) were also excluded. For instance, studies published by Kumar et al. (2020) as well as Tiwari et al. (2020) were not reviewed in the present study.

As a result, a total of 90 publications related to LTS that consisted of academic journals, conference papers, books, chapters in books, dissertations, and industrial magazines were retrieved. These publications were accessed from various databases including Emerald Insight, Science Direct, Springer Link, Taylor and Francis Online, Inderscience Publishers, ProQuest and Google Scholar. Four search keywords; 1. lean sustainability, 2. sustainable lean, 3. sustaining lean, and 4. lean maturity derived from several pilot references (Alukal, 2006b; Jørgensen et al., 2007; Mohd Yusof & Aoki, 2016; Ruffa, 2011) were used. These sources were considered as pilot references because they provided clear definitions of the LTS concept that helped the researcher to better understand this phenomenon of interest.

A total of 90 publications were deemed adequate to produce a comprehensive and critical review regarding this topic. In fact, recent studies on LTS published in top journals only reviewed 26 publications (Van Landeghem et al., 2018), 28 publications (Zanon, Ulhoa, & Esposto, 2020), 36 publications (Galeazzo, 2019), and 74 publications (Costa et al., 2019) to critically discuss the issue. Therefore, a review of 90 publications in the present study could be considered as more rigorous compared to those recent studies. Further, these 90 publications were grouped into their

respective research objectives to facilitate discussion of the topic. The research objectives were including; 1. Factors that contribute to the success and sustainability of lean transformation, 2. Relationships and underlying causality among LTS variables, 3. LTS models and frameworks development, 4. Maturity or sustainability level assessments, 5. Factors that lead to the failure of lean transformation, and 6. Success stories and best practices from sustainable lean organisations (see Table 2.4).

Table 2.4
Lean transformation sustainability studies

No	Research Objectives	Sources	Total
1.	LTS models and frameworks development	1, 2, 3, 4, 6, 10, 11, 12, 17, 23, 24, 29, 30, 34, 35, 37, 40, 41, 42, 43, 47, 48, 49, 56, 57, 61, 63, 64, 65, 67, 69, 71, 72, 74, 79, 80, 83, 84, 86, 87, 88, 90	42
2.	Relationships and underlying causality among LTS variables	6, 12, 23, 24, 29, 34, 37, 38, 40, 46, 49, 55, 57, 62, 63, 64, 65, 66, 69, 71, 72, 74, 75, 76, 80, 86, 87	27
3.	Factors that contribute to the success and sustainability of lean transformation	8, 9, 12, 16, 20, 21, 27, 28, 37, 39, 44, 52, 53, 54, 62, 68, 74, 77, 79, 84	20
4.	Assessment of lean maturity or transformation sustainability	22, 26, 35, 42, 43, 44, 45, 46, 50, 54, 58, 60, 61, 64, 72, 81, 88, 89, 90	19
5.	Factors that lead to the failure of lean transformation	7, 13, 17, 19, 25, 32, 36, 42, 49, 51, 71, 73, 82, 85	14
6.	Success stories from sustainable lean organisations	5, 14, 15, 18, 23, 24, 31, 32, 41, 48, 59, 66, 70	13

Source: 1. Popoola (2000), 2. Nightingale and Mize (2002), 3. Mann (2003), 4. Drew, McCallum, and Roggenhofer (2004), 5. Lucey et al. (2004), 6. Veech (2004), 7. Lucey et al. (2005), 8. Wood (2005), 9. Alukal (2006b), 10. Found et al. (2006), 11. Jørgensen et al. (2007), 12. Burch (2008), 13. Connell (2008), 14. Lean Learning Center (2008), 15. Hogan (2009), 16. Mann (2009), 17. Murti (2009), 18. Rentes et al. (2009), 19. Schlichting (2009), 20. Tracey and Flinchbaugh (2009), 21. Hines (2010), 22. Lyonnet, Pillet, and Pralus (2010), 23. Ramakrishnan and Testani (2010), 24. Testani and Ramakrishnan (2010), 25. Turesky and Connell (2010), 26. Bhasin (2011), 27. Hines, Found, Griffiths, and Harrison (2011), 28. Miller (2011), 29. Mohd-Zainal et al. (2011), 30. Nightingale and Srinivasan (2011), 31. Roth (2011), 32. Ruffa (2011), 33. Gregory (2012), 34. K. B. Stone (2012b), 35. W. P. Wong et al. (2012), 36. Ahmed Soliman (2013), 37. Glover, Farris, Van Aken, and Doolen (2013), 38. L. G. Jones (2013), 39. Maalouf (2013), 40. Habidin et al. (2013), 41. Taylor et al. (2013), 42. Van Landeghem et al. (2013), 43. Ahmed Soliman and Gadalla (2014), 44. Dombrowski and Mielke (2014), 45. Hallam and Keating (2014), 46. Iris and Cebeci (2014), 47. Jadhav et al. (2014), 48. Marchwinski (2014), 49. Marshall (2014), 50. Pakdil and Leonard (2014), 51. Pentlicki (2014), 52. Remy (2014), 53. Tenescu and Teodorescu (2014), 54. Tortorella and Fogliatto (2014), 55. Larteb, Haddout, and Benhadou (2015), 56. Mann (2015), 57. Pakdil and Leonard (2015), 58. Schröders and Cruz-Machado (2015), 59. Sisson and Elshennawy (2015), 60. Urban (2015), 61. Maasouman and Demirli (2016), 62. Mohd Yusof and Aoki (2016), 63. Nooraei Ashtiani (2016), 64. Setianto and Haddud (2016), 65. Pakdil and Leonard (2017), 66. Vance (2017), 67. Al Manei, Salonitis, and Tsinopoulos (2018), 68. Grigg et al. (2018), 69. Hallam, Valerdi, and Contreras (2018), 70. Poksinska and Swartling (2018), 71. Sahoo and Yadav (2018), 72. Santos Bento and Tontini (2018), 73. Van Landeghem et al. (2018), 74. Chiarini and Brunetti (2019), 75. Costa et al. (2019), 76. Galeazzo (2019), 77. Kok, Mohd Yusof, and Lau (2019), 78. Madsen et al. (2019), 79. Maginnis, Hapuwatte, and Keown (2019), 80. Santos Bento and Tontini (2019), 81. Sisson (2019), 82. Bhasin and Found (2020), 83. Devine and Bicheno (2020), 84. Gaspar and Leal (2020), 85. Gavilán and Consolación (2020), 86. Habidin et al. (2020), 87. Mousavi et al. (2020), 88. Rossini et al. (2020), 89. Silvério, Trabasso, and Pereira Pessôa (2020), 90. Zanon et al. (2020).

Table 2.4 displayed that most conducted studies were directed to develop models or frameworks of LTS and followed by studies that examined relationships and underlying causality among LTS variables. Also, there were considerable number of publications which identified factors that contribute to the success and sustainability of lean transformation. On the contrary, the least published literatures were aimed to report success stories of sustainable lean transformation from example organisations. Studies that identified factors that lead to the failure of lean transformation were also minority.

This trend appeared to be so because studies on lean transformation failure factors were literally studies that addressed lean transformation success factors from the opposite perspective (negative perception). In the same vein, studies that were conducted based on success stories and best practices of sustainable lean organisations also indirectly addressed factors that contribute to the success and sustainability of lean transformation. The only difference between these two research objectives was the studied sample. Studies that generally identified lean transformation success and failure factors did not set an exact lean transformation duration in selecting the sample of study (e.g., Marshall, 2014; Murti, 2009; Pentlicki, 2014). On the contrary, studies based on lean success stories definitely reported experience of organisations that had succeed and sustained lean transformation for a certain duration. For example, Sisson and Elshennawy (2015) studied four manufacturing companies that had started lean transformation for at least 15 years. Similarly, Taylor et al. (2013) reported the success of a manufacturing company that had deployed lean transformation for around 16 years.

In comparison, objectives of the present study were fourfold. First, this study focused on identifying factors contribute to the success and sustainability of lean transformation

based on literature. Second, this study developed hypotheses that link identified factors with the gains made from a sustainable lean transformation. Third, a statistical assessment model was developed to test the hypothesised relationships and causality between identified factors and LTS gains. Fourth, the present study assessed the level of lean transformation sustainability using tangible and intangible indicators. In short, all four objectives of this study comprised the first four prior studies' research objectives listed in Table 2.4 (i.e., identifying factors contribute to LTS, testing relationships between LTS outcomes and other organisational factors, developing of LTS model, and assessing LTS level).

2.4.1 Lean Transformation Sustainability Models and Frameworks

The terms “model” and “framework” are among popular phrases in the field of operations research and often used interchangeably. Nevertheless, a distinction between these two terms could be further discuss. From the perspective of operations research, Mohd Yusof and Aspinwall (2000) asserted that a model answers the question ‘what is’, whereas, a framework answers the question ‘how to’. However, from the perspective of research methodology scholars, both terms can be concluded as similar. For instance, De Vaus (2002) viewed a model as a theoretical specification of the way in which a set of variables are proposed to be causally related in a scientific research. Meanwhile, Fraenkel, Wallen, and Hyun (2012) viewed a framework as the theoretical approach used to structure a research study. Both definitions highlighted the use of theory as the foundation of conducting a research study. Hence, this study agreed that both terms (model and framework) can be used interchangeably, but distinction can be made if necessary, to suit the purpose of study. This study used the term ‘model’ to

generally address existing LTS models or frameworks in order to facilitate the discussion on this topic.

Further, the present study would like to specify whether existing LTS models and frameworks had been validated or remained as a concept. Validated models and frameworks were then classified according to types of research design adopted by prior scholars to validate their models. Generally, lean scholars adopted survey research, single-case study, multiple-case study, mixed methods study, action research, or focus study to validate their proposed models (Hu, Mason, Williams, & Found, 2015; Jasti & Kodali, 2015) (see Table 2.5).

Table 2.5
Lean transformation sustainability models validation modes

Validation Modes	Sources	Total
Single-case study	1, 2, 4, 10, 11, 15, 18, 22, 26, 28, 35, 41, 42	13
Survey researches	14, 16, 21, 23, 27, 32, 33, 34, 36, 39, 40	11
Conceptual	3, 5, 6, 12, 17, 29, 30, 31	8
Multiple-case study	9, 24, 37	3
Action research	7, 38	2
Mixed-methods	8	1
Focus study	Not available	-

Source: 1. Popoola (2000), 2. Nightingale and Mize (2002), 3. Mann (2003), 4. Drew et al. (2004), 5. Veech (2004), 6. Found et al. (2006), 7. Jørgensen et al. (2007), 8. Burch (2008), 9. Murti (2009), 10. Ramakrishnan and Testani (2010), 11. Testani and Ramakrishnan (2010), 12. Mohd-Zainal et al. (2011), 13. Nightingale and Srinivasan (2011), 14. K. B. Stone (2012b), 15. W. P. Wong et al. (2012), 16. Glover et al. (2013), 17. Habidin et al. (2013), 18. Taylor et al. (2013), 19. Van Landeghem et al. (2013), 20. Ahmed Soliman and Gadalla (2014), 21. Jadhav et al. (2014), 22. Marchwinski (2014), 23. Marshall (2014), 24. Mann (2015), 25. Pakdil and Leonard (2015), 26. Maasouman and Demirli (2016), 27. Nooraei Ashtiani (2016), 28. Setianto and Haddud (2016), 29. Pakdil and Leonard (2017), 30. Al Manei et al. (2018), 31. Hallam et al. (2018), 32. Sahoo and Yadav (2018), 33. Santos Bento and Tontini (2018), 34. Chiarini and Brunetti (2019), 35. Maginnis et al. (2019), 36. Santos Bento and Tontini (2019), 37. Devine and Bicheno (2020), 38. Gaspar and Leal (2020), 39. Habidin et al. (2020), 40. Mousavi et al. (2020), 41. Rossini et al. (2020), 42. Zanon et al. (2020).

Table 2.5 clearly revealed that most of the models had been validated. Only 19% of the models are conceptual. Most scholars validated their proposed model by adopting single-case study research design. No model was validated through a focus study (expert's viewpoint) and very few scholars adopted action research and mixed-methods

to validate the proposed model. There were also a fair number of studies that used survey research design to validate the model. However, it was evident that most LTS models were validated based on qualitative evidence. Both types of case studies (single or multiple), as well as action researches produced qualitative evidence (i.e. non-numerical data such as texts, images and quotes or context-specific secondary data) (Jasti & Kodali, 2015).

In fact, most LTS surveys were conducted with limited sample size which prevented prior scholars to support the model validation with rigorous quantitative evidence. For example, K. B. Stone (2012b) successfully gathered 66 samples from 66 North-American medium-sized manufacturing organisations and Larteb et al. (2015) only collected 41 samples from small and medium-sized manufacturing organisations in Morocco. Meanwhile, studies that managed to gather a quite large sample size such as Habidin et al. (2020) (227 samples) and Marshall (2014) (319 samples) were only studying individuals as the unit of analysis. Therefore, there is a need to conduct a survey with considerable number of samples at organisational level to appropriately validate a proposed LTS model using rigorous statistical analyses. This notion is also consistent to a recent review by Pearce and Pons (2019) that highlighted a rigorous quantitative evidence is needed to verify and strengthen existing literature and especially confirm the critical factors for sustaining lean transformation. Such evidence might advance industry practice, giving the tangible statistics required to convince and consult lean practitioners.

2.4.2 Lean Transformation Sustainability Contributing Factors

A number of studies had been conducted to identify and understand the factors that manipulate the process and journey of organisation's lean transformation. The effective management of these factors, to the possible extent, is critical for a successful and sustainable lean transformation. Table 2.6 showed 35 studies and the 28 factors they had identified.

Table 2.6

Lean transformation sustainability contributing factors

No	Contributing Factors	Sources	Total
1.	Management leadership	1, 6, 7, 8, 10, 11, 12, 14, 15, 17, 18, 21, 22, 24, 27, 29, 31, 32, 35	19
2.	Employee involvement / engagement / empowerment	3, 4, 5, 7, 8, 10, 11, 12, 14, 15, 17, 18, 19, 24, 28, 29, 31, 32, 35	19
3.	Management support and/or commitment	2, 3, 5, 6, 7, 10, 11, 14, 15, 18, 19, 26, 27, 28, 29, 33, 34, 35	18
4.	Regular, two-way and transparent communication	1, 3, 4, 6, 9, 10, 11, 12, 14, 17, 22, 24, 25, 28, 30, 32, 34, 35	18
5.	Training provision	3, 4, 5, 6, 8, 10, 11, 14, 17, 20, 21, 22, 25, 28, 29, 31, 35	17
6.	Performance review	2, 3, 5, 7, 8, 9, 10, 11, 14, 15, 17, 20, 24, 29, 30, 35	16
7.	Visionary / long-term thinking / forward thinking	2, 3, 8, 10, 11, 14, 17, 18, 25, 26, 27, 29, 31, 32, 35	15
8.	Teamwork (e.g., small group activities, cross-functional teams)	3, 6, 7, 8, 9, 14, 15, 23, 24, 26, 28, 31, 33, 35	14
9.	Standard work practice	2, 3, 6, 7, 10, 11, 14, 17, 19, 25, 28, 30, 33, 34	14
10.	Policy deployment / <i>hoshin kanri</i> / align vision	2, 3, 6, 10, 11, 17, 18, 24, 25, 27, 29, 31, 35	13
11.	Visual management	2, 5, 6, 7, 8, 10, 11, 13, 19, 25, 27, 30, 34	13
12.	Recognition, rewards & incentives	1, 3, 6, 8, 9, 12, 15, 17, 20, 22, 24, 28	12
13.	Expanding lean transformation to other business areas and suppliers	5, 6, 10, 11, 17, 21, 25, 28, 29, 30, 31, 35	12
14.	Ownership from employees / daily accountability / accountability management / stewardship	1, 2, 3, 8, 10, 11, 15, 17, 19, 28, 34, 35	12
15.	Invest in leadership development	6, 7, 9, 10, 11, 18, 21, 25, 28, 30, 32	11
16.	Continuous improvement program (i.e. kaizen event)	3, 4, 5, 8, 13, 14, 15, 23, 25, 26	10
17.	Resource's allocation (e.g. time, effort, budget)	3, 6, 8, 11, 17, 21, 27, 29, 35	9
18.	Full-time (dedicated) lean transformation team	3, 6, 8, 9, 10, 11, 14, 15, 25	9
19.	Utilise lean consultants / champions	3, 6, 10, 11, 14, 21, 25, 30, 35	9
20.	Value stream mapping	7, 8, 10, 11, 13, 14, 25, 27, 35	9
21.	Problem solving	7, 13, 14, 17, 18, 26, 33, 34, 35	9

Table 2.6 (continue)

No	Contributing Factors	Sources	Total
22.	Coaching	5, 6, 7, 8, 18, 24, 28, 32	8
23.	Reflection (learn from mistakes)	1, 10, 11, 14, 24, 26, 35	7
24.	Adapting lean to fit organisation's context	6, 11, 17, 21, 25, 35	6
25.	Use new, reliable, tested technology	10, 11, 14, 26, 29, 33	6
26.	Experimentation and risk taking	3, 14, 15, 24, 26, 35	6
27.	Innovation	10, 11, 14, 24, 26, 33	6
28.	Selection and hiring (recruitment)	9, 10, 11, 14, 20	5

Source: 1. Lucey et al. (2004), 2. Wood (2005), 3. Alukal (2006b), 4. Burch (2008), 5. Lean Learning Center (2008), 6. Hogan (2009), 7. Mann (2009), 8. Rentes et al. (2009), 9. Tracey and Flinchbaugh (2009), 10. Hines (2010), 11. Hines et al. (2011), 12. Miller (2011), 13. Roth (2011), 14. Ruffa (2011), 15. Glover et al. (2013), 16. Maalouf (2013), 17. Taylor et al. (2013), 18. Dombrowski and Mielke (2014), 19. Marchwinski (2014), 20. Marshall (2014), 21. Pentlicki (2014), 22. Remy (2014), 23. Tenescu and Teodorescu (2014), 24. Tortorella and Fogliatto (2014), 25. Sisson and Elshennawy (2015), 26. Mohd Yusof and Aoki (2016), 27. Grigg et al. (2018), 28. Poksinska and Swartling (2018), 29. Sahoo and Yadav (2018), 30. Van Landeghem et al. (2018), 31. Chiarini and Brunetti (2019), 32. Kok et al. (2019), 33. Maginnis et al. (2019), 34. Gaspar and Leal (2020), 35. Gavilán and Consolación (2020)

Based on Table 2.6, about 39% of the identified factors reflect exceptional behaviours, roles, and responsibilities of a lean leader. Factors that include; 1. visionary (long-term thinking), 2. policy deployment, 3. management support and/or commitment, 4. invest in leadership development, 5. top management leadership, 6. expanding lean transformation to other business areas, 7. resource's allocation, 8. utilising lean consultants, 9. coaching, 10. reflection (learn from mistakes), and 11. adapting lean fit to organisation's context are compatible with underlying characteristics of four Lean Leadership principles introduced by Liker and Convis (2012) (see Table 2.7).

Table 2.7

Compatibility between lean leadership principles and factors contribute to lean transformation sustainability

No	Lean Leadership Principles	Underlying Factors
1.	Strategy Deployment	1. Visionary (long-term thinking) 2. Policy deployment 3. Expanding lean transformation to other business areas 4. Adapting lean fit to organisation's context
2.	Support Daily Kaizen	1. Management support and/or commitment 2. Resource's allocation (e.g., time, effort, budget)
3.	Self-Development	1. Invest in leadership development 2. Utilise lean consultants 3. Reflection (learn from mistakes)
4.	Coach and Develop Subordinates	1. Top management leadership 2. Coaching

Meanwhile, there were also a fair share of factors that represent unique characteristics of a lean organisational culture. Factors which include; 1. regular, two-way and transparent communication, 2. teamwork, 3. positive work environment, 4. employee empowerment, and 5. problem solving are consistent to dimensions of lean culture proposed by Osman, Nordin, and Abd. Rahman (2021) (see Table 2.8).

Table 2.8

Compatibility between lean culture dimensions and factors contribute to lean transformation sustainability

No	Lean Culture Dimensions	Underlying Factors
1.	Organisational Environment	1. Positive work environment
2.	Effective Communications	1. Regular, two-way and transparent communication
3.	Teamwork	1. Teamwork 2. Full-time (dedicated) lean transformation team
4.	Problem Solving	1. Problem solving 2. Employee empowerment 3. Ownership (accountability)
5.	Innovation	1. Innovation 2. Reflection (learn from mistakes) 3. Experimentation and risk taking

Lastly, the remaining factors which involved; 1. continuous improvement program, 2. standard work practice, 3. value stream mapping, and 4. visual management are some of the lean building blocks recognised in previous studies (Alukal, 2006a; L. G. Jones, 2013; Kilpatrick, 2003; Manos, Sattler, & Alukal, 2006). Lean building blocks refers to a set of lean tools and techniques which can be used by practitioners to introduce, improve and sustain lean transformation in their organisation (Alukal, 2006a). Figure 2.3 illustrates the lean building blocks.

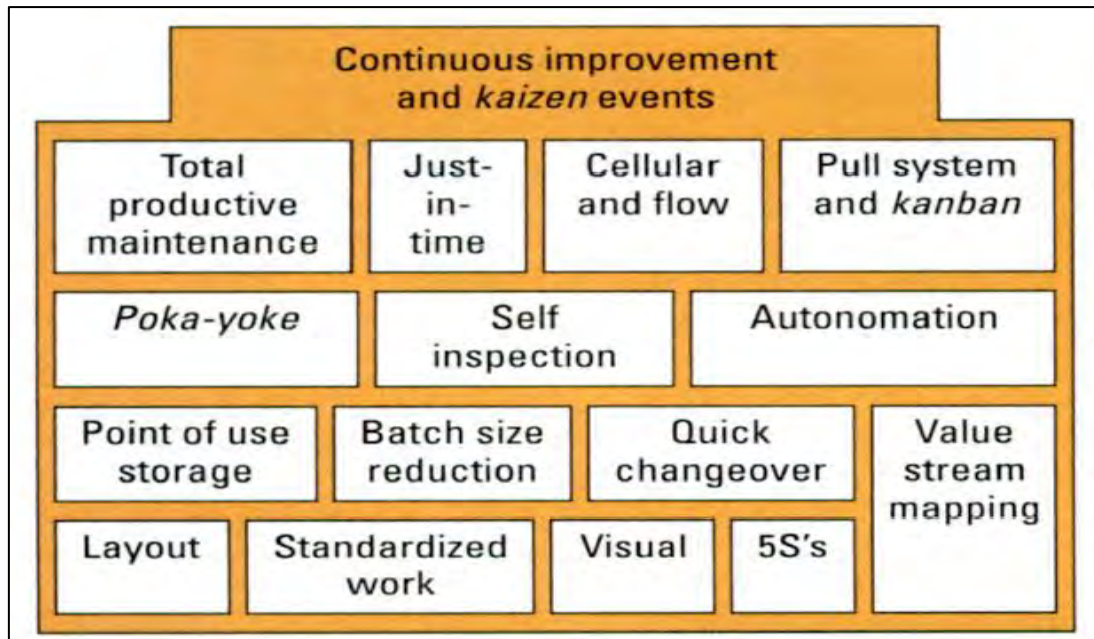


Figure 2.3

Lean building blocks

Source: Adopted from Manos et al. (2006)

Overall, the present review had identified three higher order factors namely; 1. lean leadership, 2. lean culture, and 3. lean building blocks that contribute to the sustainability of lean transformation. The distribution of factors across higher order factors also consistent with the recommendations of previous studies, which pointed out lean leadership (Dombrowski & Mielke, 2014; Nooraei Ashtiani, 2016), lean culture (Jenei et al., 2014; Urban, 2015), and lean building blocks (Marchwinski, 2014; Schlichting, 2009; Setianto & Haddud, 2016) as effective strategies for sustaining lean transformation.

2.4.3 Relationships among Lean Transformation Sustainability Variables

Similar to LTS model development studies, studies that aimed to examine relationships among LTS variables had been conducted using various research designs including; 1. 2. conceptual study, 3. expert's viewpoint, 4. single-case study, 5. multiple-case study, 6. survey, and 7. mixed methods (see Table 2.9).

Table 2.9

Research designs of lean transformation sustainability studies

Research Designs	Sources	Total
Survey	6, 7, 8, 10, 11, 12, 15, 16, 20, 21, 22, 24, 25, 26, 27	15
Conceptual	1, 5, 9, 13, 17, 19	6
Expert's viewpoint	14, 23	2
Single-case study	3, 4,	2
Mixed methods	2	1
Multiple-case study	18	1

Source: 1. Veech (2004), 2. Burch (2008), 3. Ramakrishnan and Testani (2010), 4. Testani and Ramakrishnan (2010), 5. Mohd-Zainal et al. (2011), 6. K. B. Stone (2012b), 7. Glover et al. (2013), 8. L. G. Jones (2013), 9. Habidin et al. (2013), 10. Iris and Cebeci (2014), 11. Marshall (2014), 12. Larteb et al. (2015), 13. Pakdil and Leonard (2015), 14. Mohd Yusof and Aoki (2016), 15. Nooraei Ashtiani (2016), 16. Setianto and Haddud (2016), 17. Pakdil and Leonard (2017), 18. Vance (2017), 19. Hallam et al. (2018), 20. Sahoo and Yadav (2018), 21. Santos Bento and Tontini (2018), 22. Chiarini and Brunetti (2019), 23. Costa et al. (2019), 24. Galeazzo (2019), 25. Santos Bento and Tontini (2019), 26. Habidin et al. (2020), 27. Mousavi et al. (2020)

Majority of the studies were conducted using survey design, given it is the most practical design to evaluate the significance of relationships between two or more latent variables. Survey design facilitates the collection of quantitative data that allow researchers to evaluate the significance of relationships using appropriate statistical analyses (Creswell & Creswell, 2018; Saunders, Lewis, & Thornhill, 2016). On the other hand, studies that adopted expert's viewpoint design, single-case and multiple case studies produced qualitative evidences that are not meant for generalisation of findings (Zikmund et al., 2013). Although mixed-methods design caters both qualitative and quantitative evidence, it has limited generalisability compare to quantitative data collected from a full-scale survey design (Burch, 2008; Glover et al., 2013). While survey design is the most adopted method to assess relationships among variables in the LTS context, only few studies reported rigorous empirical results produced by advanced statistical tests (see Table 2.10).

Table 2.10

Statistical analysis of relationships among LTS variables

Statistical Analysis Techniques	Sources	Total
Descriptive	6, 8, 12	3
Regression	3, 4, 11	3
Correlation	1, 2, 7	3
Covariance-based structural equation modelling (CB-SEM)	9, 10, 13	3
Partial least square structural equation modelling (PLS-SEM)	5, 14	2

Source: 1. Burch (2008), 2. K. B. Stone (2012b), 3. Glover et al. (2013), 4. L. G. Jones (2013), 5. Marshall (2014), 6. Larteb et al. (2015), 7. Nooraei Ashtiani (2016), 8. Setianto and Haddud (2016), 9. Sahoo and Yadav (2018), 10. Santos Bento and Tontini (2018), 11. Galeazzo (2019), 12. Santos Bento and Tontini (2019), 13. Habidin et al. (2020), 14. Mousavi et al. (2020)

Advanced statistical test refers to the second-generation statistical analysis techniques that accounted for measurement errors when measuring an abstract concept (latent variable) (Ramayah, Cheah, Chuah, Ting, & Memon, 2018; Šiška, 2018). Structural equation modelling (SEM) is a typical example of second-generation technique. There are two families of SEM namely; 1. Variance-based SEM or better known as PLS-SEM, and 2. Covariance-based SEM or simply called as SEM (Awang, 2015). Unlike SEM, descriptive, correlation and regression analyses belong to first-generation techniques. From Table 2.9, it was clear that very few studies used second-generation techniques to evaluate relationships among LTS variables, especially PLS-SEM. Therefore, there is a need to evaluate relationships among LTS variables using PLS-SEM for the sake of keeping up with the latest development on data analysis tools and techniques. Compare to CB-SEM, PLS-SEM is indeed more recent.

2.4.4 Lean Transformation Sustainability Assessments

As discussed earlier, there was no consensus in the literature regarding the definition and how to objectively measure the “lean transformation sustainability” concept. Indeed, two main viewpoints could be identified: one focusing on sustaining lean transformation momentum, the other on sustaining lean gains. According to the first opinion, LTS evaluates the maturity of lean tools and techniques adoption in a given

organisation (Jørgensen et al., 2007; Ruffa, 2011). The second understanding considers LTS as a measure of the extent of improvement achieved in the performance goals thanks to organisation's sustainable lean transformation (Alukal, 2006b; Burch, 2008; Glover et al., 2013).

Besides that, there were several studies that appraised the efficient utilisation of organisational resources to better achieve organisation's sustainable improvement in lean transformation journey. Organisational resources such as lean leadership (Dombrowski & Mielke, 2014; Mann, 2009; Van Landeghem et al., 2013) and development of lean culture (Jenei et al., 2014; Mann, 2015; Urban, 2015) were claimed as contributing factors to sustain lean transformation. Thus, each viewpoint suggested different set of variables to be observed or assessed (see Table 2.11).

Table 2.11
Assessed variables in previous lean transformation sustainability studies

No	Viewpoints	Variables	Source
1.	Sustaining lean transformation momentum	Lean maturity level Leanness level	1, 5, 7, 8, 14, 16, 17, 18, 20, 23 2, 3, 9, 13, 17, 22
2.	Sustaining lean transformation gains	Time effectiveness Quality improvement Cost reduction Employee productivity Process improvement Waste elimination Working conditions Inventory turnover Machine productivity Flexibility Market position Economic stability New products	3, 9, 12, 15, 16, 23 3, 9, 12, 15, 16, 23 3, 9, 12, 15, 16, 23 9, 12, 15, 19 9, 12 9, 22 2, 13 12, 16 3, 15 15, 16 12 12 16

Table 2.11 (continue)

No	Viewpoints	Variables	Source
3.	Contributing factors of lean transformation sustainability	Lean leadership Lean culture People enabled process Strategy and alignment Extended enterprise Knowledge Training HRM practices Organisational learning Problem solving Respect for people Organisational structure	3, 4, 5, 6, 11, 12, 13, 15, 21 2, 11, 12, 15, 22 12, 13, 14, 15 2, 14, 15, 16 9, 14, 15, 16 12, 22 15, 19 10 10 16 16 22

Source: 1. Lyonnet et al. (2010), 2. Bhasin (2011), 3. W. P. Wong et al. (2012), 4. Van Landeghem et al. (2013), 5. Ahmed Soliman and Gadalla (2014), 6. Dombrowski and Mielke (2014), 7. Hallam and Keating (2014), 8. Iris and Cebeci (2014), 9. Pakdil and Leonard (2014), 10. Tortorella and Fogliatto (2014), 11. Schröders and Cruz-Machado (2015), 12. Urban (2015), 13. Maasouman and Demirli (2016), 14. Setianto and Haddud (2016), 15. Sahoo and Yadav (2018), 16. Santos Bento and Tontini (2018), 17. Galeazzo (2019), 18. Santos Bento and Tontini (2019), 19. Sisson (2019), 20. Mousavi et al. (2020), 21. Rossini et al. (2020), 22. Silvério et al. (2020), 23. Zanon et al. (2020).

Table 2.11 revealed that previous studies often measured lean transformation momentum with regard to lean maturity level or leanness level. While some studies considered lean maturity and leanness as the same variable (Maasouman & Demirli, 2016; Zanon et al., 2020), Galeazzo (2019) distinguished the two variables. According to Galeazzo (2019) leanness refers to the extent to which a firm implements a variety of lean tools and techniques, while lean maturity represents number of years an organisation has been implementing lean practices. Meanwhile, Mousavi et al. (2020) argued that lean maturity should include both experience and variety of implemented lean tools and techniques along with completeness of lean implementation. On that account, this study considered leanness and lean maturity as the same variable and agrees with Mousavi et al. (2020) to assess lean maturity with regard to; 1. experience, 2. completeness, and 3. extensiveness (variety implementation of lean tools and techniques).

On the other hand, previous studies suggested more than ten variables for assessing lean transformation sustainable gains. Nevertheless, majority of recommended variables could be grouped together to form two generic latent variables namely operational performance and business performance consistent to past studies (Fullerton, Kennedy, & Widener, 2014; Jayaraman, Teo, & Keng, 2012) (see Table 2.12).

Table 2.12

Compatibility of sustainable lean gains with operational performance and business performance

Latent Variables	Sustainable Lean Gains
Operational performance	1. Time effectiveness 2. Quality improvement 3. Cost reduction 4. Employee productivity 5. Machine productivity 6. Flexibility
Business performance	1. Market position 2. Economic stability 3. New products

In the same vein, there were more than ten variables that had been considered as contributing factors of lean transformation sustainability. Similarly, majority of recommended variables could be grouped together to form higher order factors such as lean leadership and lean culture as discussed in the previous sections (see Table 2.13).

Table 2.13

Compatibility of lean transformation sustainability contributing factors with lean leadership and lean culture

Latent Variables	LTS Contributing Factors
Lean leadership	1. Strategy and alignment 2. Extended enterprise
Lean culture	1. Organisational learning 2. People enabled process 3. Problem solving 4. Respect for people

In summary, the present study aimed to assess LTS from all three viewpoints; 1. sustaining lean transformation momentum (i.e., lean maturity), 2. sustaining lean

transformation gains (i.e., operational and business performance), and 3. lean transformation sustainability contributing factors (i.e., lean leadership and lean culture). Further, this study attempted to evaluate relationships and underlying causality between variables derived from each perspective.

2.5 Sustainable Gains

The assessment of sustainable gains can be traced its origin from the concept of “holding the gains” credited to the infamous Quality Guru, Joseph M. Juran (Dale, 1996). In the present study, sustainable gains assessment reflects the facet of “persistent achievement of performance goals” in the sustainable organisational change concept advocate by Buchanan et al. (2005). In other words, sustaining gains means the ability to persistently acquire benefits and improvements from lean transformation efforts. Assessment of sustainable gains is a test of an organisation’s commitment to continuous improvement (Dale, 1996) and works as a constant stimulus which prove that the efforts of making improvement are paying off (Davies, 1992). Improvement strategies and efforts will have been in vain if gains made by the strategies are not held or endured (Burch, 2008; Dale, 1996; Rentes et al., 2009).

Gains acquired as a result of the lean transformation commonly emerge in the forms of tangible improvements such as operational (Hernandez-Matias, Ocampo, Hidalgo, & Vizan, 2020; Sahoo, 2021) and business performance (Bevilacqua, Ciarapica Filippo, & De Sanctis, 2017; Valente, Sousa, & Moreira, 2020). The operational performance reflects the performance of internal operations of the organisation in relation to waste elimination. Conversely, the business performance consisted of financial related

metrics such as return on assets and non-financial metrics such as capacity to develop a competitive profile (Jayaraman et al., 2012).

Cost saving, space optimisation, product quality, employee, machine and equipment productivity, product and volume flexibility as well as on-time delivery fulfilment are among typical indicators of operational performance (Hernandez-Matias et al., 2020; Jayaraman et al., 2012; Onofrei et al., 2019). On the other hand, common indicators of business performance are including revenue growth, net profits, return on assets, competitive profile, new product development and market development (Jayaraman et al., 2012; Losonci & Demeter, 2013; Nawanir, Lim, & Othman, 2013).

However, it could be argued that these aforementioned tangible gains of lean transformation were not the sole indicators of its sustainable gains. Some studies recognised that intangible gains such as continuous improvement capability, complement the assessment of lean transformation sustainability (Burch, 2008; Jørgensen et al., 2007; Murti, 2009). Continuous improvement (CI) capability is a set of competitive abilities that allows organisations to learn, innovate and renew (Aloini, Martini, & Pellegrini, 2011). CI capability is dynamic as it is demonstrated through ongoing activities aimed at raising the level of organisation-wide performance through focused incremental changes in processes (Galeazzo, Furlan, & Vinelli, 2017).

Jørgensen et al. (2007) asserted that concentration on both tangible and intangible gains simultaneously, creates a relative balance and synergy between the two improvement indicators. Meanwhile, a mixed-methods study on 11 manufacturing organisations in Western Massachusetts reported that most organisations indicated CI capability as a

welcome by-product of the lean transformation initiatives (Burch, 2008). Unfortunately, no organisation in Burch's (2008) study actually assessed changes in CI capability improvements. Therefore, Burch (2008) also suggested that intangible gains that reflect capability of continuous improvement in lean organisation should be assessed as it might provide a better snapshot of the lean transformation efficacy. In addition, Murti (2009) insisted that the true measure of lean transformation sustainability is when an organisation had a well-established CI capability. No matter how good the organisation becomes, a well-established CI capability would create new opportunities for improvement. However, the result of his study on nine manufacturing organisations in New Zealand revealed that lean transformation was not sustained. Most organisations demonstrated lack of CI capability (i.e., lack of focus on learning and solving problems) that had resulted in stagnated lean transformation.

Given the above considerations, the present study aimed to assess sustainable gains in three dimensions namely; 1. operational performance, 2. business performance, and 3. CI capability. Operational performance and business performance represented the tangible gains, while CI capability served as the intangible gain.

2.6 Lean Tools Adoption Maturity

Lean maturity assessment was originally developed based on a Capability Maturity Model format (Nightingale & Mize, 2002; Santos Bento & Tontini, 2018). This format indicates the most important criteria for measuring progression relative to lean transformation (Malmbrandt & Åhlström, 2013). The assessment of lean maturity offers a huge assistance to organisations embarking on lean transformation by highlighting potential elements that require concentration (Iris & Cebeci, 2014). For

instance, lean tools and techniques which are described with high applications may be maintained, the ones which lack applications may be improved, and anything overlooked may be initiated.

In most cases, lean maturity level indicates the completeness to which an organisation utilises lean principles, tools and techniques to eliminate wastes and deliver maximum value for its clients (Ahmed Soliman & Gadalla, 2014; Iris & Cebeci, 2014; Santos Bento & Tontini, 2018; Setianto & Haddud, 2016). Ratings such as “no implementation”, “little implementation”, “some implementation”, “extensive implementation”, and “complete implementation” (Iris & Cebeci, 2014) or “not implemented”, “informal implementation”, “formally implemented”, “documented implementation”, “under controlled implementation”, and “continuously improving implementation” (Santos Bento & Tontini, 2018, 2019) were used to describe each maturity level. According to Mousavi et al. (2020) the completeness to which an organisation utilises lean principles, tools and techniques is in accordance with fidelity of the corporate practices diffusion process.

Instead, Galeazzo (2019) indicated lean maturity level by measuring the extent to which an organisation applies a variety of lean tools and techniques. This is because, the choice of lean tools and techniques is one of the critical factors that determine the success or failure of the lean transformation in organisations. In fact, the lean maturity level and its associated goals only will be achieved, if lean tools and techniques have been correctly selected and systematically applied (Anvari, Zulkifli, Sorooshian, & Boyerhassani, 2014; Galeazzo, 2019; Santos Bento & Tontini, 2018). On that account, lean building blocks applications were deemed fit to represent the variety and correct

choice of lean tools and techniques to sustain lean transformation (Alukal, 2006b). Lean building blocks are including; 1. total productive maintenance, 2. just-in-time, 3. cellular manufacturing, 3. pull system and kanban, 4. error proofing, 5. self-inspection, 6. automation, 7. point of use storage, 8. small lot production, 9. quick setup, 10. value stream mapping, 11. streamlined layout, 12. standardised work, 13. visual control, and 14. 5S's (Alukal, 2006a; Kilpatrick, 2003). The extent to which an organisation applies lean tools and techniques also can be viewed from how widely lean tools and techniques are applied in an organisation (Mousavi et al., 2020; Netland & Ferdows, 2016). From this view, the wideness (extensiveness) of lean applications is assessed by observing whether lean building blocks are only applied in few departments or in the entire organisation's structure.

Meanwhile, other studies attempted to relate the organisation's level of lean adoption to its duration of lean journey (Agus & Iteng, 2013; G. L. D. Wickramasinghe & Wickramasinghe, 2017). These prior studies showed that experience of an organisation in lean journey could increase the effectiveness of its application. Concerning the plan-do-check-act cycle, the more an organisation is experienced with lean adoption, the more obstacles that hinder lean transformation progress can be overwhelmed. Persistence adoption of lean tools and techniques implies that mature lean organisations have moved along the learning curve and accumulated broader experience than young lean organisations (Galeazzo, 2019). As a result, organisations embarking lean transformation over a longer period of time are more likely to apply lean tools and techniques in a more efficient and effective way than organisations with shorter experience. Thus, the organisation's experience with lean adoption could indicate the maturity of the lean transformation.

This is why recent study by Mousavi et al. (2020) simultaneously indicated all three criteria; i.e. completeness (fidelity), variety (extensiveness), and duration (experience) of lean tools and techniques adoption in assessing Lean Maturity level. According to Mousavi et al. (2020), three criteria should be taken into account when measuring the progress of a transformation initiative on a system, namely, how, where, and when. The degree of completeness (fidelity) addresses the “how”, the degree of extensiveness addresses the “where”, and the “when” item is associated with the time span that lean tools and techniques have been adopted in an organisation. Taking this notion into account, the present study intended to assess maturity of lean tools and techniques adoption level following these criteria.

Besides that, previous studies had measured lean maturity level using two different scales, 1. definition-oriented scales, and 2. rating scales (Likert or interval). Studies that used definition-oriented scales are including; 1. Lean Enterprise Self-Assessment Tool (LESAT) (Nightingale & Mize, 2002), 2. Lean Capability Model (Jørgensen et al., 2007), 3. NEMSE lean maturity level assessment (Lyonnet et al., 2010), 4. Lean Management System (LEMAS) (Van Landeghem et al., 2018), and 5. Lean Maturity Level (Zanon et al., 2020). Others, such as in Urban (2015) and Setianto and Haddud (2016), used rating scales for describing to what extent lean tools and techniques had been adopted.

However, Malmbrandt and Åhlström (2013) argued that definition-oriented scales described maturity level too detail, which tended to make them very long. This led to a reconfiguration of the lean maturity level measurement and an initiative to simplify

them in order to have a simpler scale without compromising its level of comprehensiveness. This initiative allows the self-assessment lean maturity instrument to be more practical and user friendly. Therefore, studies that used rating scales to assess lean maturity level began to make appearance. Studies that used rating scales ranged their measurement items from “absolutely no” to “definitely yes” in extreme end-points interval scale (Urban, 2015) or full-anchored Likert-scale such as “extremely poor”, “below average”, “average”, “above average” and “excellent” (Setianto & Haddud, 2016). On that account, this study preferred to assess maturity of lean tools and techniques adoption level using rating scales as demonstrated in recent studies (Mousavi et al., 2020; Santos Bento & Tontini, 2019).

2.7 Lean Leadership

Lean Leadership is a unique leadership style shaped from personalities, values, and experience of the LPS founders that distinguished it from other conventional leadership styles (Trenkner, 2016). Many lean scholars agreed that implementing lean tools represents only 20% of the effort in lean transformations. The remaining 80% rests on efforts of changing leaders’ mindset and ultimately their behaviours (Bhasin & Found, 2020; Mann, 2009; Novac & Mihalcea, 2014; van Assen, 2018). Although Lean Leadership has been studied by many scholars, there is no universal definition and measurement. Table 2.14 summarised variations of Lean Leadership definitions and measurements used in the previous studies.

Table 2.14

Definitions and dimensions of lean leadership construct

No	Definitions (Authors)	Measurements
1	Measurable knowledge, skills, traits and behaviours that allow an individual to effectively perform a lean leadership role (Seidel & Saurin, 2020).	Lean leadership competencies: 1. Identify what adds value to internal and external clients 2. Identify and solve problems with their teams using the PDCA principle (coaching) 3. Use continuously lean practices and principles 4. Manage with emphasis on value flow rather than on isolated operations 5. See the problems with own eyes (based on data and facts) 6. Lead through example 7. Stabilize processes 8. Provide value-added information clearly and objectively 9. Put the group's interests above the individual ones 10. Develop and implement guidelines, plans and policies aiming at people's development 11. Practice self-development and professional and personal continuous evolution 12. Identify and manage barriers during LP journey 13. Practice lean philosophy as an interrelated system of principles and practices 14. Develop actions based on long term views 15. Develop actions that, based on ethical principles, respect the community, the environment and the workers' safety 16. Develop innovative and challenging actions
2	Exact management practices and behaviours that help deploy lean thinking in an organisation (Netland et al., 2020).	Lean leadership practices: 1. Go and see 2. Daily layered accountability 3. Structured problem-solving 4. Continuous improvement 5. Coaching 6. Strategic alignment
3	Leaders' role, necessary behaviours, values, competencies, skills, attributes or characteristics for effective lean transformation (Gundes de Almeida et al., 2018).	Lean leadership behaviours: 1. Demonstrating commitment and support 2. Developing and training employees 3. Creating a learning environment 4. Empowering employees 5. Formulating and communicating goals and objectives 6. Committing to self-development 7. Visiting the work floor (<i>gemba</i> walk) 8. Getting and giving information 9. Acting as a role model 10. Showing modesty and openness 11. Celebrating and recognizing success 12. Intellectual stimulation 13. Monitoring and evaluating 14. Experimenting 15. Visibly apply lean

Table 2.14 (continue)

No	Definitions (Authors)	Measurements
4	Characteristics of effective lean leaders to achieve lean thinking in an organisation (Aij & Teunissen, 2017).	Lean leadership attributes: 1. Task identity 2. Feedback 3. Autonomy 4. Believe in improvement 5. Honesty 6. Show interest 7. Facilitate resources 8. Emotional intelligence 9. Visualizing greatness 10. Aware of own status 11. Skills 12. Empowerment 13. Trust 14. Engagement 15. Communication 16. Clarification 17. Governance and consistency 18. Fit for purpose 19. Care 20. Recognition 21. Leader-employee relationship 22. Fairness
5	How leaders influence the tasks and relationships of subordinates in their efforts to sustain the implementation of lean methodologies (Vance, 2017).	Lean leaders' behaviours: 1. Management commitment 2. Culture change 3. Employee empowerment 4. Communication 5. Link business strategy with lean transformation 6. Learn from experts
6	A leadership style that is similar to transformational leadership and servant leadership (Holmemo & Ingvaldsen, 2016).	Lean leadership characteristics: 1. Visionary 2. Inspiring communication 3. Intellectual stimulation 4. Supportive 5. Personal recognition 6. Humility 7. Empowerment 8. Standing back
7	Responsibilities to influence and change followers and keep them on track by constantly challenging and coaching them while clearly defining and communicating the organisation's values, vision, and goals (Nooraei Ashtiani, 2016).	Lean leadership practices: 1. Respect for people 2. Self-development 3. Supporting structure 4. Day-to-day management

Table 2.14 (continue)

No	Definitions (Authors)	Measurements
8	A leadership style that is consistent to transformational leadership, servant leadership and empowering leadership (van Assen, 2016a).	Lean leader's behaviour: 1. Commitment, involvement, persistence and role modelling 2. Visioning the True North (open and inspirational communication of the future) 3. Empowerment and promotion of employee responsibility 4. Building and fostering a culture of trust 5. Respect for people 6. Coaching of teams and facilitating teamwork 7. High expectations, setting ambitious goals and intellectual stimulation 8. Timely feedback and information 9. Management by facts and use of objective data, visual monitoring of performance, rational persuasion 10. Celebrating and recognising subordinate's success.
9	Convincing workers that lean transformation will benefit them, listening to their concerns and letting them choose to follow you of their own free will (Ballé, Jones, & Orzen, 2015).	Lean leaders' habits: 1. Go and see for themselves at the work place to find facts first hand 2. Challenge subordinates to see problems and relate them to overall improvement intent 3. Listen to the obstacles face by subordinates 4. Teach subordinates problem-solving and develop their autonomy in solving their own difficulties 5. Support subordinates' initiatives and give them permission to try new things on their own 6. Develop teamwork through each person's ability to work with their colleague across functions 7. Learn from what subordinates have learnt.
10	Leadership attributes based on Global Leadership and Organizational Behaviour Effectiveness (GLOBE) project (Gelei, Losonci, & Matyusz, 2015).	Lean leadership profile: 1. Confidence builder 2. Collaborative 3. Improvement oriented 4. Inspirational 5. Formal 6. Excellence oriented 7. Communicative 8. Consultative 9. Motive arouser 10. Performance oriented 11. Micromanager
11	A direct role demonstrated by lean leaders in helping their team adapt to the lean system, with a focus on mind-sets and behaviours (Wuestman & Casey, 2015).	Lean leaders' actions: 1. Model the behaviours for the team to emulate 2. Make goals, measures, and actions visible 3. Consistent and sincerely demonstrate lean behaviours to the team 4. Train managers to become coach to subordinates 5. Enhance communication by fostering two-way, open dialogues and idea generation 6. Solve problems with subordinates 7. Adopt a coaching approach to help subordinates think and own improvements

Table 2.14 (continue)

No	Definitions (Authors)	Measurements
12	A methodical system for the sustainable implementation and continuous improvement of LPS (Dombrowski & Mielke, 2014).	Lean leadership rules: 1. Improvement culture 2. Self-development 3. Qualification 4. <i>Gemba</i> 5. <i>Hoshin kanri</i>
13	Engaging employees' body, mind, heart and spirit to generate a sustained lean philosophy (Gregory, 2012).	Lean leadership elements: 1. Inspire trust 2. Clarify purpose 3. Align systems 4. Unleash talents
14	Leading lean transformation based on the 'Toyota Way' principles (Liker & Convis, 2012).	Lean leadership principles: 1. Commitment to self-development 2. Coach and develop others 3. Support daily <i>kaizen</i> 4. Create vision and align goals
15	The set of leadership behaviours and structures that make up a lean management system (Mann, 2009).	Lean leader's roles: 1. Developing and implementing structures and processes that anticipate and respond to the difficulties of a lean initiative that crosses internal boundaries 2. Transforming commitments to change into actual change, supporting and sustaining new behaviours and practices 3. Increasing the odds that process improvements survive the transition from project mode to ongoing process 4. Establishing and maintaining new, process-focused measures alongside conventional measures of results 5. Creating conditions in which a sustainable lean culture of continuous improvement can develop
16	Leading people towards daily pursuit of perfection (Flinchbaugh, Carlino, & Curtis-Hendley, 2008).	Lean leaders' moves: 1. Teaching 2. Creating tension as opposed to stress 3. Eliminating fear and comfort 4. Leading through participation 5. Building lean into personal practice
17	The capacity to influence others through a dynamic, reciprocal covenant aimed toward identifying and accomplishing a sustainable lean transformation (Orr, 2005).	Lean leadership behaviours: 1. Teaching and commitment of working groups 2. Respect for people 3. Focus on the process 4. Support and appreciation of accomplishments 5. Giving examples 6. Implementation of policies and determination of objectives 7. Pursuit of standardization 8. Long-term vision and principles 9. Supporting the change process

Table 2.14 compiled 17 different definitions of Lean Leadership with more than 22 indicators used in previous studies to measure this variable. The terms used to represent the set of indicators for measuring Lean Leadership are also varied. Terms such as lean

leadership behaviours (Gundes de Almeida et al., 2018; Orr, 2005; van Assen, 2016a; Vance, 2017), lean leadership characteristics (Holmemo & Ingvaldsen, 2016), lean leadership attributes (Aij & Teunissen, 2017), lean leadership roles (Mann, 2009), and lean leadership competencies (Seidel & Saurin, 2020) were used. On that account, this study agreed with the all-inclusive definition introduced by Gundes de Almeida et al. (2018) which refers Lean Leadership as organisation leaders' necessary roles, values, competencies, skills, attributes or characteristics for effective lean transformation.

Nevertheless, the Lean Leadership model introduced by Liker and Convis (2012) was more aligned to the objective of this study, since none of its principle overlapped with other variables observed in this study. The four principles in the model were including; 1. self-development, 2. coach and develop subordinates, 3. supporting daily *kaizen*, and 4. strategy deployment. Moreover, this model was inspired from the "Toyota Way", the origin of lean philosophy itself. Based on years of observations and practical experience in Toyota Motor, Liker and Convis (2012) derived these principles from the Toyota Way. Besides that, it was evident that these four principles could harbour most of the Lean Leadership measurements (i.e., roles, values, competencies, skills, attributes or characteristics of lean leaders) identified in other Lean Leadership studies (see Table 2.15).

Table 2.15

Synthesisation of lean leadership measurements

No	Principles	Related Measurements
1.	Self-Development	1. Lead through example, practice professional and personal continuous evolution, use continuously lean practices and principles (Seidel & Saurin, 2020) 2. Committing to self-development, acting as a role model, visibly apply lean (Gundes de Almeida et al., 2018) 3. Aware of own status, skills, governance and consistency (Aij & Teunissen, 2017) 4. Learn from experts (Vance, 2017) 5. Role modelling (van Assen, 2016a) 6. Humility (Holmemo & Ingvaldsen, 2016) 7. Self-development (Nooraei Ashtiani, 2016) 8. Learn from what subordinates have learnt (Ballé et al., 2015) 9. Improvement oriented, inspirational (Gelei et al., 2015) 10. Model the behaviours for the team to emulate, consistent and sincerely demonstrate lean behaviours to the team (Wuestman & Casey, 2015) 11. Self-development (Dombrowski & Mielke, 2014) 12. Leading through participation, building lean into personal practice (Flinchbaugh et al., 2008) 13. Giving examples (Orr, 2005)
2.	Coach and Develop Subordinates	1. Identify and solve problems with the teams using the PDCA principle (coaching)(Seidel & Saurin, 2020) 2. Coaching (Netland et al., 2020) 3. Developing and training employees, intellectual stimulation (Gundes de Almeida et al., 2018) 4. Feedback, clarification, leader-employee relationship (Aij & Teunissen, 2017) 5. Intellectual stimulation (Holmemo & Ingvaldsen, 2016) 6. Respect for people (Nooraei Ashtiani, 2016) 7. Respect for people, coaching of teams and facilitating teamwork, timely feedback and information (van Assen, 2016a) 8. Train managers to become coach to subordinate employees, adopt a coaching approach to help employees think and own improvements (Wuestman & Casey, 2015) 9. Consultative, and motive arouser (Gelei et al., 2015) 10. Teach subordinates problem-solving and develop their autonomy in solving their own difficulties, Challenge subordinates to see problems and relate them to overall improvement intent (Ballé et al., 2015) 11. Qualification (Dombrowski & Mielke, 2014) 12. Unleash talents (Gregory, 2012) 13. Teaching (Flinchbaugh et al., 2008)

Table 2.15 (continue)

No	Principles	Related Measurements
3.	Support Daily <i>Kaizen</i>	1. See the problems with own eyes (based on data and facts) (Seidel & Saurin, 2020) 2. Go and see, daily layered accountability (Netland et al., 2020) 3. Demonstrating commitment and support, visiting the work floor (<i>gemba</i> walk), monitoring and evaluating (Gundes de Almeida et al., 2018) 4. Show interest, facilitate resources (Aij & Teunissen, 2017) 5. Management commitment, culture change (Vance, 2017) 6. Supportive (Holmemo & Ingvaldsen, 2016) 7. Day-to-day management (Nooraei Ashtiani, 2016) 8. Commitment and persistence involvement, management by facts and use of objective data, visual monitoring of performance, rational persuasion (van Assen, 2016a) 9. Solve problems with your employees (Wuestman & Casey, 2015) 10. Go and see for themselves at the work place to find facts first hand, listen to the obstacles face by subordinates, support subordinates' initiatives and give them permission to try new things on their own (Ballé et al., 2015) 11. Confidence builder, collaborative (Gelei et al., 2015) 12. Improvement culture, <i>Gemba</i> (Dombrowski & Mielke, 2014) 13. Inspire trust (Gregory, 2012) 14. Creating conditions in which a sustainable lean culture of continuous improvement can develop (Mann, 2009) 15. Creating tension as opposed to stress, eliminating fear and comfort (Flinchbaugh et al., 2008) 16. Supporting the change process (Orr, 2005)
4.	Strategy Deployment	1. Develop and implement guidelines, plans and policies aiming at people's development, practice lean philosophy as an interrelated system of principles and practices, develop actions based on long term views (Seidel & Saurin, 2020) 2. Strategic alignment (Netland et al., 2020) 3. Formulating and communicating goals and objectives (Gundes de Almeida et al., 2018) 4. Task identity (Aij & Teunissen, 2017) 5. Link business strategy with lean transformation (Vance, 2017) 6. Visionary (Holmemo & Ingvaldsen, 2016) 7. Visioning the True North (open and inspirational communication of the future) (van Assen, 2016a) 8. <i>Hoshin kanri</i> (Dombrowski & Mielke, 2014) 9. Developing and implementing structures and processes that anticipate and respond to the difficulties of a lean initiative that crosses internal boundaries (Mann, 2009) 10. Implementation of policies and determination of objectives, long-term vision and principles (Orr, 2005)

Given the above considerations, the present study intended to assess Lean Leadership following these principles.

2.8 Lean Culture

Many prior studies were suggesting that a sustainable lean transformation is dependent on the culture change. Majority of lean scholars claimed that change in organisational or corporate culture determines the sustainability of lean transformation (Bhasin, 2013; Pakdil & Leonard, 2015; Zarbo, 2012). Other group of scholars asserted that change in national or societal culture as the determinant of lean transformation sustainability (Kull, Yan, Liu, & Wacker, 2014; Larteb et al., 2015; Pakdil & Leonard, 2017). In addition, there were few scholars who perceived both organisational and national culture contribute to a sustainable lean transformation (Erthal & Marques, 2018; Taherimashhadi & Ribas, 2018). Regardless of which types of culture that needs changing, practitioners first need to know what are the criteria of the ‘ideal culture’ that is supportive for lean transformation journey. This ideal culture can be referred as the ‘Lean Culture’.

However, various conceptualisations of Lean Culture were provided by scholars over the years (Dorval, Jobin, & Benomar, 2019). As a result, a widely accepted Lean Culture measurement is still absent in the literature. Basically, there are two different concepts of assessing culture in the context of lean transformation research:

1. using renowned organisational or national culture measurement models such as Schein’s Levels of Culture (Schein, 1985), The GLOBE Model (House, Hanges, Javidan, Dorfman, & Gupta, 2004), Hofstede’s Cultural Profile (Hofstede, Neuijen, Ohayv, & Sanders, 1990), and Competing Values Framework (Cameron & Quinn, 2011) to examine what types of cultural profile that influence lean transformation success, or

2. assessing to what extent business organisations have transformed their prevailing organisational culture to one that aligned with lean thinking.

With respect to the former, the example studies are including Bortolotti, Boscari, and Danese (2015), Pakdil and Leonard (2015), Losonci, Kása, Demeter, Heidrich, and Jenei (2017), Paro and Gerolamo (2017), Taherimashhadi and Ribas (2018), Antomarioni, Ciarapica, De Sanctis, and Ordieres-Meré (2019), Cadden et al. (2020), and Hardcopf, Liu, and Shah (2021). These studies aimed to identify and evaluate if a specific cultural profile is supporting the adoption of lean tools and techniques. On the other hand, the latter concept is related to studies such as Jenei et al. (2014), Salah and Sayed (2015), Urban (2015), Pedersen-Rise and Haddud (2016), van der Merwe (2016), Vlachos and Siachou (2018), Iranmanesh et al. (2019), Hernandez-Matias et al. (2020), and Osman et al. (2021). These studies intended to assess the current organisational culture criteria relative to the ideal culture that is fit enough to keep up with lean transformation journey. The present study was directed towards the latter concept.

In this study, the Lean Culture measurement model developed by Osman et al. (2021) was adopted to assess if Malaysian lean manufacturers' actual organisational culture is close or distant from the ideal Lean Culture criteria. Osman et al. (2021) defined Lean Culture as an ideal organisational (corporate) culture that foster the success and sustainability of lean transformation in business organisations and proposed five dimensions to measure the concept namely; 1. Positive Work Environment, 2. Effective Communications, 3. Teamwork, 4. Problem Solving, and 5. Innovation.

This study decided to adopt Osman's et al. (2021) measurement model for several reasons. Firstly, it was because of the affinity between Osman's et al. (2021) objectives

and the aims of the present study. According to Hardcopf et al. (2021) this rational is fundamental in the selection of an appropriate measurement model. In fact, one of the main objectives of Osman's et al. (2021) study was to design and develop a valid and reliable measurement model that can objectively assess Lean Culture and subsequently produce quantitative evidence. Most importantly, none of its dimension redundant with other variables observed in this study. Lean Culture measurement models developed by other scholars such as Jenei et al. (2014), Urban (2015), and van der Merwe (2016) included "leadership" as one of the culture dimensions. On the contrary, the present study considered leadership (i.e., Lean Leadership) as a separate independent construct to be observed.

Second, this measurement model was inspired from solid concepts and sound theoretical foundations. Based on an in-depth literature review and extensive content analysis of 23 Lean Culture definitions and 26 existing measurement models, Osman et al. (2021) established their own measurement model. Broad comparisons with previous studies provide better insights that might facilitate theory building on Lean Culture measurement and expand its body of knowledge. Compared to other measurement models, a further relevant and recognised contribution of Osman's et al. (2021) model was considering measurement theories such as Rules of Correspondence, Classical Test Theory and Item Response Theory in its design. By following these theories, Osman's et al. (2021) Lean Culture measurement model had complied with various validity requirements including; content validity, convergent validity, and discriminant validity (Boateng et al., 2018).

Finally, this measurement model offered the balance between the number of the measurement items and its content validity necessity. Albeit there were other Lean Culture measurement models available, the number of measurement items proposed were either too many or too few. For instance, Jenei et al. (2014) measured Lean Culture with 61 items, under 12 dimensions. On the other hand, Welo and Ringen (2015) measured Lean Culture with only two items. Measurement model that contains too many items may cause respondents to provide superficial answers and will receive low response rate (De Vaus, 2002; Fowler, 2014). Meanwhile, measurement models with very few items are unlikely to provide adequate measures and full meaning of the variable of interest. As a consequence, it is lack of content validity (Hayduk & Littvay, 2012; Isaac & Michael, 1995). Given the overwhelming rationales, this study believed that using Osman's et al. (2021) Lean Culture measurement model was especially appropriate.

2.9 Hypotheses Development

Generally, a hypothesis means a prediction of study outcomes (Fraenkel et al., 2012). In a business study, a hypothesis refers to a tentative, yet testable, statement that is proposed to predict what researchers expect to find in their empirical data (Sekaran & Bougie, 2016). It is often a tentative descriptive statements that describes the relationship between two or more variables (Bryman, 2012; Cooper & Schindler, 2014; Fraenkel et al., 2012). Despite substantial number of studies on lean transformation sustainability, there were few quantitative evidences that explain relationships between Sustainable Gains and its contributing factors (i.e., Lean Tools Adoption Maturity, Lean Leadership, and Lean Culture).

Nevertheless, researchers are still allowed to explore possible relationships and searching for potential associations that may lead to theory development, although limited quantitative evidences are available (Ramayah et al., 2018). In-line with this notion, researchers are acknowledged to propose hypotheses based on qualitative studies and subsequently test the hypotheses in quantitative studies (Hair, Anderson, Babin, & Black, 2010). Hence, this study attempted to establish relationships between Lean Tools Adoption Maturity, Lean Leadership, and Lean Culture with Sustainable Gains using combination of both quantitative and qualitative evidences from the literature. Specifically, this study was proposing hypotheses on relationships between Lean Tools Adoption Maturity, Lean Leadership, Lean Culture with Sustainable Gains based on findings from several surveys, case studies, and recommendations from conceptual articles.

2.9.1 Relationship between Lean Tools Adoption Maturity and Sustainable Gains

The impact of lean adoption has been a controversial and much disputed subject when it comes to sustaining gains acquired from lean transformation. Several conceptual and case studies had explored the association between lean transformation and its sustainable gains (Hallam et al., 2018; Mann, 2003; Rossini et al., 2020; Schlichting, 2009), but quantitative evidence that explain how lean transformation contributes to sustainable gains is still lacking.

Despite plenty of evidences on positive relationships between lean transformation and various performance gains such as operational performance (Hardcopf et al., 2021; Sahoo, 2021), financial performance (Galeazzo, 2019; Shashi et al., 2019), business

performance (Iteng, Abdul Rahim, & Ahmad, 2017; Nawanir, Lim, & Othman, 2016), and even Sustainable Performance (Iranmanesh et al., 2019; Sajan, Shalij, Ramesh, & Augustine, 2017), these performance gains might not last for a long period as desired. There were many industrial reports that revealed lean transformation eventually failed to deliver sustainable gains to the practising organisations after a certain period (Ahmed Soliman, 2013; Costa et al., 2019; Jadhav et al., 2014; Pearce & Pons, 2019; Sisson & Elshennawy, 2015; Van Landeghem et al., 2013). Hence, there was a misleading assessment of organisation's lean transformation level in academic studies compare to the real scenario happening in industries.

This misleading assessment was the result of a narrow focus on certain criteria in measuring organisation's lean transformation level (Galeazzo, 2019). Most studies measured the magnitude to which an organisation utilised lean practices, tools and techniques as a proxy to measure lean transformation level (Ahmed Soliman & Gadalla, 2014; Iris & Cebeci, 2014; Santos Bento & Tontini, 2018; Setianto & Haddud, 2016). Whereas, the lean transformation concept is generally included the magnitude (fidelity), wholeness (extensiveness), and depth of change (experience) needed by an organisation to fully adopt lean thinking (Mousavi et al., 2020; Roth, 2011). The fidelity, extensiveness and experience of an organisation in its lean transformation is called "lean maturity" (Mousavi et al., 2020).

Surprisingly, lean maturity has not yet been empirically tested its effect on any outcome variable. Thus, relationship between Lean Tools Adoption Maturity and Sustainable Gains remains unexplained. The only exception was the study by Mousavi et al. (2020) that investigated Lean Practices Maturity in association with Occupational Health and

Safety (OHS) Performance. Their findings showed Lean Practices Maturity positively influenced OHS Performance ($\beta = 0.304, p < 0.05$). A high degree of Lean Practices Maturity identifies organisations that is concurrently adopting lean tools and techniques intensively (fidelity), across many departments (extensiveness), and for a long duration (experience). The interplay among these criteria leads to synergic effects that may positively influence organisations' ability to sustain gains from their lean transformation. For this reason, the conjoint measurement of different criteria in lean adoption improves organisations' competency to align lean transformation progress with the targeted gains. Given the above insights, the present study hypothesised that the relationship between maturity of lean tools and techniques adoption and sustainable gains is positive.

H1: Lean Tools Adoption Maturity has a positive influence on Sustainable Gains.

2.9.2 Relationship between Lean Leadership and Sustainable Gains

There were only few quantitative evidences on the relationship between Lean Leadership principles and Sustainable Gains found in the previous studies. These studies were including; Dombrowski and Mielke (2013), Mulders (2016), and Nooraei Ashtiani (2016). However, none of this study produced quantitative evidence using advanced statistical analyses.

Dombrowski and Mielke (2013) conducted a simple survey to identify the level of Lean Leadership principles application among 91 international manufacturing enterprises. In comparison to this study, they were studying five Lean Leadership principles namely; 1. Self-Development, 2. Improvement Culture, 3. Qualification, 4. *Gemba* and 5.

Hoshin Kanri. Principles of *Gemba* and Qualification have a similar concept with Coach and Develop Subordinate's principle of this study. Meanwhile, Improvement Culture and *Hoshin Kanri* equal to Support for Daily Improvement Process and Strategy Deployment principles that were being observed in this study respectively.

The results revealed that, 92% of the respondents claimed that they were implementing the Improvement Culture principle and perceived it as a very important principle to sustain lean improvement. The rank was followed by Qualification principle (83%), *Gemba* principle (50%), Self-Development principle (42%) and the least implemented principle was *Hoshin Kanri* (Strategy Deployment) principle (29%).

Further, Mulders (2016) adopted the same set of Lean Leadership principles introduced by Dombrowski and Mielke (2013) to study team leaders of inpatient clinics at two hospitals in Sweden. Through a multiple linear regression analysis, Mulders (2016) finds there were significant effects of self-development ($\beta = 0.677, t = 2.94, p = 0.01$) and *Gemba* ($\beta = 0.278, t = 2.062, p = 0.048$) principles on lean transformation Sustainable Success. However, there was no significant effect of Improvement Culture ($\beta = 0.165, t = 1.22, p = 0.243$) and *Hoshin Kanri* ($\beta = -0.112, t = 2.066, p = 0.388$) principles on lean transformation Sustainable Success.

On the contrary, Nooraei Ashtiani (2016) found a significant relationship between *Hoshin Kanri* and lean initiatives Sustain Level ($\tau_b = 0.485$ and $p < 0.001$) in an online survey among 49 organisation leaders who are practising Lean Leadership practices. In addition, there were also significant relationships between other similar Lean Leadership practices and lean initiatives Sustain Level. The practices were including;

Genchi Genbutsu, *Kaizen* Participation, People Development, lean knowledge, on-the-job training and training under lean *sensei*. *Genchi Genbutsu* practice is similar to *Gemba* principle, while *Kaizen* Participation is equals to the principle of Support for Daily Improvement Process. Similarly, lean knowledge, on-the-job training and training under lean *sensei* are a part of Self-Development principle.

Through Kendall's Tau-b correlation test, Nooraei Ashtiani (2016) found significant relationships between these practices and lean initiatives Sustain Level as the following;

1. *genchi genbutsu* ($\tau_b = 0.407, p = 0.007$), 2. *kaizen* participation ($\tau_b = 0.607, p = 0.05$),
3. people development ($\tau_b = 0.415, p = 0.002$), 4. lean knowledge ($\tau_b = 0.402, p = 0.008$),
5. on-the-job training ($\tau_b = 0.539, p < 0.001$) and 6. training under lean *sensei* ($\tau_b = 0.245, p = 0.095$).

Moreover, qualitative evidence claimed that weak leadership of senior leaders was the root-cause of problems related to lean transformation sustainability (Lucey et al., 2005; Murti, 2009; Pentlicki, 2014). Pentlicki (2014) denoted that senior leaders among Colorado SME's manufacturers were unaware of their role and responsibility in leading the lean transformation. Besides, they also had a low degree of leadership knowledge. Murti (2009) found that weak leadership among senior leaders was also manifested in their high dependency on external lean consultants or champions. This dependency had caused the organisation's failure to develop their own lean leaders and champions. Studies by Pentlicki (2014) and Lucey et al. (2005) also revealed the same disappointing findings.

Therefore, many lean advocates strongly recommend that senior leaders need to undergo training to gain full understanding on lean philosophy (Hines et al., 2008; Liker & Convis, 2012; Mohd Yusof & Aoki, 2016; Pentlicki, 2014). Senior leaders should have a passion for excellence and instinctively adapt to lean thinking. They also should notice the need to improve themselves in order to effectively lead their employees. This description was in-lined with the principle of Self-Development in Lean Leadership construct.

Another problem which hindered lean transformation sustainability was lack of employee engagement (Lucey et al., 2005; Murti, 2009; Pentlicki, 2014). In some cases, employees even quit their job when they did not feel engaged (Murti, 2009; Nordin & Md Deros, 2010). Employees tend to resist from accepting changes brought through lean transformation program if they are unengaged and this is a common issue happening globally (Murti, 2009).

One of the sources of employees' resistance within the organisations is related to issue of ownership and controls (Hines et al., 2008). Senior leaders need to trust their employees and empower them to get control on their own job. For instance, by authorising them to prepare work standardisation and improvement (Veech, 2004) as well as setting the organisation's key performance indicators (Hines et al., 2008). Gregory (2012) also advocated that senior leaders should engage subordinates by inspiring trust, clarifying goals, aligning systems and nurturing talents to sustain Lean Transformation. These notions are consistent to the principles of Coach and Develop Subordinates and Support for Daily Improvement Process in Lean Leadership construct.

Hence, by adopting Lean Leadership principles, senior leaders are able to overcome the problem of employee's resistance towards lean transformation sustainability.

Meanwhile, the importance of Strategy Deployment principle in Lean Leadership construct to sustain lean transformation is evident in both success (Sisson, 2014; Vance, 2017) and failure (Murti, 2009; Pentlicki, 2014) case studies. One of the critical indicators to represent Strategy Deployment is long-term thinking (Dombrowski & Mielke, 2014; Liker & Convis, 2012; Nooraei Ashtiani, 2016). Multiple case studies by Murti (2009) revealed that senior leaders of New Zealand's manufacturers viewed lean transformation just as an ordinary productivity improvement operation, not as a long-term continuous improvement strategy. Hence, they decided to stop lean transformation activities as soon as they failed to acquire immediate gains. The same disappointing findings were reported in Pentlicki (2014) study.

In contrast, many LPS scholars agreed that an organisation should never abandon long-term goals in favour of short-term gains to sustain lean transformation (Al Najem, Dhakal, & Bennett, 2012; Hines et al., 2008; Liker, 2004; Mohd Yusof & Aoki, 2016; Society of Automotive Engineers, 1999). In fact, case studies on sustainable lean organisations confirmed that senior leaders who adopted long-term thinking consistent to lean philosophy were successfully led their organisations to sustain lean transformation (Sisson, 2014; Taylor et al., 2013; Vance, 2017). Thus, Strategy Deployment principle may have positive impact on Sustainable Gains from lean transformation.

The principle of Strategy Deployment also promotes senior leaders to expand lean transformation into other business functions and business partners such as human resource, product development and sales (Dombrowski & Mielke, 2014; Hines et al., 2008; Liker & Convis, 2012). However, due to weak leadership skill, senior leaders of Colorado's SME manufacturers struggled to expand lean transformation into support departments like administrative functions, engineering, and sales (Pentlicki, 2014).

On the contrary, senior leaders from Sisson (2014) study claimed that the key to successfully sustain lean transformation is to make sure it is a corporate-wide effort. Sisson (2014) reported that one of the reasons that cause lean transformation to fail is that some organisations focus their efforts only in manufacturing areas and not extending the transformation to the rest of the business, like product development, sales and marketing, procurement, shipping, and customer service. The expansion and alignment of lean transformation across the organisation is also evident in a case study conducted by Popoola (2000). Again, qualitative findings hinted the possible relationship between Strategy Deployment principle and lean transformation sustainability.

Given the overwhelming evidences of possible associations between Lean Leadership and lean transformation Sustainable Gains from both quantitative and qualitative findings, this study hypothesised that the relationship between Lean Leadership and Sustainable Gains is positive.

H2: Lean Leadership has a positive influence on Sustainable Gains.

2.9.3 Relationship between Lean Culture and Sustainable Gains

Although many lean scholars emphasised cultural change as a prerequisite for sustaining gains associated with lean transformation, there had been little effort to statistically prove this association. Due to small number of survey respondents, studies such as Jenei et al. (2014), Salah and Sayed (2015), and Pedersen-Rise and Haddud (2016) only conducted descriptive analysis and presented their findings in the form of web charts. The web charts were used to indicate how far organisational culture of respondent organisations deviate from the ideal lean culture and visualise areas of strength and weakness in their current organisational culture to continue pursuing lean transformation.

Despite the absence of studies on proving association between Lean Culture and Sustainable Gains, there were few studies that examined the relationship between Lean Culture and other types of performance gains attributed to lean transformation. Noori (2015) studied the effect of Lean Culture formation in Tehran hospitals on their Lean Transformation Success in terms of productivity improvement, cost reduction, and waste reduction. The finding indicated that Lean Culture had a positive and significant effect on Lean Transformation Success ($\beta = 0.50, p < 0.01$). Thus, this finding served as an evidence that showed positive association between Lean Culture and lean transformation gains.

Besides that, Vlachos and Siachou (2018) evaluated the impact of Lean Culture on four measures of Lean Performance that include; 1. Continuous Improvement, 2. Waste Management, 3. Ergonomic, and 4. Product Quality. Findings revealed that Lean Culture positively affected all four Lean Performance measures; Continuous

Improvement ($\beta = 0.90, p < 0.001$), Waste Management ($\beta = 0.28, p < 0.001$), Ergonomic ($\beta = 0.73, p < 0.001$), and Product Quality ($\beta = 0.71, p < 0.001$). Hence, this was another evidence that demonstrated positive association between Lean Culture and lean transformation gains.

Lloyd, Harris, Gholston, and Berkowitz (2020) also reported that Lean Culture had a significant and positive effect on Lean Transformation Results ($\beta = 0.404, p < 0.001$). Lloyd et al. (2020) specified Lean Transformation Results by respondent organisations' ability to fulfil customers' order at the lowest possible cost, highest possible quality, and delivery within desired timeframe. Meanwhile, Iranmanesh et al. (2019) found that Lean Culture had a significant positive effect on Sustainable Performance ($\beta = 0.235$ and $p < 0.001$). They measured Sustainable Performance based on triple bottom-line concept (Kono, 2014) that include Financial Performance, Environmental Performance and Social Performance. Nevertheless, there was also a study that recorded a non-significant relationship between Lean Culture and lean transformation gains. Hernandez-Matias et al. (2020) reported that Lean Culture did not have a direct and significant relationship with Operational Performance, measured by waste reduction and production flexibility.

Albeit no exact evidence from existing studies that showed Lean Culture did contribute to Sustainable Gains, it was safe to predict that Lean Culture would show significant impact on Sustainable Gains. This is because, evidences from past studies had shown that individual performance gains like continuous improvement (Vlachos & Siachou, 2018), operational performance (Lloyd et al., 2020; Noori, 2015) and financial performance (Iranmanesh et al., 2019) that were used to form Sustainable Gains

measures in the present study did demonstrate significant relationships with Lean Culture. After all, it is one of the novelties claimed in the present study to explain nascent relationship between Lean Culture and Sustainable Gains (combination of continuous improvement, operational performance, and financial performance) using quantitative evidence. Therefore, this study hypothesised that the relationship between Lean Culture and Sustainable Gains is positive.

H3: Lean Culture has a positive influence on Sustainable Gains.

2.9.4 Mediating Effects of Lean Leadership and Lean Culture

Most studies evaluating lean transformation observed that it had a positive and significant impact on various measures of performance gains; including operational performance (Hardcopf et al., 2021; Sahoo, 2021), financial performance (Galeazzo, 2019; Shashi et al., 2019), business performance (Iteng et al., 2017; Nawanir et al., 2016) and sustainable performance (Iranmanesh et al., 2019; Sajan et al., 2017).

However, some authors found that only certain lean tools and techniques positively influenced performance gains (Iranmanesh et al., 2019; Marodin, Frank, Tortorella, & Fetterman, 2019; van Assen, 2016b). Notably, a considerable group of studies reported these performance gains would eventually dissipated (Ahmed Soliman, 2013; Costa et al., 2019; Jadhav et al., 2014; Pearce & Pons, 2019; Sisson & Elshennawy, 2015; Van Landeghem et al., 2013). Besides the inaccurate measurement of lean transformation as discussed in 2.7.1, this study believed the inconsistent results could be explained by some intervening variables.

Among the intervening variables that had been tested to mediate the effect of lean transformation on performance gains in previously published quantitative studies were including formal training (Ramlee, 2017), quality practices (Onofrei & Fynes, 2019), organisational cultural practices (Cadden et al., 2020) and agile manufacturing practices (Khalfallah & Lakhal, 2021). However, none of these variables specifically mediated the effect of lean tools adoption maturity and sustainable gains. Ramlee (2017) tested formal training as a mediator in the relationship between lean practices and organisational performance. Meanwhile, Onofrei and Fynes (2019) assessed the mediating effect of quality practices which include six sigma, ISO 9000, supplier certification and statistical process control on the relationship between lean practices and production fitness. In the following year, Cadden et al. (2020) investigated the indirect relationship between lean practices and operational performance through organisational culture practices. Recently, Khalfallah and Lakhal (2021) assessed the effect of agile manufacturing as the mediator between lean practices and operational performance as well as financial performance.

On the other hand, existing qualitative evidences suggested Lean Leadership (Gregory, 2012; Holmemo & Ingvaldsen, 2016; Mann, 2009; Orr, 2005) and Lean Culture (Liker, 2004; Mann, 2003) as the two potential mediators in the relationship between lean transformation and sustainable gains. Mann (2003, 2009) clearly posited that Lean Leadership and Lean Culture are the missing links that supposed to bridge a critical divide (gap) between adoption of lean tools and development of lean thinking, which subsequently sustain lean transformation. This notion was further supported by Oon (2018) that also proposed leadership engagement and employee engagement as the mediators to link lean transformation initiatives and operational excellence in a

conceptual article. Thus, there was a good reason to believe that Lean Leadership and Lean Culture might work as mediators to explain the inconsistent link between lean transformation (measured by Lean Tools Adoption Maturity) and performance gains (measured by Sustainable Gains).

In addition, there were considerable number of studies that emphasised integration of hard lean practices (application of lean tools and techniques) with soft lean practices (concerning human factors) to determine various performance gains (Costa et al., 2019; Gaiardelli, Resta, & Dotti, 2019; Oon, 2018; Sahoo, 2019). Leadership and some elements of Lean Culture (teamwork, communication, and working environment) are among soft lean practices that have been observed. Integration between hard and soft lean practices is implying that the maturity of lean tools and techniques adoption is somehow related to human factors such as Lean Leadership and Lean Culture. This link fulfilled the requisite relationship between an independent variable and an intervening variable in theorising a mediating effect (Baron & Kenny, 1986; Preacher & Hayes, 2008). Thus, this notion become another support that hints Lean Leadership and Lean Culture are the mediators to bridge Lean Tools Adoption Maturity and Sustainable Gains.

Specifically, the present study assumed that Lean Tools Adoption Maturity precedes Lean Leadership, thus has a causal effect on Lean Leadership. The concept of lean maturity originates from the idea of measuring organisation's progression relative to lean transformation (i.e., adoption of lean tools and techniques) (Karlsson & Åhlström, 1996; Nightingale & Mize, 2002). Meanwhile, Lean Leadership is a contemporary leadership style formulated by lean scholars based on observations and self-practical

experiences while leading lean transformation in their organisations (Flinchbaugh et al., 2008; Liker & Convis, 2012; Mann, 2009). On that account, no practitioner would recognise Lean Leadership unless he/she has been exposed to adoption of lean tools and techniques in advance. This chronology clearly showed that Lean Leadership principles are practised after the lean practitioners decided to initiate lean transformation. In this case, the maturity of lean tools and techniques adoption influences the adoption of Lean Leadership principles that are believed to assist lean practitioners to sustain lean transformation gains. Thus, this chronology fits the description of a mediator that always been considered as a third variable which represents the generative mechanism through which the focal independent variable is able to influence the dependent variable of interest (Baron & Kenny, 1986; Glen, 2021; www.statisticssolutions.com, 2021).

The final part of the argument for a mediation effect is that many lean scholars agreed Lean Culture is both an enabler and a result of a successful and sustainable lean transformation (Hines et al., 2011; Liker, 2004; Novac & Mihalcea, 2014; Urban, 2015). In other words, Lean Culture was a by-product (outcome) from lean transformation attempt (Vance, 2017; Walentynowicz, 2014) and a factor that determined lean transformation success (Mohd Yusof & Aoki, 2016; Sisson & Elshennawy, 2015). Hence, this assertion strengthened the present study's motivation to investigate the role of Lean Culture as a mediator between Lean Tools Adoption Maturity and Sustainable Gains. To conclude, this study proposed the following hypotheses:

H4: Lean Tools Adoption Maturity has a positive influence on Lean Leadership.

H5: Lean Tools Adoption Maturity has a positive influence on Lean Culture.

H6: Lean Leadership mediates the relationship between Lean Tools Adoption Maturity and Sustainable Gains.

H7: Lean Culture mediates the relationship between Lean Tools Adoption Maturity and Sustainable Gains.

2.10 Summary of the Chapter

In regards to Lean Production System (LPS) history and its development phases in both global and local settings, this study believed that sustaining lean transformation is the current concern in LPS research direction. Definitions and terminologies related to LPS such as “lean philosophy”, “lean thinking”, “lean principles”, “lean production”, “lean manufacturing”, and “lean enterprise” also had been clarified in this chapter. Furthermore, based on extensive review of previous studies, this study proposed a new and all-inclusive definition of Lean Transformation Sustainability (LTS). From the proposed definition, four interrelated variables namely; Sustainable Gains, Lean Tools Adoption Maturity, Lean Leadership, and Lean Culture were derived.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

Research methodology refers to the theory of how a research should be conducted, including the theoretical and philosophical assumptions upon which research is based (Saunders et al., 2016). Research methodology also involves the format of data collection and techniques of data analysis that researchers propose in a study (Creswell, 2014). Therefore, this chapter presented the framework of this study along with relevant theories as the foundation of constructs (variables) in the propose research framework. The proposed research framework was further described through providing operational definition of each observed construct. In addition, this chapter discussed adopted research designs that justifies strategy for data collection procedures. Lastly, sampling process, instrument development, and selection of data analysis techniques were also explained.

3.2 Underpinning Theories

This study presented underpinning theories into a separate section in a research proposal as recommended by Creswell (2014). Creswell (2014) asserted that writing the theoretical explanation in a separate section provides a complete explication of the theory section, its application, and how it relates to the study. Hence, readers can clearly identify the theory from other components. A theory refers to an explanation of a specific social phenomenon that describes a set of causally relevant factors (Abend, 2008; Neuman, 2014). Such factors may be in the form of characteristic, trait, or attribute that are known as variables (Cooper & Schindler, 2014; De Vaus, 2002). In

the same light, a theory logically establishes a connection between two or more variables through a set of general propositions (Abend, 2008; Zikmund et al., 2013).

Meanwhile, organisational theories refer to philosophical commentaries on how organisations are functioning, how they affect and are affected by the environment in which they operate (G. R. Jones, 2013). Most organisation theories claim to guide organisations on how to identify where they are and where they should be. Therefore, organisation theories are also regarded as theories of change (Burnes, 2017; Jørgen & Bindslev, 2006). Organisation theories address the issue of change management either explicitly or implicitly (Burnes, 2017). Moreover, previous studies have associated lean transformation with models and theories related to organisational change management strategies such as Kurt Lewin's Planned Change model, Kotter's 8-steps for Leading Change (Lucey et al., 2004, 2005), Dawson's Emergent Change strategy (Nordin, Md Deros, Abd Wahab, & Ab Rahman, 2011; Smeds, 1994) and Burke-Litwin's Organisational Performance and Change (K. B. Stone, 2010). While those are considered as traditional approaches in managing change, this study proposed something more contemporary as underpinning theories called Theory E and Theory O.

Theory E and Theory O were first introduced by Michael Beer and Nitin Nohria, Harvard Business School professors (Beer & Nohria, 2000b). Theory E stands for Economic value while Theory O represents Organisation's capability. As described by their names, Theory E and Theory O are primarily distinguished based on their core objectives. Theory E has the purpose of creating economic value, also expressed as the hard approach (Beer & Nohria, 2000a). It is process-driven as its main focus is on formal structure and systems (Hodges & Gill, 2015). On the other hand, Theory O is a

soft approach with the major goal of developing organisation's human capability to implement strategy and learn from the effectiveness of changes that are made (Beer & Nohria, 2000a). It centres on the development of a high-commitment culture which is also perceived as people-driven change (Hodges & Gill, 2015).

As both theories have distinct and contradict core objectives, change management scholars recommend organisations to adapt both theories (Beer & Nohria, 2000b; Hodges & Gill, 2015; Luecke, 2003). Combined adaptation of these theories enable organisation to survive and prosper in the long run. Beer and Nohria (2000b) believed that the integration of Theories E and O creates the best and most effective change strategy to organisational change. This is the way to enact rapid economic value improvement while also building organisational capability which are essential for gaining sustainable advantage. Sustainable advantage can be gained only from simultaneous and equal emphasis on optimising economic value and developing organisational capabilities.

Specific to the context of this study, sustainable advantage was depicted as the criterion variable namely Sustainable Gains. Meanwhile, strategies to improve economic value and organisational capability in realising sustainable advantage were manifested as the predictor variables (i.e., Lean Tools Adoption Maturity, Lean Leadership and Lean Culture). Theory E which aims to optimise economic value was obviously in-lined with one of the core lean principles which is creating customer value. Hence, enduring and persistent applications of lean principles (i.e., Lean Tools Adoption Maturity) could be explained by Theory E. On the contrary, Theory O which emphasises on organisation's capabilities development was consistent to Lean Leadership and Lean Culture.

Beer and Nohria (2000a) described the integrated Theories E and O characteristics using five key dimensions namely; 1. goals, 2. leadership, 3. focus, 4. process, and 5. consultants' appointment. Hence, to further clarify how Theories E and O are compatible to explain the theoretical framework of this study, comparisons between constructs under study and these key dimensions were made as in Table 3.1.

Table 3.1

Compatibility of studied constructs with Theories E and O

Key Dimensions	Integration of Theories E and O	Related Constructs
Goals of Corporate Change	Simultaneous aims for economic value and organisational capability	Sustainable Gains • Operational Performance (economic value) • Business Performance (economic value) • Continuous Improvement Capability (organisational capability)
Leadership of Corporate Change	Set direction from the top management and engage the employee from below	Lean Leadership • Strategy Deployment • Support Daily Improvement Process • Coach & Develop Subordinates
Focus of Corporate Change	Simultaneously focus on the hard (structures and systems) and the soft (corporate culture) approaches	• Lean Tools Adoption Maturity: Hard approach • Lean Leadership: Hard and soft approaches • Lean Culture: Soft approach
Process of Corporate Change	Devising plans, establishing programs, experimenting and keep evolving	• Lean Leadership: Strategy Deployment • Lean Culture: Problem Solving and Innovation
Appointment of Consultants	Use consultants as expert resources to mentor internal change leaders while empowering lower-level employees	• Lean Leadership: Self-Development • Lean Leadership: Support Daily Improvement Process

Source: Adapted from Beer and Nohria (2000a)

Table 3.1 revealed that the goal of integrated Theories E and O was consistent to key target construct of this study (i.e., Sustainable Gains). The three features of Sustainable Gains were implying that lean manufacturers need to simultaneously embrace economic value and organisational capability to sustain their transformation. For instance, both tangible gains (i.e., Operational Performance and Business Performance)

represented the economic value goal. On the other hand, intangible gain (i.e., Continuous Improvement Capability) represented the organisational capability goal.

Further, the integrated Theories E and O promotes the change leaders to set direction from top management, while at the same time engage lower-level employees. This characteristic is clearly visible in Lean Leadership. The principle of Strategy Deployment suggests senior leaders to set clear strategic direction for lean transformation in their organisations and set lean transformation as the key operational strategy to improve organisational performance. On the other hand, Coach and Develop Subordinates as well as Support for Daily Improvement Process principles comprised of senior leaders' efforts to engage lower level employees (Dombrowski & Mielke, 2014; Liker & Convis, 2012; Nooraei Ashtiani, 2016).

In addition, the simultaneous focus on both hard (i.e., structures and systems) and soft (i.e., corporate culture) approaches can be well-translated with all the predictor variables of this study. Organisations that effectively integrate hard and soft focus to change are expected to reap considerable returns in profitability and productivity (Beer & Nohria, 2000a). Focus on structures and systems may involve restructuring of corporate departments, operating units, and/or assigned employees to eliminate redundancies and inefficiencies in the organisation (Burnes, 2017; Hodges & Gill, 2015; Luecke, 2003). In-line with this focus, employment of Lean Tools Building Blocks (i.e., proxy measure of Lean Tools Adoption Maturity) can help organisation to eliminate redundancies and inefficiencies in its system (Ballé, 2015; Dennis, 2016; Lean Enterprise Institute, 2014; Society of Automotive Engineers, 1999). Meanwhile, Lean Leadership and Lean Culture could be considered as enabling structures (Mann,

2015; van der Merwe, 2016) that underpinned successful adoption of integrated Theories E and O.

Luecke (2003) also claimed that gains acquired from change initiatives could be consolidated and cemented through policies that described how work was to be done and proper information systems. This statement could be directly associated to Lean Leadership principle of Strategy Deployment and Lean Culture dimension, Effective Communication. Strategy Deployment principle in Lean Leadership construct also could be linked to the hard focus of integrated Theories E and O. The use of *hoshin kanri* (policy deployment) to realise Strategy Deployment principle is implying that this principle is focusing on organisation's structures and systems.

Nevertheless, other principles of Lean Leadership and dimensions of Lean Culture were closely related to the soft focus of this theory (i.e., corporate culture). Principles of Coach and Develop Subordinates as well as Support for Daily Improvement Process are meant for developing corporate culture through encouraging participation from employees and fostering employee behaviours and attitudes that will sustain change (Hodges & Gill, 2015; Liker & Convis, 2012).

In the same vein, Lean Culture was clearly translating the soft focus of this integrated theories. Developing human capability through individual and organisational learning are a part of Theories E and O integrated soft focus (Beer & Nohria, 2000a). Lean Culture dimensions such as Problem Solving and Innovation represent learning culture at both individual and organisational level. Soft focus also seeks to improve the competitiveness of the organisation's corporate culture by making it less bureaucratic,

strengthen bonds between the organisation and its staffs and more customer-focused (Hodges & Gill, 2015; Luecke, 2003). Thus, it was consistent to dimensions of Positive Work Environment, Effective Communication and Teamwork in Lean Culture construct.

Further, Beer and Nohria (2000a) remarked that devising plans, launching programs and experimentation to keep evolving as the process of corporate change which are comply to Theories E and O. In relation to this study, devising plans and program launches for lean transformation are included in Strategy Deployment principle of Lean Leadership construct. Meanwhile, the experimentation process promotes in Theories E and O is parallel with Innovation dimension of Lean Culture construct. Through Innovation, organisations are encourage to achieve breakthroughs by attempting new strategies and testing assumptions (experimentation) (Alukal, 2006b; Jenei et al., 2014).

Lastly, the theory also highlighted that consultants are only appointed to mentor internal change leaders while empowering lower-level employees instead of as problem solver or decision maker for the organisation. This assertion is indeed in-line with Self-Development principles of Lean Leadership construct which also demands lean leaders to learn from lean sensei or experts (Nooraei Ashtiani, 2016; Sisson, 2014; Vance, 2017). In addition, under Coach and Develop Subordinates principle lean leaders are also expected to mentor and empower their lower level employees to run their own work area (Dombrowski & Mielke, 2014; Hines et al., 2008; Zarbo, 2012). Thus, this principle was also in-lined with Theories E and O belief.

Overall, it was clear that all variables proposed in this study could be logically explained using the integrated approach of Theories E and O. These theories suggested that organisation's goal to change must be both economic value and organisational capabilities oriented. Only by integrating both goals, sustainable competitive advantage is possible to achieve. In the context of this study, Sustainable Gains was perceived as sustainable competitive advantage that lean manufacturers are aiming for. In order to successfully gain sustainable competitive advantage, integrated Theories E and O demand organisations to deploy corporate change in organisation's focus, process, leadership, and appointment of consultants. Thus, this study assumed Lean Tools Adoption Maturity, Lean Leadership, and Lean Culture as the relevant variables to represent these corporate changes.

3.3 Research Framework and Operational Definitions

A research framework refers to a network of associations among variables of interest in a research study that is logically developed, described, and explained (Sekaran & Bougie, 2016). On the other hand, operational definitions are definitions for variables that is specific to testing criteria, specifying what must be gathered, measured or computed from the researcher's perspective (Cooper & Schindler, 2014). Operational definitions also provide the translation of a variable into a set of indicators and the decisions about how to classify an individual variable (De Vaus, 2002).

Based on extensive and in-depth review of literatures in Chapter Two, a causal model with double mediators was proposed in this study that include Lean Tools Adoption Maturity as the independent variable, Lean Leadership and Lean Culture as mediators, and Sustaining Gains as the dependent variable (see Figure 3.1).

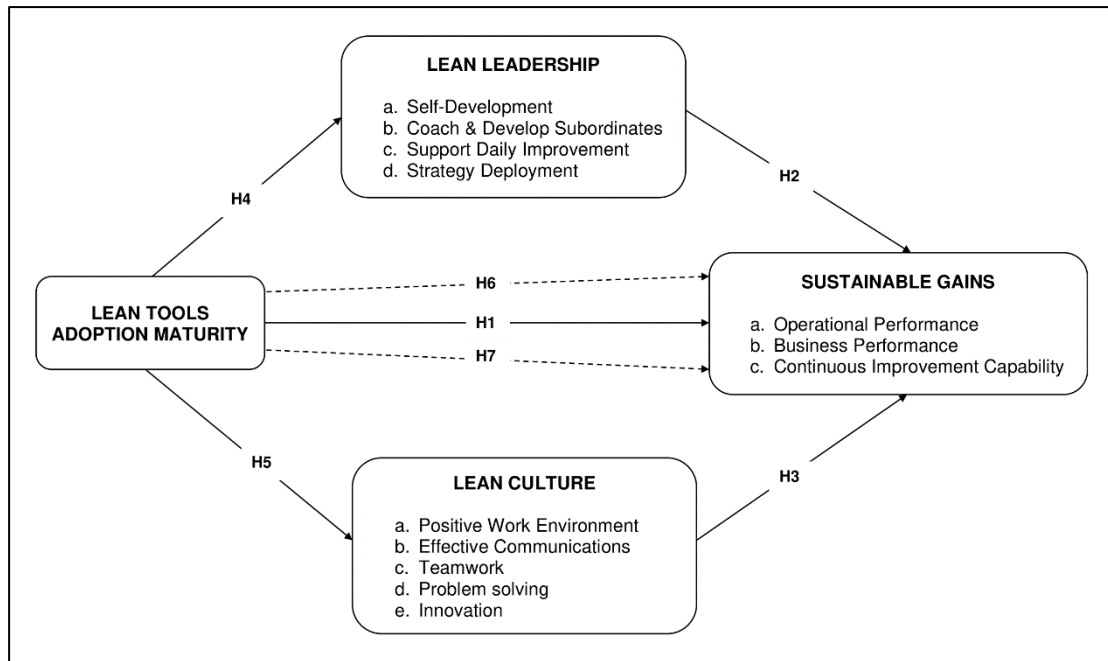


Figure 3.1
Lean Transformation Sustainability Model

Figure 3.1 displayed the proposed research framework named as Lean Transformation Sustainability Model. This model illustrates the relationships between Sustainable Gains and its determinants (i.e., Lean Tools Adoption Maturity, Lean Leadership, and Lean Culture). All variables in this model were multi-dimensional constructs, except Lean Tools Adoption Maturity. The arrows in the figure represent the hypothesised relationships. The hypotheses were stated as the following:

1. H1: Lean Tools Adoption Maturity has a positive influence on Sustainable Gains.
2. H2: Lean Leadership has a positive influence on Sustainable Gains.
3. H3: Lean Culture has a positive influence on Sustainable Gains.
4. H4: Lean Tools Adoption Maturity has a positive influence on Lean Leadership.
5. H5: Lean Tools Adoption Maturity has a positive influence on Lean Culture.
6. H6: Lean Leadership mediates the relationship between Lean Tools Adoption Maturity and Sustainable Gains.

7. H7: Lean Culture mediates the relationship between Lean Tools Adoption Maturity and Sustainable Gains.

Further, each construct and its dimensions were operationally defined as followed (see Table 3.2).

Table 3.2
Constructs' operations definitions

No	Construct / Dimension	Definition
1.	Sustainable Gains	The ability to persistently acquire benefits and improvements from lean transformation efforts that include both tangible and intangible gains.
	a. Operational Performance	Gains from internal operation of the company in terms of cost reduction, product quality improvement, flexibility enhancement, delivery performance, and productivity increment (Jayaraman et al., 2012).
	b. Business Performance	Gains from financial aspects, such as revenue growth, net profits, return on assets, and non-financial aspects, such as capacity to develop a competitive profile, new products, and market shares (Jayaraman et al., 2012).
	c. Continuous Improvement Capability	Competitive abilities that allows organisations to learn, innovate and renew (Aloini et al., 2011).
2.	Lean Tools Adoption Maturity	The magnitude (completeness), extensiveness (how wide), and duration (experience) of lean tools and techniques adoption in the organisation (Mousavi et al., 2020)
3.	Lean Leadership	Organisation leaders' necessary roles, values, competencies, skills, attributes or characteristics for effective lean transformation (Gundes de Almeida et al., 2018).
	a. Self-Development	The extent to which top management are aware to make self-improvement and personally lead subordinates in lean transformation.
	b. Coach and Develop Subordinates	The extent to which production managers/ supervisors use coaching as a means of facilitating learning, growth and development of their subordinates.
	c. Support Daily Improvement Process	The extent to which managers at all levels demonstrate commitment and support by interacting with employees on a daily/regular basis.
	d. Strategy Deployment	The extent to which top management adopt long-term thinking and align lean transformation with corporate strategic direction.

Table 3.2 (continue)

No	Construct / Dimension	Definition
4.	Lean Culture	An ideal organisational (corporate) culture that foster the success and sustainability of lean transformation in business organisations.
	a. Positive Work Environment	The extent to which non-blaming and process-driven working environment inspire mutual trust and respect for people among organisation members in a lean organisation.
	b. Effective Communication	The extent to which important information on lean transformation journey is effectively transferred between organisation members.
	c. Teamwork	The extent to which lean transformation and problem resolution activities are handled in teams.
	d. Problem Solving	The extent to which problem resolution activities are carried out based on lean thinking.
	e. Innovation	The extent to which organisation members welcome new ideas and allowed innovations to take place through experimentation and risk-taking.

3.4 Research Design

Research designs are research inquiries within qualitative, quantitative, or mixed methods studies that provide specific direction for procedures in fulfilling research objectives and answering research questions (Cooper & Schindler, 2014; Creswell, 2014). Research design also works as a blueprint for providing reasoned justification on selection of data sources, collection methods and analysis techniques (Saunders et al., 2016).

However, prior to selecting the appropriate data sources, collection methods and analysis techniques to answer the research questions, Saunders et al. (2016) advised researchers to make clarifications on other research inquiries such as philosophical stance, adopted approach to theory development, and methodological choice through the "Research Onion" (see Figure 3.2). In this sense, this section sequentially clarified other inquiries pertaining to research design according to the Research Onion.

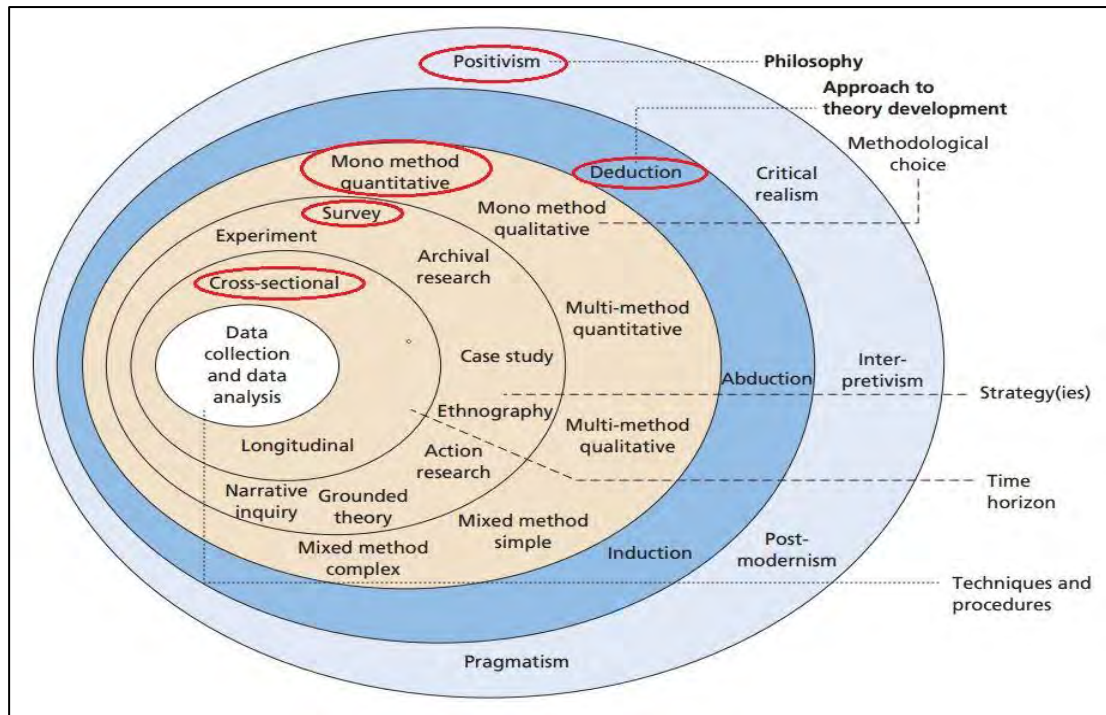


Figure 3.2

Adopted research design inquiries according to Research Onion

Source: Adapted from Saunders et al. (2016)

3.4.1 Research Philosophy

Research philosophy refers to a system of beliefs and assumptions about the development of knowledge and the nature of that knowledge in relation to research (Saunders et al., 2016). Figure 3.2 illustrates five types of research philosophies which include; 1. positivism, 2. critical realism, 3. interpretivism, 4. post-modernism, and 5. pragmatism. This study adopted positivism as the philosophical stance in conducting the research on Lean Transformation Sustainability.

Positivism philosophy advocates the application of the deductive rule and quantitative methods to the study of social reality and beyond (Sekaran & Bougie, 2016). Researchers who adopted positivism is an empiricist (Bryman, 2012). Hence, this philosophical stance was in-lined with the objective of this study which aimed to

empirically evaluate the impact of Lean Tools Adoption Maturity, Lean Leadership, and Lean Culture on lean transformation Sustainable Gains.

Moreover, an empirical evaluation involves observations and knowledge acquisition based on experience and senses derived by methods of inductive logic, statistics or mathematics (Bryman, 2012; Cooper & Schindler, 2014). In the same light, this study attempted to acquire statistical evidence on Lean Transformation Sustainability among lean organisations in Malaysia's manufacturing sector by deriving hypotheses from experience of other lean organisations (i.e., success stories and past failure). Hence, it was true that this study adopted positivism philosophical stance.

3.4.2 Approach to Theory Development and Methodological Choice

According to Saunders et al. (2016) there are three approaches to theory development including; 1. abduction, 2. deduction, and 3. induction. This study had decided to adopt deduction approach or also called deductive reasoning. In fact, from a positivist perspective, a research tends to lead to deductive reasoning (Holden & Lynch, 2004). Deduction reasoning is simply defined as the application of a general theory to a specific case (Sekaran & Bougie, 2016). In this study, the general theory in used were Theory E and Theory O and these theories were applied in the case of Lean Transformational Sustainability.

Deductive reasoning also describes the process whereby specific expected outcomes or hypotheses are logically derived from more general principles (De Vaus, 2002). Consistent to this depiction, research hypotheses in this study are certainly derived from general principles like sustainable organisational change (Buchanan et al., 2005), Lean

Leadership principles (Liker & Convis, 2012) and organisational culture (Schein, 1985). Hence, it is certain that the adoption of deductive approach is theoretically appropriate for this study.

Specifically, this study was designed according to hypothetico-deductive method. Hypothetico-deductive method involves seven-steps research process including; 1. identifying a broad problem area, 2. defining the problem statement, 3. hypotheses development, 4. determining measures, 5. data collection, 6. data analysis, and 7. data interpretation (Sekaran & Bougie, 2016). All these steps were certainly followed in the writing of this thesis (see Figure 3.3).



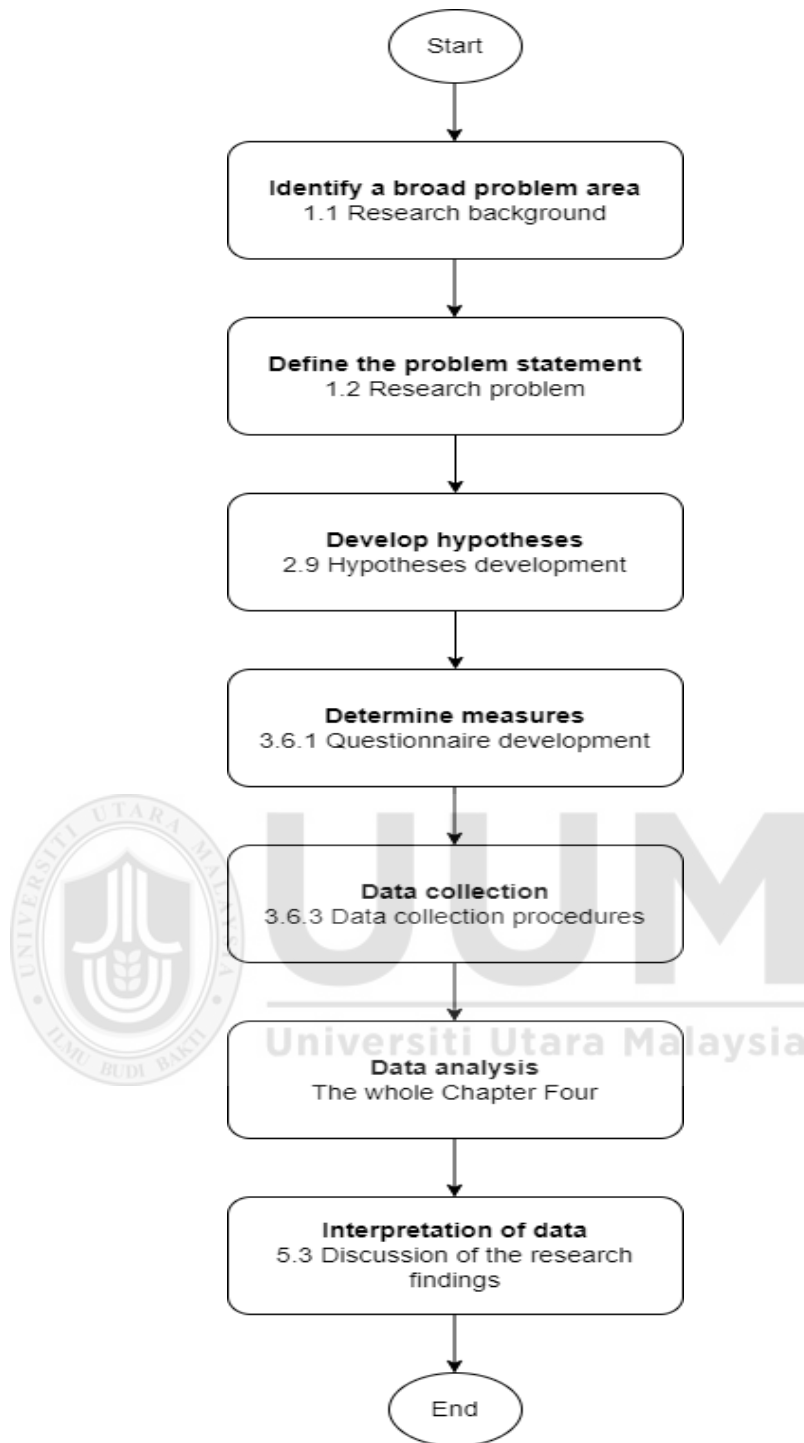


Figure 3.3
Flow chart of overall research process

Figure 3.3 displayed the overall research process undertaken in the present study. The figure also depicted how seven-steps of hypothetico-deductive research process outlined by Sekaran and Bougie (2016) corresponded with the organisation of this thesis.

Further, Saunders, Lewis, and Thornhill (2009) categorised methodological choices into three major options namely; 1. mono method, 2. multiple-method and 3. mixed-method. Each option can be further classified into quantitative and qualitative mono methods, quantitative and qualitative multiple-methods, as well as simple and complex mixed-methods (Saunders et al., 2016). In the context of this study, a mono method quantitative is considered adequate to answer the posited research questions and fulfil proposed research objectives. Mono method means using a single data collection technique and corresponding analysis procedures (Saunders et al., 2016). Specifically, this study is solely relied on quantitative data and corresponding analyses (see Figure 3.4).

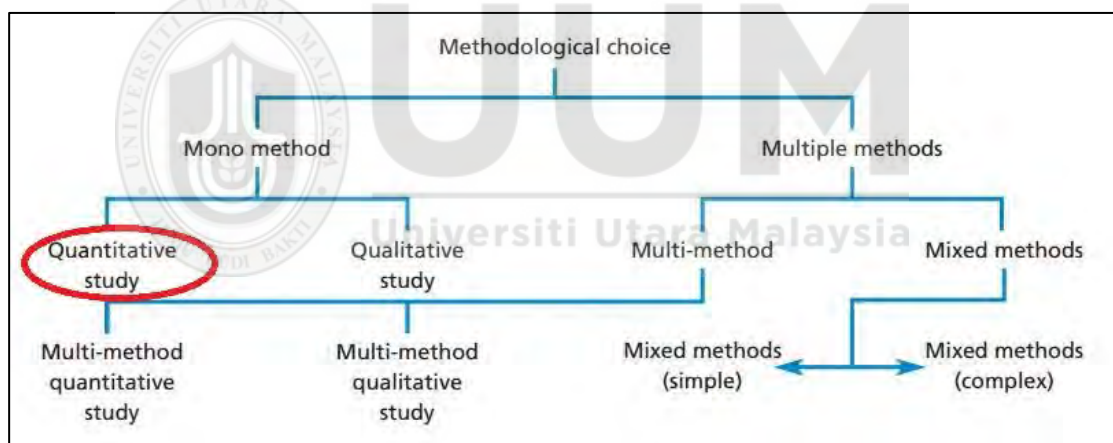


Figure 3.4

Methodological choices

Source: Adapted from Saunders et al. (2016)

Quantitative method operates more within the deductive groundwork of fixed and specified research objectives (Creswell, 2014), and rely more on positivism philosophy (Neuman, 2014). Consistent to these statements, this study deductively used vast literatures as the foundation for deriving the research questions and developing hypotheses to fulfil research objectives. Based on the literatures, qualitative researchers

also attempt to comprehensively define all relevant terms at the beginning of studies or use accepted (adopt) definitions found in the literature (Creswell, 2014). This is exactly what was done in the first three chapters of this thesis.

There are also several advantages of quantitative method over qualitative method. Cooper and Schindler (2014) denoted that business senior managers view qualitative data as too subjective and susceptible to human error. This will cause bias in data collection and interpretation. They also believe such method provides an unstable foundation for expensive and critical business decisions. Moreover, the fact that findings in quantitative studies can be generalised to a larger population is considered as fundamental favour over qualitative studies (Cooper & Schindler, 2014; Sekaran & Bougie, 2016).

3.4.3 Research Strategy

A quantitative study can be conducted using three strategies including; 1. experiment, 2. archival research and 3. survey (Creswell, 2014; Saunders et al., 2016; Sekaran & Bougie, 2016). As mentioned earlier, this study intends to employ mono method data collection, hence survey strategy was the only selected strategy. Survey is often associated with a deductive research approach and regarded as common strategy in business and management research (Saunders et al., 2016). In fact, it is also widely viewed as being inherently quantitative and positivistic (De Vaus, 2002) which was consistent to philosophical stance and theory development approach of this study.

More importantly, survey is the most preferred data collection strategy to gather quantitative evidences for answering causal research questions (Creswell & Creswell,

2018; Sekaran & Bougie, 2016). Causal studies test whether or not one variable causes another variable to change. In a causal study, the researcher is interested in delineating one or more factors that are causing a problem (Sekaran & Bougie, 2016). This notion totally reflects the purpose of this study that aimed to test whether Lean Tools Adoption Maturity, Lean Leadership and Lean Culture cause Sustainable Gains to change.

Moreover, surveys provide a quick, inexpensive, efficient, and accurate means of assessing information about a population. Over the last two decades, survey research strategies and standards have become utterly scientific and accurate. Surveys are quite flexible and when appropriately administered, offers extremely valuable insights to the business managers (Zikmund et al., 2013).

Another major advantage of survey research is that it has the potential to provide researchers with huge amount of information obtained from a reasonable number of samples (Fraenkel et al., 2012). Surveys enable for the characteristics of thousands of people to be estimated with considerable precision by collecting information from only a few hundred rather than everyone in the population. This allows researchers to focus their resources on maximizing response rate and ensuring the acquired responses are as accurate as possible (Dillman, Smyth, & Christian, 2014).

3.4.4 Time Horizon

Time horizon or sometimes called time dimension refers to time points or moments when the research data is gathered (Cooper & Schindler, 2014; Neuman, 2014). Data for a research can be collected in two different time horizons, either cross-sectional or longitudinal. Cross-sectional study refers to a research design that requires the

collection of data just once (a single point in time) to answer research questions. On the contrary, longitudinal study research design in which data are collected on a sample at multiple time points to answer research questions (Bryman, 2012; Sekaran & Bougie, 2016).

Data collection through survey strategy is normally based on cross-sectional time horizon, where data is gathered from a relatively large number of cases only at a particular time, since sample groups are derived based on existing differences (De Vaus, 2002; Kothari, 2004). The time horizon for data collection is usually determined according to the appropriateness and need to answer the posited research questions (Creswell & Creswell, 2018). This study employs cross-sectional data collection due the following reasons:

1. in answering the causal research questions, the time change is irrelevant and can be ignored because it will not give a significant impact on the findings to be obtained (Chua, 2014),
2. cross-sectional survey provides a more valid information than longitudinal survey because it is easier to gather representative samples (Greener, 2008). Representative samples mean samples that are nearly identical to the population characteristics in all circumstances (Darusalam & Hussin, 2018), and
3. longitudinal studies are difficult to conduct truthfully, since certain information cannot be collected a second time from the same individual without the risk of bias (Cooper & Schindler, 2014).

Thus, based upon these arguments and sufficiency of answering the research questions, a cross sectional survey study was considered appropriate to be employed in this study.

3.5 Sampling Process

Sampling is the process of selecting appropriate number of the representative samples from a population (Sekaran & Bougie, 2016). This process is important to ensure the selected samples are accurately and precisely representing the characteristics or properties of the population it purports to represent (Cooper & Schindler, 2014). Accurate and precisely selected samples enable the examination of characteristics or properties under study to be generalised for the entire cases or units in the population (Neuman, 2014; Sekaran & Bougie, 2016).

However, researchers need to use rigorous sampling techniques to make an accurate and precise samples selection in quantitative research. These techniques rely on the mathematics of probabilities and hence, are called probability sampling (Neuman, 2014). Therefore, this study decided to apply one of the probability sampling techniques to draw the appropriate number of representative samples.

Sekaran and Bougie (2016) listed five proper sequences in executing the sampling process. The sequences were as followed:

1. defining the population,
2. determining the sample frame,
3. deciding the sampling technique,
4. estimating the appropriate sample size, and
5. executing the sampling process.

Thus, this section was presented following these sequences.

3.5.1 Population, Target Population and Sampling Frame

A population in research studies refers to the entire group of people, events, or things that the researcher desires to investigate (Sekaran & Bougie, 2016). It is also referring to the group which researchers prefer the results of a study to be generalisable (Fraenkel et al., 2012). In the context of this study, manufacturing organisations in Malaysia was the population under study. The total population of manufacturing organisations in Malaysia is unknown, since the Department of Statistics Malaysia (DOSM) also does not declare the number (Department of Statistics Malaysia, 2021). Saunders et al. (2016) stated that researchers may redefine a population as something more manageable whenever not all units or cases in such population are known or accessible to the researchers. This subset of the population is often called as the target population.

The target population means the complete set of cases or units that is the actual focus of the research questions and from which samples are to be drawn (Bryman, 2012; Saunders et al., 2016). Consistent to the cited definition, this study targeted all manufacturing organisations in Malaysia that are currently practising lean principles. Only the lean practitioners among manufacturing organisations were qualified to participate in this study and enable the researcher to answer the posited research questions. Unfortunately, there was no directory that list such information currently available. Hence, the target population is also unknown and inaccessible.

The common directory used in previous studies within the same research context is published by Federation of Malaysian Manufacturers (FMM). FMM is the largest private sector Malaysia's premier economic organisation that has consistently led Malaysian manufacturers in spearheading the nation's growth and modernisation.

Although FMM's latest directory (51st Edition) contains profiles of over 3,300 manufacturing and industrial service companies of varying sizes (Federation of Malaysian Manufacturers, 2021) and reputed as the most effective medium for business contacts, it still cannot be used as the sampling frame to represent the target population. This directory does not specifically classify whether the listed companies are lean practitioners or not.

Obtaining a sampling frame is a must if researchers intend to use probability sampling (Cooper & Schindler, 2014; Saunders et al., 2016). A sampling frame is a full list of all the cases in the target population from which the samples are drawn (Sekaran & Bougie, 2016; Zikmund et al., 2013). Without a sampling frame, researchers unable to properly draw samples from the target population as the chance or probability of every case being selected is unknown and might be zero (Cooper & Schindler, 2014; Saunders et al., 2016). Nevertheless, Saunders et al. (2016) suggested that, if researchers still wish to use probability sampling where no suitable directory exists, they are permitted to compile their own sampling frame as long as the sources are credible.

Therefore, this study made a self-compilation directory based on the unpublished record of lean organisations, courtesy of Malaysia Productivity Corporation (MPC). As narrated in the Chapter Two, MPC is a federal government agency that led the promotion and dissemination of productivity related information and issues. Since LPS is known as a world class productivity improvement strategy, MPC started to venture and train small and medium private organisations and public sector in lean transformation programmes.

This directory was derived from the list of organisations that have been participated in MPC's Lean Transformation Program and Assessment. Overall, there were more than 250 organisations all over the country that had participated in the programmes from year 2015 to 2018. These organisations had been recognised their lean status by MPC with the help of their Lean Strategic Partners. MPC's Lean Strategic Partners are industrial players in Malaysian manufacturing sector that had been practising lean principles long before MPC venture into lean transformation program including; MODENAS, Sime Darby Holdings, and Toyota UMW. However, after excluding organisations that belonged to service and public sectors, only 213 organisations were remained in the list.

The filtered 213 manufacturing organisations composed of 11 different industries namely; 1. food and beverages (F&B), 2. wood-based, 3. electrical and electronics (E&E), 4. automotive, 5. iron and steel (I&S), 6. pharmaceuticals, 7. chemicals and petrochemicals (C&P), 8. machinery and equipment (M&E), 9. rubber, 10. textiles, and 11. aerospace components. These industrial classifications are set by the Ministry of International Trade and Industry (MITI) (Ministry of International Trade and Industry, 2017).

Manufacturing organisations listed in this directory were also considered as the accessible population of this study. Accessible population refers to the population from which the researcher can realistically draw cases or units as samples, and to which the researcher is entitled to generalise findings (Fraenkel et al., 2012). Hence, the self-compiled directory in this study posed as the accessible population where researcher can realistically draw units (i.e., manufacturing organisations) as samples.

3.5.2 Unit of Analysis and Eligible Respondents

Unit of analysis refers to case about which the data is collected. It is the unit about which researchers are collecting information that are not necessarily a person or individual, might be objects, groups or organisations (De Vaus, 2002; Fraenkel et al., 2012). Based on earlier discussion, the unit of analysis in this study was certainly the organisation.

Meanwhile, eligible respondents refer to individuals who are qualified to verbally answer an interviewer's questions or provide answers to written questions (Zikmund et al., 2013). Following previous studies (Netland et al., 2020; van der Merwe, 2016), managerial level staffs (top, middle or first-line managers) were regarded as qualified individuals to provide answers regarding lean transformation inquiries in their respective organisations. All managerial level staffs are regarded as eligible respondents because in successful lean organisations, lean transformation strategy is deployed from top to down, but its execution works from down to top (Mann, 2015; Poksinska & Swartling, 2018; Sisson & Elshennawy, 2015). Hence, all managerial staffs are directly involved in lean transformation program according to their designated roles. First-line managers in charge of operational duties, middle managers are responsible for tactical tasks, and top management devises strategic planning (Gundes de Almeida et al., 2018; Netland et al., 2020). Therefore, this study attempted to approach these individuals as respondents.

Another criterion to consider for eligible respondents is the duration of lean transformation has been implemented in the target organisations. This study decided to

observe lean organisations that have ventured in lean transformation journey for at least two years. The duration taken for lean transformation gains begin to visible was rarely addressed in previous studies, especially studies conducted within cross-sectional timeframe. Even so, few action researches and case studies did briefly describe the time taken for lean transformation to take effect and paid off practitioners' efforts.

Karim and Arif-Uz-Zaman (2013) conducted an action research in an Australian company producing electrical module. They reported that the lean project team in the case company worked for only several months before the process in cubicle assembly line started to show significant improvements. During those several months the project team had studied, analysed and implemented several basic lean tools which resulting in reduction of unnecessary motions, average production time, as well as total effectiveness.

Another action research was conducted in an aerospace composite manufacturing plant also reveal that manufacturers can obtain gains from lean transformation within a quite short period. Puvanasvaran et al. (2009) focused on People Development System (PDS) in Kitting Department of the case company. The system involves training sessions to enhance skill, knowledge and communication besides promoting teamwork and task delegation among employees. PDS successfully helps the department achieve Key Performance Indicators (KPI) set by the company after past one year. KPI measures include scrap level, absenteeism rate, stop time and overtime work duration.

Meanwhile, Wan Mahmood and Muhamad (2008) conducted a case study in the same setting (i.e., aerospace composite manufacturing plant). The case company had shown

significant gains in productivity and employee involvement after only six months of lean transformation. They also reported the case company did a lot of process improvement within two years of its lean journey. These findings were also in-lined with Degirmenci's (2008) notion that claimed full lean transformation takes approximately five years in normal pace. However, this transformation process can be shortened to only two years if lean management standards are used.

In addition, this decision was consistent with a number of previous studies that also observed lean transformation progress for a period of two-years (Galeazzo, 2019; Madsen et al., 2019; Murti, 2009; Van Landeghem et al., 2013). Madsen et al. (2019) suggesting that the diffusion and use of the lean principles stand a good chance of keeping its current level and momentum after two years of its deployment. Two-year delay after lean transformation initiation is long enough for organisations to learn to be lean and develop necessary capabilities to capitalise on its potential benefits.

3.5.3 Sampling Technique

In general, there are two major techniques of sampling namely; 1. probability sampling, and 2. non-probability sampling. Probability sampling means selection of sampling techniques in which the chance or probability of every unit being selected from the population is known and is not zero. In contrast, non-probability sampling is selection of sampling techniques in which the chance or probability of each unit being selected is unknown and probably zero (Saunders et al., 2016). While both techniques have own unique purposes, the validity of samples is the major concern in most quantitative studies.

Validity of a sample depends on the degree to which bias is absent from the sample (i.e. accuracy) and how closely the sample represents the population (i.e. precision) (Cooper & Schindler, 2014). Whereas, only probability sampling techniques provide estimates of precision (i.e., representativeness) upon the target population. Representativeness is necessary to enable the generalisation of research findings from the analyse sample to the target population from which they are selected (Bryman, 2012; Cooper & Schindler, 2014; Sekaran & Bougie, 2016). Hence, this is the primary consideration of why this study resorted to probability sampling technique.

In addition, quantitative researchers prefer probability sampling because it is very efficient. This sampling technique can save a lot of time and cost for the accuracy it is offering. A properly conducted probability sample may cost 1/1000 the cost and time of gathering information on an entire population, yet it will yield virtually identical results (Neuman, 2014). Probability sampling is therefore a compromise between the accuracy of the research findings and the amount of time and budget researchers invest in collecting, checking and analysing the data (Saunders et al., 2016).

Probability sampling relies on random selection processes. Random selection means a selection process without any pattern (Cooper & Schindler, 2014; Neuman, 2014). Random sampling yields samples most likely to truly represent the entire population and allows researchers us to statistically calculate the deviation between what is in the sample data and an ideal population parameter due to random processes (i.e. sampling error) (Neuman, 2014).

Moreover, drawing cases or units randomly is the most rigorous sampling since randomisation offers generalisation upon the target population (Creswell, 2014). Generalisations about target populations from data collected using probability sampling is based on statistical probability. The larger the sample's size the lower the likely error in generalising to the target population (Saunders et al., 2016). This is the reason why random sampling is considered as the best technique for the selection of representative samples (Kothari, 2004).

Further, social and business research methodologists suggest several techniques to execute probability or random sampling including; 1. simple random, 2. systematic random, 3. cluster sampling, and 4. stratified sampling. This study applied the simple random technique because it is the purest form of probability sampling and easy to implement (Cooper & Schindler, 2014). Hence, it has the least bias and offers the most generalisability compare to other probability sampling techniques (Sekaran & Bougie, 2016).

For instance, simple random sampling has better precision and statistical efficiency compares to cluster sampling because clusters often do not meet the need for heterogeneity (Cooper & Schindler, 2014; Kothari, 2004). Statistical efficiency means the relative efficiency of between-test comparisons based on the ratio of sample sizes required for the tests to have equal probabilities of detecting the same false null hypothesis (i.e., both tests reach a certain power against the same alternative hypothesis) (Kenett, Coleman, & Stewardson, 2003).

In the same vein, systematic random technique is exposed to subtle biases such as oversampling or under-sampling and periodicity caused by monotonic trend or systematic pattern in the sample frame (Cooper & Schindler, 2014; Kothari, 2004; Saunders et al., 2016; Zikmund, Babin, Carr, & Griffin, 2010). Lastly, stratified sampling which involves extra stage in the sampling procedure also incur extra time and extra effort for researchers. Besides, stratified sampling is more difficult to explain than simple random technique (Saunders et al., 2016; Zikmund et al., 2010).

3.5.4 Sample Size

Sample size refers to the actual number of subjects selected as a sample to represent the population characteristics, with subject means a single member of the sample (Sekaran & Bougie, 2016). Many social and business research scholars claim that minimum number of samples can be determined based on two considerations including; 1. population characteristics, and 2. types of data analysis to be employed (Creswell, 2014; Neuman, 2014; Saunders et al., 2016; Zikmund et al., 2010). Hence, this study determined minimum number of samples following these considerations.

However, there are difficulties in determining sample size based on population characteristics consideration (De Vaus, 2002; Neuman, 2014). Researchers must have a rough idea on the degree of diversity or dispersion in the population on key variables under study (Cooper & Schindler, 2014; De Vaus, 2002; Saunders et al., 2016). Apart from requiring researchers to estimate the degree of population diversity needed, researchers must also account for population mean (Cooper & Schindler, 2014; Kothari, 2004; Sekaran & Bougie, 2016). Unfortunately, such information are rarely known by most social and business researchers (De Vaus, 2002; Neuman, 2014).

Therefore, the present study resorted to determine minimum number of samples based on types of data analysis to be employed. Following Memon et al. (2020) recommendation, this study calculated required sample size using G*Power program. G*Power is a free-to-use statistical power calculator used to compute sample size required in statistical analyses like F-tests and t-tests. It is developed by Faul, Erdfelder, Buchner, and Lang (2009). Based on the maximum number of arrows pointed at a construct in the research model to represent number of predictors (i.e., three arrows pointed at Sustaining Gains construct), effect size (f^2) of 0.15, significance level (α) of 0.05, and 80% statistical power ($1-\beta$), the calculated total sample size was 77 (see Figure 3.5).

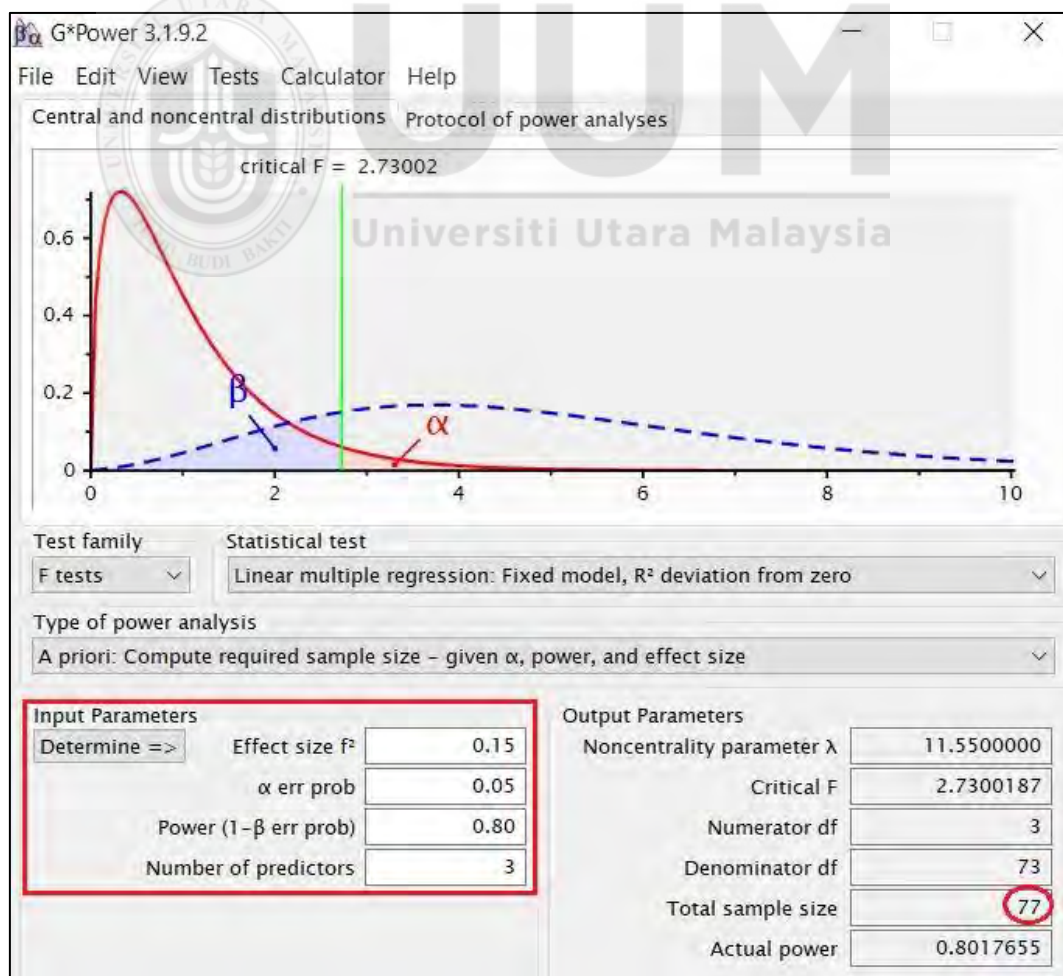


Figure 3.5
Sample size calculation using G*Power

Therefore, the minimum number of samples required for this study was determined at $n = 77$, since it is adequate to produce results with considerable statistical power. Although some scholars recommended census survey for small target population (De Vaus, 2002; Israel, 1992), the low response rate (i.e. not more than 32%) recorded by previous studies in the similar research context (Iteng, 2015; Mohamed Ismail, 2014; Nordin et al., 2010b; Y. C. Wong et al., 2009) might prohibit this.

Census survey in Malaysian manufacturing sector is deemed impractical, since manufacturing industries are private organisations that have their own rights to refuse from participating in the survey. The researcher also did not have legit authority to force them. Moreover, census data is not appropriate for hypothesis testing purpose using inferential statistics (Alexander, 2015). Ultimately, this study considered the sampling of 77 organisations from the total of 213 lean manufacturing organisations listed in the sampling frame as optimum. Nonetheless, the present study distributed the survey questionnaires to all 213 lean manufacturing organisations listed in the sample frame for precautions (i.e., to make up for reluctance to participate, ineligibility or unengaged answers).

3.6 Instrumentation

Instrumentation refers to instruments and procedures used in collecting data in a study (Fraenkel et al., 2012). Thus, this section narrates the following procedures:

1. design and development of the survey questionnaires
2. pre-testing the survey questionnaires, and
3. data collection

3.6.1 Questionnaire Development

This study used a self-administered questionnaire (SAQ) as the instrument for data collection. SAQ is a survey instrument in which each respondent reads and answers the same set of questions in a pre-determined order without the presence of the researcher (Saunders et al., 2016). Survey strategy using SAQ is popular as it enables the collection of standardised data from a sizeable population in a highly economical way, allowing easy comparison (Saunders et al., 2016). It is relatively inexpensive and can be administered by the researcher alone (or with only a few assistants) (Fraenkel et al., 2012). A single researcher can administer this type of survey at very low cost while covering a wide geographical area (Neuman, 2014).

Another advantage is that researchers might have better luck to reach target respondents that might be hard to access (Cooper & Schindler, 2014; Fraenkel et al., 2012). Some target respondents, such as major corporate executives are difficult to reach in person or by phone, as gatekeepers (i.e., security personnel, secretaries, and personal assistants) limit access. Even so, with SAQ researchers still have the chance to access these restrictive respondents by mails (postal or electronics) (Cooper & Schindler, 2014). In fact, this approach is very effective and can achieve acceptable response rates from an educated sample that has a strong interest in the topic or the survey organisation (Neuman, 2014).

Moreover, this approach is perceived as more impersonal, providing more anonymity than the other data collection modes, such as observations and interview sessions (Cooper & Schindler, 2014). Such advantage also may avoid interviewer bias (Neuman, 2014). Besides, self-administered questionnaires permits the respondents to take

sufficient time to give thoughtful answers to the questions asked (Fraenkel et al., 2012). The respondent may complete the questionnaire whenever convenient and can check personal records for information if necessary (Neuman, 2014). In sum, SAQ was appropriate and feasible for this study.

In order to serve as an effective data collection instrument, SAQ needs to be carefully designed. This is especially important when the response rate, reliability and validity of the data is affected by the design of questionnaires (Saunders et al., 2016). Hence, various aspects were considered in designing the questionnaires including choice of words, sequence of the questions and the scale selection. The questionnaire form was designed into six separate sections (Section 1 to Section 6). Each section was intended to measure a specific content (variable) that is either adapted or developed from several related studies. This design technique is called “proximal separation” and was recommended by Podsakoff, MacKenzie, and Podsakoff (2012) to prevent the possibility of common method bias (CMB) occurrence.

For the same purpose, Podsakoff et al. (2012) also suggested researchers to utilise different “scale properties” (e.g., number of scale points and anchor labels) in designing measurement items for survey questionnaire. Meanwhile, survey methodologists recommended five to seven scale points for either Likert or interval-type scales to capture more valid and reliable respondents’ perceptions compare to shorter or longer points (Krosnick & Fabrigar, 1997; Meyers, Gamst, & Guarino, 2017). Likert-type scale and interval scale are distinguished by its labelling format. Likert-type scale is labelled on each of its measurement point (known as anchor), while interval scales are only labelled on its measurement end-points (Weijters, Cabooter, & Schillewaert, 2010).

On that account, this study utilised different scale properties to measure different variables. Table 3.3 summarised the development of SAQ based on discussed considerations.



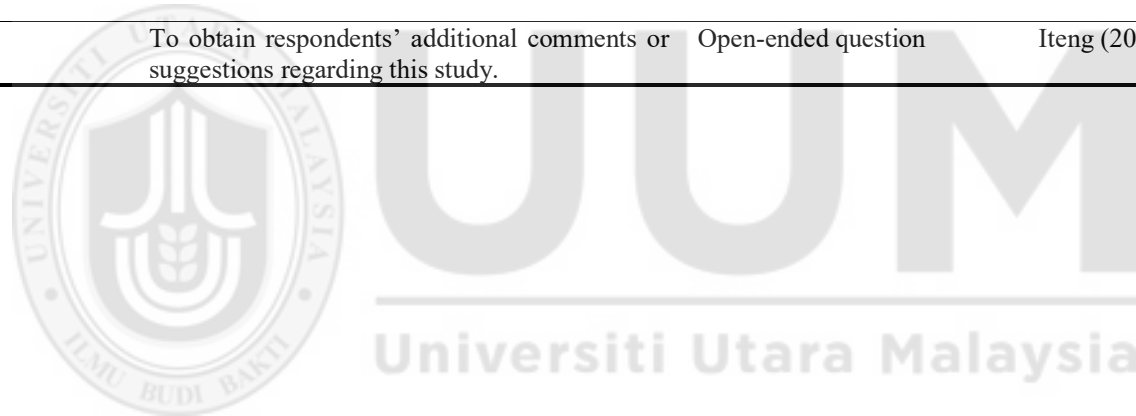
Table 3.3

Development of lean transformation sustainability SAQ

Section	Purpose	Scale Properties	Source
Section 1 (a): Lean Tools Building Blocks (1 item)	To assist respondents to recall what kind of lean tools and techniques that have been adopted in their manufacturing plants and guide them to answer questions regarding lean maturity level.	Nominal scale: Select all that apply answer choices	Alukal (2006a) and Kilpatrick (2003)
Section 1 (b): Lean Tools Adoption Maturity (4 items)	To obtain respondents' perception about the current adoption level, how extensive and for how long lean tools and techniques have been implemented in their manufacturing plants.	5-points Likert scale with mixed anchor labels	Mousavi et al. (2020)
Section 2: Sustainable Gains a. Operational performance (8 items) b. Business performance (6 items) c. Continuous improvement capability (7 items)	To obtain respondents' perception on how much operational and business performance indicators have evolved in the last three years and to what extent continuous improvement capabilities have been developed in their manufacturing plants.	5-points Likert scale: 1 = Significant decrease 2 = Moderate decrease 3 = Little or no change 4 = Moderate increase 5 = Significant decrease	a. Jayaraman et al. (2012) b. Jayaraman et al. (2012) and Fullerton et al. (2014) c. Gaiardelli et al. (2019) and van Assen (2020)
Section 3: Lean Leadership a. Strategy Deployment (10 items) b. Self-Development (6 items) c. Support for Daily Improvement (6 items) d. Coach & Develop Subordinates (8 items)	To obtain respondents' perception related to the extent of lean leadership principles are adopted by managerial staffs at all levels.	6-points Likert scale: 1 = Strongly disagree 2 = Disagree 3 = Slightly disagree 4 = Slightly agree 5 = Agree 6 = Strongly agree	a. Galeazzo et al. (2017) and Narasimhan, Swink, and Kim (2006) b. K. B. Stone (2012b), Nooraei Ashtiani (2016) and van Assen (2016a) c. Beraldin, Danese, and Romano (2019) d. Beraldin et al. (2019) and Pedersen-Rise and Haddud (2016)
Section 4: General Information	To obtain the general information about the respondents' manufacturing plants.	Nominal scale and open-ended questions	Iteng (2013) and Mohamed Ismail (2014)

Table 3.3 (Continue)

Section	Purpose	Scale Properties	Source
Section 5: Lean Culture	To obtain respondents' perception on the extent of their manufacturing plants' adherence to lean organisational culture.	7-points interval scale: 1 = Strongly disagree 7 = Strongly agree	Jenei et al. (2014), Pedersen-Rise and Haddud (2016), Galeazzo et al. (2017), G. L. D. Wickramasinghe and Wickramasinghe (2017)
a. Positive Work Environment (7 items)			
b. Effective Communication (8 items)			
c. Teamwork (7 items)			
d. Problem Solving (8 items)			
e. Innovation (6 items)			
Section 6: Comment	To obtain respondents' additional comments or suggestions regarding this study.	Open-ended question	Iteng (2013) and Mohamed Ismail (2014)



3.6.2 Questionnaire Pre-Test

A pre-test refers to the assessment of questions and instruments before the start of a study (Cooper & Schindler, 2014). Its purpose is to test the understandability and appropriateness of the questions planned to be included in the actual survey (Sekaran & Bougie, 2016). Pre-test is also considered as an established practice for discovering errors in questions including; leading, confusing, ambiguous, sensitive, skipped questions, its sequencing and missing instructions (Carpenter, 2018; Cooper & Schindler, 2014). Generally, there are seven strategies to pre-test a survey instrument, including; 1. evaluation from panel of experts, 2. group or individual debriefing, 3. cognitive interview, 4. experiments, 5. focus group discussion, 6. pilot survey, and 7. data analysis (Carpenter, 2018; Fisher, 2020).

Considering the limited number of target respondents in the sample frame and difficulties to physically access target respondents during recent Movement Control Order (MCO), the present study conducted evaluation from panel of experts through electronic mails. Evaluations by panel of experts are intended for producing content validity evidences. Content validity means the degree to which an instrument logically appears to measure an intended variable (Fraenkel et al., 2012). As advocated in the literatures (Carpenter, 2018; Fisher, 2020; Rubio, Berg-Weger, Tebb, Lee, & Rauch, 2003), this study requested professional opinions from two groups of experts;

1. topic experts that have vast knowledge and practical experience about the subject matter, and
2. survey methodologists that can offer credible advice on how to collect the most accurate data for answering research questions.

The questionnaire set was also sent for proof-reading by an English course instructor from School of Languages, Civilisation & Philosophy (SLCP) of Universiti Utara Malaysia (UUM) to check on the choice of words and meaning of each sentence before it was distributed to panel of experts. The English course instructor has 10-years' experience in teaching foundation students for Malaysian University English Test (MUET) preparation subject and also currently work as a document translator at the UUM Registrar office.

Experts' evaluation was systematically employed using formalised scaling (Boateng et al., 2018) with clear instructions (Carpenter, 2018) to avoid bias and subjective assessment from experts. Hence, this study utilised a content validation rubric (see Appendix B) that required panel of experts to review and rate each item's representativeness and clarity on four-point Likert scale (1 = item is not representative, 2 = item needs major revisions, 3 = item needs minor revisions, and 4 = item is representative). This content validation rubric is also recognised as a standard format to report content-oriented evidence as advocated by The American Educational Research Association, American Psychological Association, and National Council on Measurement in Education (2014). The rubric also contained blank spaces to encourage experts to remark on choice of words and other content validity aspects such as double-barrelled, leading, difficult, redundant, or sensitive questions.

In this study, 15 experts who are well-versed in lean manufacturing study and/or have in-depth practical experiences in lean transformation programmes were approached as panel of experts. These 15 experts consisted of eight academic scholars with doctoral degrees or in the pursuit of doctoral degrees in lean manufacturing discipline, three lean

consultants, and four lean practitioners from industries. Besides, one of the academic scholars also adept in scale development and statistical analyses. Thus, the researcher specifically requested him to evaluate the scale appropriateness and statistical potential of the proposed questionnaire set. These professionals were initially given a week to return the validation rubric. However, considering their hectic working schedule, the researcher spent approximately one month to gather feedback from all contacted experts. Soft reminders through WhatsApp texting and phone calls were made once or twice every week to alert the experts until they returned the rubric.

Yet, the researcher only managed to obtain feedback from 11 experts. Four from the 11 experts did not rate the items, but they left general comments on how to improve the questionnaire set. Four experts who responded but did not rate the items were including two lean consultants, one practitioner from automotive manufacturing industry and one senior lecturer. Thus, only seven completed validation rubrics received from seven experts were remained for the analyses (see Table 3.4).

Table 3.4
Profile of lean experts

Expert Code	Gender	Education	Designation (Organization)	Relevance
Expert #1	Male	PhD	Senior lecturer (UMP)	10 years' experience in lean manufacturing research and lean industrial collaboration
Expert #2	Female	PhD	Senior lecturer (UniKL)	8 years' experience in lean manufacturing research and lean industrial collaboration
Expert #3	Male	Masters	Lecturer (Polytechnic)	5 years' experience in lean manufacturing research and the winner of public university's lean project competition
Expert #4	Female	Masters	Senior lecturer (UiTM)	6 years' experience in lean manufacturing research and the winner of public university's lean project competition
Expert #5	Male	Degree	Lean executive (Automotive parts manufacturing)	10 years experienced practitioner

Table 3.4 (continue)

Expert Code	Gender	Education	Designation (Organization)	Relevance
Expert #6	Male	Degree	Manufacturing engineer (Electrical & electronics manufacturing)	9 years experienced practitioner
Expert #7	Male	Masters	Deputy Director (MPC)	5 years' experience as the lead consultant of lean transformation projects

According to Boateng et al. (2018), a range of five to seven experts are sufficient for content validation purpose, while considering the panels should belong from different background. As mentioned earlier, experts should consist of subject-matter researchers, methodologists, and professionals from the target population (Carpenter, 2018; Fisher, 2020). Apparently, the present study managed to gather seven experts that consist of academic lean scholars (subject-matter experts and methodologists), lean consultant (subject-matter experts), and lean practitioners (experts from target population). Thus, fulfilled the required number of experts and background match as recommended in the literatures.

As a result, most of the experts rated the questionnaire items with score 3 (item needs minor revisions) or 4 (item is representative) to represent the construct. All ratings given by panel of experts for each questionnaire item were attached in Appendix C. Further, content validity index (CVI) and inter-rater agreement (IRA) were calculated to decide for retaining, revising, replacing or removing the rated items based on objective measures (Polit & Beck, 2006; Rubio et al., 2003). From the ratings given by panel of experts on each questionnaire item, CVI and IRA were calculated using the following formula:

$$CVI = \frac{n_r}{N_e} \quad (1)$$

in which the n_r represents the number of experts rated the item as “representative” (score 3 and 4) and N_e is the total number of experts.

$$IRA = \frac{\sum n_a}{N_i} \quad (2)$$

in which the $\sum n_a$ represents the sum of individual item’s agreement and N_i is the total number of items for every dimension.

While equation 1 and equation 2 was used to calculate item-level CVI (I-CVI) and item-level IRA (I-IRA), the present study also calculated scale-level CVI (S-CVI) and scale-level IRA (S-IRA). To calculate S-CVI and S-IRA, the average was calculated across all items. Calculating S-CVI and S-IRA using the average across all items are only recommended when the number of experts exceeds five (Rubio et al., 2003), which definitely suitable for this study that had gathered evaluations from seven experts. Table 3.5 to Table 3.8 present the results of CVI and IRA calculations for both item-level and scale-level.

Table 3.5
CVI and IRA for Lean Building Blocks and Lean Tools Adoption Maturity constructs

Constructs	Item Code	n_r	I-CVI	S-CVI	$\sum n_a$	I--IRA	S-IRA
Lean Building Blocks	LBB01	7	1.000	.969	7	1.000	.980
	LBB02	7	1.000		7	1.000	
	LBB03	7	1.000		7	1.000	
	LBB04	7	1.000		7	1.000	
	LBB05	6	.857		6	.857	
	LBB06	7	1.000		7	1.000	
	LBB07	7	1.000		7	1.000	
	LBB08	7	1.000		7	1.000	
	LBB09	7	1.000		7	1.000	
	LBB10	6	.857		7	1.000	
	LBB11	7	1.000		7	1.000	
	LBB12	7	1.000		7	1.000	
	LBB13	7	1.000		7	1.000	
	LBB14	6	.857		6	.857	
Lean Tools Adoption Maturity	LM01	7	1.000		6	.857	.905
	LM02	7	1.000		6	.857	
	LM03	7	1.000		7	1.000	

Table 3.6
CVI and IRA for Sustainable Gains constructs

Dimensions	Item Code	n_r	I-CVI	S-CVI	$\sum n_a$	I--IRA	S-IRA
Operational Performance	SOP01	7	1.000	.982	7	1.000	.964
	SOP02	6	.857		6	.857	
	SOP03	7	1.000		7	1.000	
	SOP04	7	1.000		7	1.000	
	SOP05	7	1.000		7	1.000	
	SOP06	7	1.000		7	1.000	
	SOP07	7	1.000		6	.857	
	SOP08	7	1.000		7	1.000	
Business Performance	SBP01	7	1.000	1.000	6	.857	.857
	SBP02	7	1.000		6	.857	
	SBP03	7	1.000		6	.857	
	SBP04	7	1.000		6	.857	
	SBP05	7	1.000		6	.857	
	SBP06	7	1.000		6	.857	
Continuous Improvement Capability	SCI01	7	1.000	.918	7	1.000	.857
	SCI02	6	.857		6	.857	
	SCI03	7	1.000		7	1.000	
	SCI04	6	.857		5	.714	
	SCI05	6	.857		6	.857	
	SCI06	6	.857		5	.714	
	SCI07	7	1.000		6	.857	

Table 3.7
CVI and IRA for Lean Leadership constructs

Dimensions	Item Code	n_r	I-CVI	S-CVI	$\sum n_a$	I--IRA	S-IRA
Strategy Deployment	LLS01	7	1.000	.957	7	1.000	.957
	LLS02	7	1.000		7	1.000	
	LLS03	7	1.000		7	1.000	
	LLS04	7	1.000		7	1.000	
	LLS05	6	.857		6	.857	
	LLS06	6	.857		6	.857	
	LLS07	6	.857		6	.857	
	LLS08	7	1.000		7	1.000	
	LLS09	7	1.000		7	1.000	
	LLS10	7	1.000		7	1.000	
Self-Development	LLD01	7	1.000	.952	7	1.000	1.000
	LLD02	6	.857		7	1.000	
	LLD03	7	1.000		7	1.000	
	LLD04	7	1.000		7	1.000	
	LLD05	6	.857		7	1.000	
	LLD06	7	1.000		7	1.000	
Support for Daily Improvement	LLI01	7	1.000	.898	7	1.000	.877
	LLI02	6	.857		6	.857	
	LLI03	6	.857		6	.857	
	LLI04	6	.857		6	.857	
	LLI05	7	1.000		7	1.000	
	LLI06	6	.857		5	.714	
	LLI07	6	.857		6	.857	

Table 3.7 (continue)

Dimensions	Item Code	n_r	I-CVI	S-CVI	Σn_a	I--IRA	S-IRA
Coach and Develop Subordinates	LLC01	7	1.000	1.000	7	1.000	1.000
	LLC02	7	1.000		7	1.000	
	LLC03	7	1.000		7	1.000	
	LLC04	7	1.000		7	1.000	
	LLC05	7	1.000		7	1.000	
	LLC06	7	1.000		7	1.000	
	LLC07	7	1.000		7	1.000	
	LLC08	7	1.000		7	1.000	

Table 3.8

CVI and IRA for Lean Culture constructs

Dimensions	Item Code	n_r	I-CVI	S-CVI	Σn_a	I--IRA	S-IRA
Positive Work Environment	LCE01	7	1.000	1.000	7	1.000	0.959
	LCE02	7	1.000		7	1.000	
	LCE03	7	1.000		6	0.857	
	LCE04	7	1.000		6	0.857	
	LCE05	7	1.000		7	1.000	
	LCE06	7	1.000		7	1.000	
	LCE07	7	1.000		7	1.000	
Effective Communications	LCC01	7	1.000	1.000	6	0.857	0.982
	LCC02	7	1.000		7	1.000	
	LCC03	7	1.000		7	1.000	
	LCC04	7	1.000		7	1.000	
	LCC05	7	1.000		7	1.000	
	LCC06	7	1.000		7	1.000	
	LCC07	7	1.000		7	1.000	
	LCC08	7	1.000		7	1.000	
Teamwork	LCT01	7	1.000	1.000	7	1.000	0.980
	LCT02	7	1.000		7	1.000	
	LCT03	7	1.000		7	1.000	
	LCT04	7	1.000		7	1.000	
	LCT05	7	1.000		7	1.000	
	LCT06	7	1.000		6	0.857	
	LCT07	7	1.000		7	1.000	
Problem Solving	LCP01	7	1.000	1.000	7	1.000	0.946
	LCP02	7	1.000		6	0.857	
	LCP03	7	1.000		7	1.000	
	LCP04	7	1.000		7	1.000	
	LCP05	7	1.000		7	1.000	
	LCP06	7	1.000		7	1.000	
	LCP07	7	1.000		6	0.857	
	LCP08	7	1.000		6	0.857	
Innovation	LCI01	6	0.857	0.905	5	0.714	0.857
	LCI02	7	1.000		6	0.857	
	LCI03	6	0.857		6	0.857	
	LCI04	6	0.857		6	0.857	
	LCI05	6	0.857		6	0.857	
	LCI06	7	1.000		7	1.000	

According to Davis (1992), CVI of 0.80 is adequate to declare that content validity for a variable is evident. Similarly, Lynn (1986) suggested that IRA of 0.80 indicates

acceptable inter-rater reliability for measuring a variable. Therefore, all constructs had sufficient evidence of content validity and inter-rater reliability. Hence, no item was removed from the questionnaire set due to lack of representativeness.

Nevertheless, some items were revised according to written comments left by the experts in the provided spaces. Items that were deemed redundant (LBB03: Visual management and LBB14: *Andon*), as remarked by Expert #5 were merged by making “*andon*” as one of the examples to clarify “visual management” technique. Besides that, Expert #3 commented that “SOP02: value-added activity” as indicator that is too subjective for measuring Operational Performance. Meanwhile, Expert #1 suggested to add “space optimisation” as one of the indicators to measure Operational Performance. Therefore, “space optimisation” was used to replace “value-added activity” as one of the Operational Performance’s indicators. In addition, Expert #2 advised to reword and standardise some terms used in Lean Leadership measurement items, such as “plant manager” to “the management” or “top management”.

Lastly, the content validation rubric (see Appendix B) also included questions regarding the appropriateness of lean transformation sustainability concept and measurement. The following questions were asked:

1. How do you perceive lean transformation sustainability?
2. Do you agree with the definition of lean transformation sustainability used in this study?
3. Do you agree gains acquired from the lean transformation should include both tangible and intangible indicators?

4. What are the appropriate aspects to indicate sustainable gains acquired from the lean transformation?

As a result, majority of experts agreed with the definition and measurement of lean transformation sustainability proposed by the researcher. Responses for these questions also worked as the supporting evidences for defining the lean transformation sustainability concept and partially validate the measurement of sustainable lean transformation gains that used both tangible and intangible indicators. The next step is to obtain construct validity evidence to fully claim that Sustainable Gains measurement is completely valid.

3.6.3 Data Collection Procedures

There are five basic modes to collect data in a survey research which include; 1. directly administering the survey instrument to a group of respondents, 2. through postal mail, 3. by phone calls, 4. through face-to-face interviews, and 5. by electronic or web-based (online) survey (Fraenkel et al., 2012; Sekaran & Bougie, 2016). Researchers are also encouraged to employ multimode data collection to increase the survey response rate (Dillman et al., 2014; Fowler, 2014). Therefore, this study distributed the survey questionnaire forms through e-mails and social media channels (i.e., WhatsApp and Telegram). The researcher also prepared the survey questionnaire forms in two format:

1. softcopy form in word document format using Microsoft Word, and
2. online electronic form designed with Google Forms application.

Initially, all respondents (person in-charge of lean transformation program) listed in the sample frame were contacted through e-mails for the purpose of formality, although the

directory contained their personal phone numbers. This precaution act was to avoid any unwanted conflict with the respondents for invading their privacy. The e-mails contained introduction message that explain about the purpose of the study and asking respondents for their voluntary participation in the survey. Both word document and link to access Google Forms questionnaire were attached in the e-mails.

The e-mail was sent to all 213 respondents listed in the sample frame to be completed electronically in early October 2020. Reminder e-mails and/or social media messages were subsequently sent in November to December. If an e-mail was failed to deliver because the e-mail address was no longer exist, internet searches were conducted to locate the organisation's phone number. When a contact number was identified, the targeted organisation was contacted through phone call and requested his/her cooperation in completing the questionnaire after first explaining its objectives.

Any respondent indicating that his/her organisation was no longer implementing lean tools and techniques, the organisation was excluded from the study (i.e., non-eligible respondents). Otherwise, the e-mail or social media messages with the link to the questionnaire was resent to enable an electronic response. Finally, any targeted respondent who was not responding to social media message and who had been repeatedly phoned on at least three occasions, on different days and at different times of the day, were considered unreachable and omitted from the study.

3.7 Data Analysis Techniques

There are two types of data analysis technique used in the present study. The first technique used was descriptive statistics to describe basic characteristics of the research

data in a meaningful manner. In addition, partial least square structural equation modelling (PLS-SEM) was used to answer all posited research questions.

3.7.1 Descriptive Statistics

Descriptive statistics are general type of simple statistics such as frequencies, the mean, and the standard deviation, used to describe basic pattern in the research dataset (Sekaran & Bougie, 2016). In order to describe respondents' demographics using numerical indices, frequency analysis running on IBM SPSS version 26 was employed. Besides that, descriptive analysis was performed to compute basic central tendency indices such as mean and standard deviation for every variable observed in the present study.

3.7.2 PLS-SEM

Structural Equation Modelling (SEM) is a second generation multivariate analysis technique that combines multiple regression analysis and factor analysis (Hair et al., 2010; Ramayah et al., 2018). It is purposely developed to overcome some limitations in the first generation techniques such as; 1. modelling and analysing latent variables, 2. accounting for measurement error, and 3. evaluating inter-relationship among multiple variables simultaneously (Awang, 2015; Hair, Hult, Ringle, & Sarstedt, 2017). These were the main reasons why this study preferred SEM over traditional multiple linear regressions (MLR) commonly running on Statistical Package for Social Science (SPSS) to test the proposed hypotheses.

The benefits of using latent variables over traditional summated scores in first generation technique can be recognised in two aspects; 1. better representation of

theoretical concepts, and 2. improve statistical estimation. Theoretical concepts can be better represent using latent variables compare to summated scores. A latent variable is measured indirectly by assessing consistency among manifest variables (i.e., indicators) which are gathered through data collection (Hair et al., 2010). Individual indicator's loading and weight can be assessed directly from the model.

In contrast, summated scores in first generation techniques are commonly measured using mean score of the manifest variables to represent a concept (i.e. variable) (Ramayah et al., 2018). Individual indicator's loading and weight are excluded from the measurement. In this sense, latent variable measurement allows more information to be extracted from the model, hence provides better representation of the theoretical concept (Hair et al., 2010; Hair, Hult, et al., 2017; Ramayah et al., 2018).

Moreover, summated scores calculation disregard measurement errors that exist in a theoretical concept (Hair et al., 2010; Hair, Hult, Ringle, & Sarstedt, 2014). Measurement errors commonly exist due to inaccurate responses (i.e., respondents provide unsure answer or interpret questions different from researcher's intention) and natural degree of inconsistency when using multiple items to measure the same concept (Šiška, 2018). In SEM, measurement errors are incorporated into the latent variables calculation and offer better representation of a theoretical concept (Hair, Hult, et al., 2017; Ramayah et al., 2018). The assessment of measurement error is interpreted as indicator reliability. In this way, lower measurement error is associated with higher reliability.

In the same light, the accounting of measurement errors in latent variables provides further advantage when SEM can also automatically correct those errors. Therefore, SEM offers the second advantage over first generation technique (i.e., MLR) (Hair et al., 2010). Regression models become weaker whenever measurement errors are present. However, with SEM applications, regression models with no measurement error presence can be estimated. Hence, SEM tends to produce larger regression coefficients compare to traditional MLR analysis.

In addition, the first generation technique does not clearly distinguish confirmatory analysis from exploratory analysis (Kline, 2015; Ramayah et al., 2018). Confirmatory analyses are performed to assess relationships based on a readily established theories and concepts, while exploratory analyses are utilised to evaluate under-developed theories and concepts. For instance, factor analysis running on SPSS is exploratory oriented. In contrast, multiple regression running in the same software is confirmatory oriented.

Unlike first generation technique, SEM clearly differentiate confirmatory analysis from exploratory analysis (Hair, Hult, et al., 2017; Ramayah et al., 2018). Both factor analysis and path analysis (i.e., simultaneous regression analysis) running on SEM are confirmatory oriented. Since this study has proposed multi-dimensional variables which are deduced on theoretical basis, higher-order confirmatory composite analysis (CCA) need to be performed to validate these variables. Hence, SEM application is more feasible and appropriate to perform such analysis (Hair, Black, Babin, & Anderson, 2019; Sarstedt, Hair, Cheah, Becker, & Ringle, 2019). Thus, concluded the reasons of selecting SEM over first generation technique for the purpose of this study.

As mentioned earlier, there are two alternatives of SEM analysis which include CB-SEM and PLS-SEM. In Malaysia, common software used by researchers to apply CB-SEM is AMOS, whereas for PLS-SEM application is SmartPLS. This study prefers PLS-SEM over CB-SEM for several reasons. PLS-SEM proponents have listed several rules of thumb for choosing PLS-SEM over CB-SEM (Hair, Hollingsworth, Randolph, & Chong, 2017; Ramayah et al., 2018). The following rules were deemed consistent to the requirement of this study.

Firstly, PLS-SEM is preferred for theory exploration research. Theory exploration research is conducted when tangible evidence to propose explanatory relationships are limited, but there is enough information to make conceptual distinctions. Hence, researchers are allowed to generate hypotheses from qualitative evidence and subsequently test those hypotheses using quantitative techniques (Hair, Black, et al., 2019). This is exactly what was done in this study. Since there were limited empirical evidence that demonstrated relationships between Lean Tools Adoption Maturity, Lean Leadership and Lean Culture with Sustainable Gains, this study utilised qualitative evidence from case studies and experts' viewpoints to generate the hypotheses. A theory exploration research is also implying that researchers are aiming to explore possible relationships between data structures (i.e. independent and dependent variables) based on potential associations that eventually lead to theory development (Shmueli, 2010). Indeed, this study aimed to explore whether Lean Tools Adoption Maturity, Lean Leadership and Lean Culture have a significant impact on Sustainable Gains.

Furthermore, Ramayah et al. (2018) asserted that PLS-SEM is preferred when a research model is developed based on a soft theory. Examples of soft theory are Resource Based View (RBV) and Contingency Theory while hard theory are including Theory of Planned Behaviour (TPB) and Service Quality (SERVQUAL). In-line to this notion, the present study was founded based on soft theories (i.e., integration of Theory E and Theory O) too.

Distinctions between hard and soft theory can be further explained by linking them with statistical modelling theory. There are two types of modelling theory which include; 1. measurement theory and 2. structural theory (Hair, Hult, et al., 2017; Ramayah et al., 2018). Usually, a hard theory has both strong measurement and structural theories, while a soft theory only has either one. CB-SEM works well if the research model is founded on both strong measurement (i.e., well-developed and well-validated items to measure variables) and structural theory (i.e., well-established causal relationship between variables). In contrast, PLS-SEM is preferred when only one of the modelling theories is strong. Hence, PLS-SEM was more appropriate for this study since causal relationships between Lean Tools Adoption Maturity, Lean Leadership, Lean Culture and Sustainable Gains are less-developed.

Lastly, PLS-SEM is favourable when measurement and/or structural model are complex (i.e., contains more than 50 items and/or more than six constructs). This study had a measurement model with more than 50 items. Thus, PLS-SEM was the right selection. Overall, this section emphasised the advantages of SEM over traditional regression model. Distinctions between CB-SEM and PLS-SEM were made and this study decided to employ PLS-SEM based on its compatibility to this study.

3.8 Summary of the Chapter

In conclusion, this chapter had presented the framework of this study along with in-depth discussion about Theory E and Theory O to provide logical explanation on connections between Sustainable Gains with its contributing factors (i.e., Lean Tools Adoption Maturity, Lean Leadership, and Lean Culture). The research framework was further described by defining each proposed variable to suit the context of this study. In addition, this study adopted positivism philosophical stance and deductive reasoning as the approach to theory development.

A mono-method quantitative study (i.e., survey research) was deemed adequate to answer all three research questions posited in this study. The target population was lean practitioner organisations in manufacturing sector. Lean manufacturing organisations under the tutelage of MPC are considered as the accessible population. A self-compiled sample frame shared by MPC was used to access the target respondents. This study also had determined 77 lean manufacturing organisations as the minimum number of samples required for producing results with adequate statistical power. A self-administered questionnaire was designed to be used as the instrument for data collection. Finally, this study chose PLS-SEM over first generation technique (e.g., exploratory factor analysis, linear regression) to perform the data analysis.

CHAPTER FOUR

ANALYSIS & FINDINGS

4.1 Introduction

This chapter presented the results of conducted data analyses to answer the research questions and fulfil the research objectives. Data analysis reporting were divided into seven phases as the following; 1. response rate and test of non-response bias, 2. data screening procedures, 3. respondents' demographic information, 4. descriptive analysis, 3. common method bias test, 6. measurement model assessment, and 7. structural model assessment reporting. The sequence of this reporting was arranged according to the software utilised in this study.

4.2 Response Rate

A response rate refers to the ratio of the number of returned survey over the number of eligible respondents who were asked to participate in the survey (Saunders et al., 2016; The American Association for Public Opinion Research, 2016; Zikmund et al., 2013). Nevertheless, the number of returned surveys depends on how researchers counted it. Some researchers considered the total number of returned surveys as the total number of returned questionnaires. On the other hand, other group of researchers only acknowledged fully completed questionnaires as the number of returned surveys (Hulland, Baumgartner, & Smith, 2018).

Taking the former opinion, this study counted the number of returned surveys equals to the total number of returned questionnaires which was 92. The reason was because the incomplete questionnaire forms returned by the respondents contained only few

missing responses. There were only two sets of questionnaire forms that had missing responses (see 4.3.1 for a detailed report). Meanwhile, the number of eligible respondents were 183. These 183 eligible respondents belonged to 183 manufacturing organisations listed in MPC's lean practitioners' directory. Although the initial list contained 213 lean organisations, 30 of them had informed the researcher that their organisations were no longer applying lean tools and techniques. Thus, their organisations current lean adoption status has made them not legit to be selected as respondents for this study. As a result, the present study acquired a response rate of 50.27% which was satisfactory and exceeded the minimum required sample size (see Table 4.1).

Table 4.1
Survey information

Information	Total	Rate (%)
Distributed questionnaires	213	NA
Non-eligible respondents	30	NA
Eligible respondents	183	100.00
Returned questionnaires	92	50.27
Questionnaires with incomplete responses	2	1.24
Questionnaires with completed responses	90	49.03
Minimum sample size required	77	NA

According to Sekaran and Bougie (2016), a 30% response rate is considered acceptable for electronic and online survey in many circumstances. In fact, the present study managed to acquire higher response rate compare to previous studies in the same research context and setting, which commonly below 32% (Daud & Zailani, 2011; Hasan, 2021; Iteng, 2013; Mohamed Ismail, 2014; Nordin et al., 2010b; Y. C. Wong et al., 2009).

4.2.1 Post-Hoc Power Analysis

The post-hoc power analysis was conducted to confirm that acquired sample size was adequate to produce results with considerable statistical power. Post-hoc power analysis is a statistical test to determine statistical power of a regression-based model after a research is conducted based on the actual sample size obtained and the lowest effect size among the variables that are being studied (Cohen, 1988). Meanwhile, statistical power means the probability of correctly rejecting the null hypothesis (Fraenkel et al., 2012; Sekaran & Bougie, 2016). Again, G*Power program (Faul et al., 2009) was used for this purpose (see Figure 4.1).



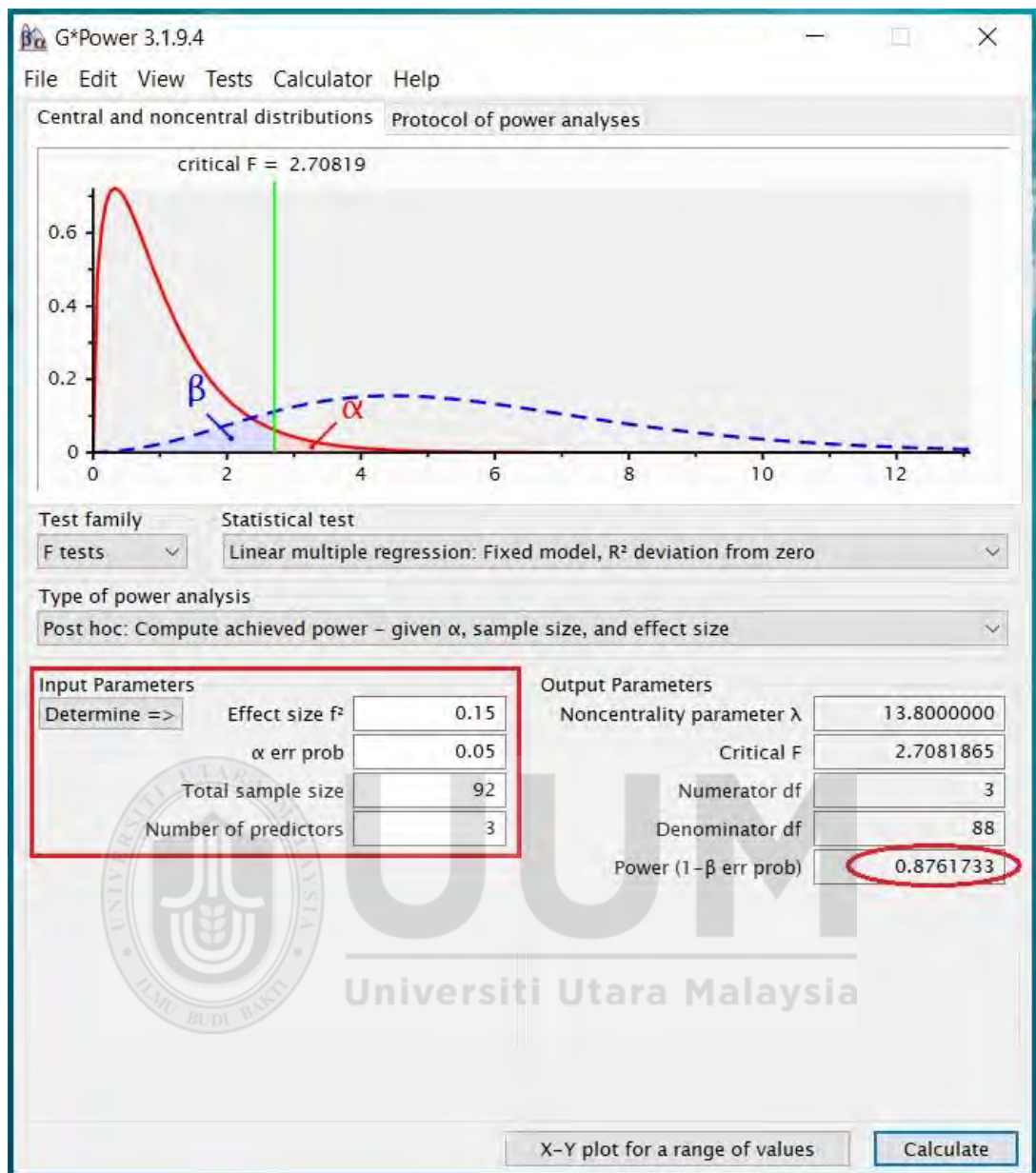


Figure 4.1
Post-hoc power analysis using G*Power

As a result, G*Power program showed that the statistical power produced for three predictors, based on 92 samples at $f^2 = 0.15$ and $\alpha = 0.05$ is 0.876 (87.6%). According to Ellis (2010) and Gefen, Rigdon, and Straub (2011), most researchers assessed the power of their statistical models at the power of 80% ($1 - \beta = 0.80$) as a standard for adequacy. Hence, it was confirmed that Lean Transformation Sustainability model was able to produce results with adequate statistical power at sample size equals to 92 ($n = 92$).

4.2.2 Non-Response Bias Test

Non-response bias or sometimes called non-response error refers to bias in findings caused by respondents who refuse to participate in the survey (Saunders et al., 2016). The purpose of non-response bias test is to identify whether those respondents completing the survey differ systematically from those who do not. Since the acquired response rate was below 80%, the test of non-response bias need to be conducted (Fowler, 2014).

The common technique used in most previous studies to examine non-response bias is called “extrapolation technique” introduced by Armstrong and Overton (1977). This technique advocates survey researchers to compare early respondents against late respondents, by assuming the late respondents are similar to the non-respondents. However, Hulland et al. (2018) argued that extrapolation is irrelevant, especially when the constructs being studied are not expected to vary over a short time delay. On that account, the present study compared the key demographic characteristics of the respondent group to those of the sampling frame to examine non-response bias, following Hulland et al. (2018) recommendation. This technique also had been adopted in other LPS research such as Shah and Ward (2007). Since demographic data gathered in this study were categorical, chi-square (χ^2) test of association in IBM SPSS was utilised to examine the differences (see Table 4.2).

Table 4.2
Non-response bias results

Demographics	Subgroups	Not Responded	Responded	χ^2 p-value
Region	North	21	25	.693
	South	11	14	
	East	8	14	
	West	9	8	
	Centre	21	37	
Types of Industry	Aerospace	0	1	.190
	Automotive	5	9	
	C&P	16	8	
	E&E	4	14	
	F&B	19	20	
	I&S	3	8	
	M&E	6	5	
	Pharmaceuticals	4	8	
	Rubber	2	2	
	Textiles	2	1	
	Wood-based	9	16	

Note. C&P = Chemical & Petrochemicals, E&E = Electrical & Electronics, I&S = Iron & Steel, M&E = Machinery & Equipment

The results of chi-square (χ^2) test presented in Table 4.2 indicated that there was no significant difference between respondents and non-respondents across their demographics at $p > 0.05$. Hence, the results were suggesting that non-response bias was not evident in the present study.

4.3 Data Screening

Data screening is the process of ensuring the dataset is clean and ready to go before further statistical analyses are conducted. Data must be screened in order to ensure the data is useable, reliable, and valid for testing causal theory (Gaskin, 2017b). Hair, Hult, et al. (2017) outlined four data screening procedures that need to be conducted before proceeding to PLS-SEM analysis. The procedures are including;

1. missing data (e.g., unanswered questions, miscoded response, etc.)
2. suspicious response patterns (e.g., straight lining answers)
3. outlier cases, and
4. normality of data distribution.

Hence, the present study conducts data screening procedures following these sequences.

4.3.1 Missing Data

Missing data or sometimes referred to as missing values means information that is missing about a participant or data record (Bryman, 2012). Missing data is a common problem in social science research since many studies seek and obtain the required data through survey approach (Hair, Hult, et al., 2017). Frequency analysis running on IBM SPSS was performed to check the missing data. As a result, there were few missing data for the following items (see Table 4.3).

Table 4.3
List of missing data

Items	Case Number	Frequency	Percentage (%)
SOP07	62	1	1.1
LCI01	56	1	1.1
LCI02	56	1	1.1

Table 4.3 revealed missing values for three questionnaire items that were contributed by two cases (respondents) in the dataset. All identified items, had only one missing value which accounted for 1.1% from the whole dataset. Meanwhile, case number 56 did not answer two out of 96 items (2.1%). According to Hair, Hult, et al. (2017), when more than 5% of data per item are missing, that particular item should be removed from the dataset. Besides that, when more than 15% of data per case (respondent) are missing, the case should be eliminated from the dataset. Otherwise, researchers are allowed to use systematic imputation to replace the missing data if it occurs in a specific non-random fashion (systematic pattern) (Hair, Black, et al., 2019).

Taking these assertions into account, Little's Missing Completely at Random (MCAR) test was conducted to confirm that the missing values were truly random and showed no systematic pattern. As a result, the observed missing values pattern in the dataset was not significant at $p = 0.138$. Hence, this study employed expectation maximisation (EM) algorithm to systematically imputing the missing data as recommended by Meyers et al. (2017). Thus, all missing values were properly replaced and no item or case (sample) was deleted. The present study proceeds to the next data screening step with 92 samples ($n = 92$) and 96 items.

4.3.2 Suspicious Response

Suspicious responses in the dataset were traced by computing standard deviation values of each response case. Zero standard deviation interprets that there is no variation in every response (answer) given by a particular case (respondent) (Gaskin, 2017a). No variation signifies that all questions have been answered with the same rating score by a particular respondent (i.e., straight lining answers) (Hair, Hult, et al., 2017). As a result, no respondent demonstrated standard deviation value equals to zero in the dataset of the present study. Hence, no sample was removed from the dataset and all 92 respondents ($n = 92$) were retained.

4.3.3 Outlier Cases

Outlier cases refer to extreme responses to a particular or all questions in a survey questionnaire (Hair, Hult, et al., 2017). There are three types of outlier namely; univariate, bivariate, and multivariate (Pallant, 2016; Tabachnick & Fidell, 2014). Since this study employed multivariate analysis to test the hypotheses, only multivariate outliers were traced. Normally, Mahalanobis distance (D^2) values are used to trace

significant multivariate outliers in the research data (Byrne, 2016; Tabachnick & Fidell, 2014). IBM SPSS version 26 was used to compute D^2 .

Based on the rule of thumb, the maximum D^2 should not exceed the critical chi-square (χ^2) value, given the number of predictors as the degree of freedom (df). Otherwise, the dataset may contain cases posed as outliers (Byrne, 2016; Hair et al., 2010). Hence, it means that the higher the D^2 value the more likely a case becomes a significant multivariate outlier. The number of predictors in this study were three; 1. Lean Tools Adoption Maturity, 2. Lean Leadership, and Lean Culture (i.e., $df = 3$), while a probability estimate for a case being an outlier, is when $p \leq 0.001$ for the χ^2 value (Tabachnick & Fidell, 2014). Thus, χ^2 value at $df = 3$, $p \leq 0.001$ is 16.266 (see Appendix G). Top 10 cases with the highest D^2 values were listed in Table 4.4 to specify the outliers.

Table 4.4
Summary of outliers' detections

No	Case Number	Mahalanobis Distance (D^2)
1	63	13.790
2	29	13.458
3	16	9.726
4	40	9.003
5	43	9.003
6	92	8.599
7	24	8.009
8	4	7.277
9	91	6.842
10	55	6.828

Note. *Sorted based on case number D^2 values

Results in Table 4.4 showed that none of the cases in the research data showed Mahalanobis values that exceeded the critical chi-square value. Hence, no significant outlier case was detected. It is common to have no outliers in the research data, especially when the samples are properly selected based on certain control criteria. As

explained in Chapter Three, only manufacturing organisations that had initiated lean transformation journey for at least two years were selected as samples and only managerial level staffs were approached to participate in this study. Therefore, no sample was removed and all 92 samples in the dataset were carried forward to the next screening procedure.

4.3.4 Normality of Data Distribution

Normality of data distribution is the benchmark for selecting appropriate statistical techniques for analysing the research data (Hair, Black, et al., 2019). Data distribution is regarded as normal when its shape for an individual metric variable is correspondent to the normal distribution. Following Hair, Hult, et al. (2017) recommendation, this study assessed normality of data distribution using skewness and kurtosis distributions. Skewness and kurtosis distributions allow researchers to evaluate the extent of the data deviates from the normal distribution.

Since this study employed multivariate analysis to examine relationships between variables that are being studied, Mardia's multivariate skewness and kurtosis were used to assess the normality of data distribution. Following Ramayah, Yeap, Ahmad, Abdul Halim, and Abidur Rahman (2017), the presents study used a statistical power analysis online calculator named WebPower (Zhang & Yuan, 2018) to calculate Mardia's multivariate skewness and kurtosis. This online calculator can be accessed at <https://webpower.psychstat.org> and the full result of data normality test retrieved from the WebPower is attached in Appendix H.

According to Kline (2011) data distribution is within acceptable range when the Mardia's multivariate skewness are not exceeding ± 3 and Mardia's multivariate kurtosis are not beyond ± 20 . As a result, this dataset demonstrated non-normal multivariate distributions at Mardia's multivariate skewness ($\beta = 1.902, p > 0.05$) and Mardia's multivariate kurtosis ($\beta = 25.210, p > 0.05$). Nevertheless, this dataset still could be used to test causal theory between variables being studied using appropriate statistical analysis technique such as PLS-SEM. PLS-SEM is a non-parametric statistical method that does not require the dataset to be normally distributed (Reinartz, Haenlein, & Henseler, 2009). In fact, PLS-SEM can handle extremely non-normal data (Hair, Hult, et al., 2017). Therefore, this study applied PLS-SEM technique on SmartPLS 3 software to test the hypothesised relationships.

4.4 Demographic Information

This study utilised 92 eligible samples that represent 92 manufacturing organisations who are currently practising lean principles in their production system. These organisations also had started their lean transformation journey for at least two years. To ensure the accuracy and credibility of the responses, every selected organisation was represented by the most knowledgeable personnel with major decision-making roles in lean transformation activities to fill-up the questionnaire form. They are among top, middle or first-line managers in their respective organisations.

Demographic section in the questionnaire form requested the respondents to provide both organisations' profiles; 1. years in operation, 2. types of ownership, 3. types of industry, 4. number of full-time employees, 5. annual sales turnover, 6. types of production process, 7. duration of lean transformation journey (see Table 4.5), and

respondents' personal information; 1. current position level, 2. full job title, and 3. tenure in the current position (see Table 4.6).

Table 4.5
Demographic information: Organisations' profile

Information	Frequency	Percentage
1. Years in Operation		
Below 10 years	13	14.1
10 to 20 years	39	42.4
21 to 30 years	25	27.2
31 to 40 years	11	12.0
41 to 50 years	2	2.2
Over 50 years	2	2.2
Total	92	100.0
2. Types of Ownership		
Local	83	90.2
Foreign / Multinational	6	6.5
Joint-venture	3	3.3
Total	92	100.0
3. Types of Industries		
Food and beverages	19	20.7
Wood-based (e.g., furniture, plywood, panel board, cardboard, paper)	17	18.5
Electrical and electronics	14	15.2
Automotive	8	9.8
Chemical and petrochemical (e.g., plastic, paint, detergent, pesticide)	8	8.7
Iron and steel	8	8.7
Pharmaceuticals (e.g., medicine, healthcare supplement, cosmetics)	8	7.6
Machinery and equipment	5	5.4
Rubber	2	2.2
Textile (e.g., apparel, footwear)	2	2.2
Aerospace	1	1.1
Total	92	100.0
4. Number of Full-time Employees		
5 to 74	56	60.9
75 to 199	26	28.3
200 and more	10	10.9
Total	92	100.0
5. Annual Sales Turnover (in MYR)		
Less than 15 million	55	59.8
15 to 50 million	21	22.8
More than 50 million	16	17.4
Total	92	100.0

Table 4.5 (continue)

Information		Frequency	Percentage
6. Types of Production Process			
	Batch	31	33.7
	Continuous flow	26	28.3
	Mass customisation	21	22.8
	Job shop	7	7.6
	Repetitive	7	7.6
	Total	92	100.0
7. Duration of lean transformation journey			
	2 to 3 years	1	1.1
	3 to 4 years	3	3.3
	4 to 5 years	51	55.4
	More than 5 years	37	40.2
	Total	92	100.0

Note. Sorted descending according to percentage

Table 4.5 displayed that most of the organisations had been operated for about 10 to 20 years (42.4%), followed by organisations that were in operations for 21 to 30 years (27.2%). On the contrary, organisations that had been operated for about 41 to 50 years are the minority (2.2%). Surprisingly, there were few organisations that were established over 50 years ago (2.2%). Also, there were almost equal number of young organisations (14.1% of below 10 years) and mature organisations (12.0% of 31 to 40 years) in the acquired samples. In terms of ownership, 90.2% were local manufacturing organisations, with only few multinational (6.5%) and joint-venture (3.3%) manufacturing organisations in the sampled dataset.

Moreover, this study had successfully captured the diversity of manufacturing sector in Malaysia by obtaining respondent organisations that were belonged to 11 different industrial classifications set by MITI. Out of 92 eligible respondent organisations, majority were producing food and beverages (F&B) products (20.7%), while aerospace components manufacturer was the minority (1.1%). Besides F&B, other major respondent organisations were among wood-based products manufacturers (18.5%), electrical and electronics (E&E) devices manufacturers (15.2%) and automotive parts

producers (9.8%). Meanwhile, chemical and petrochemical (C&P) products manufacturers, iron and steel (I&S) producers, and pharmaceutical manufacturers shared the same proportion of 8.7% from the total eligible samples. Other minor industries included in the sampled dataset are machinery and equipment (5.4%), rubber (2.2%) and textile (2.2%) manufacturing.

In comparison to other LPS researches in Malaysia which only studied single industry like aerospace components (Puvanasvaran et al., 2008), E&E devices (Y. C. Wong & Wong, 2011), automotive parts (Habidin et al., 2020), M&E (Chong, Puvanasvaran, & Feng, 2020), and F&B (Khusaini, Jaffar, & Yusoff, 2014) manufacturing, this study had proved that LPS were being adopted beyond these industrial settings.

According to SME Corporation Malaysia, the size of a manufacturing organisation can be determined based on its number of full-time employees. Manufacturing organisations are categorised as “small-sized” enterprise when it has 5 to 74 employees. Meanwhile, manufacturing organisations that employed 75 to 199 employees are categorised as “medium-sized” enterprises (SME Corporation Malaysia, 2021). On that account, manufacturing organisations with 200 and more employees can be considered as “large-sized” enterprises. Accordingly, it was found that 60.9% of the respondent organisations were small-sized enterprises, 28.3% were medium-sized enterprises, and 10.9% were large-sized enterprise. Therefore, small-sized enterprises dominated the sampled dataset. Although previous studies claimed that large-sized enterprises were more likely to implement LPS (Nordin et al., 2010b; Rahman, Laosirihongthong, & Sohal, 2010; Shah & Ward, 2003), the present study proved otherwise. In some target population, small-sized enterprises are the majority lean practitioners.

In addition, it was noticed that the majority of the organisations participated in this study applied batch production (33.7%), followed by continuous flow (28.3%), and mass customisation (22.8%) productions. On the other hand, both job shop and repetitive productions' users were the minority which accounted only 7.6% from the total sampled data. This acquired information partially supports previous studies that claimed LPS is most famous among batch and continuous flow manufacturers, but less popular among mass customisation and job shop manufacturers due to some flexibility (volume-mixed) issues (Slomp, Bokhorst, & Germs, 2009; Todorova, 2013).

More importantly, all 92 organisations were the lean practitioners. Majority of the companies had adopted LPS for about four to five years (55.4%) and none of the organisation had been adopting LPS for less than two years, as aimed during data collection procedure. There were also 40.2% from the total respondents' organisations with four to five years' LPS adoption experience. Meanwhile, the rest had adopted LPS around two to four years (4.4%). Therefore, this information confirms that all respondents' companies were among lean practitioners and eligible for the purpose of this study.

Table 4.6
Demographic information: Respondents' profile

Information	Frequency	Percentage
1. Position Level		
Top manager (e.g., director, president, chairman, senior executive, senior manager)	27	29.3
Middle manager (e.g., general manager, plant manager, department head, engineer, executives)	63	68.5
First-line manager (e.g., supervisor, foreman, team leader)	2	2.2
Total	92	100.0
2. Job Title		
Admin executive	10	10.9
Director	10	10.9
Managing director	8	8.7
General manager	7	7.6
Operations manager	5	5.4
Human resource manager / executive	5	5.4
Manager	5	5.4
Production manager	4	4.3
Quality manager	4	4.3
Assistant production manager	3	3.3
Executive director	3	3.3
Senior manager	3	3.3
Factory manager	3	3.3
Head of department	3	3.3
Personal assistant to director	3	3.3
Chief executive officer	2	2.2
Plant manager	2	2.2
Lean manager	2	2.2
Production supervisor	2	2.2
Others (i.e., CEO, COO, lean engineer, lean specialist, project manager, industrial engineer, and manufacturing engineer)	8	8.7
Total	92	100.0
3. Tenure in current position		
Below 5 years	35	38.0
5 to 10 years	40	43.0
11 to 15 years	10	10.9
16 to 20 years	4	4.3
Over 20 years	3	3.3
Total	92	100.0

To further comprehend on the respondents' demographic, this study also observed the personal information of individuals who filled-up the questionnaires on behalf of their organisations. It was found that the main respondents were middle managers (68.5%), followed by top managers (29.3%), and first-line managers (2.2%). Middle manager positions were including general manager, plant manager, head of departments (Netland et al., 2020; van der Merwe, Pieterse, & Lourens, 2014), engineers and executives (sprigghr.com, 2020). Examples of middle managers' job titles acquired in

the present study were Head of System and Sustainability, Operations Manager, Production Manager, Project Manager, Plant Manager, Factory Manager, Administration Executive, Industrial Engineer, Manufacturing Engineer, Lean Engineer, and Lean Specialist.

Meanwhile, top management refers to positions such as director, president, chairman, senior executive, and senior manager of an organisation (Netland et al., 2020; van der Merwe et al., 2014). The present study obtained top management respondents with job titles such as Managing Director, Executive Director, Director of Manufacturing, Chief Executive Officer, Chief Operating Officer, and Senior Manager (Manufacturing). Lastly, the minority first-line managers acquired as samples in this study were titled as Production Supervisor. Overall, these acquired respondents were considered as qualified to participate in the present study based on the rational justified in Chapter Three.

Although prior local researchers did not consider administration personnel such as Human Resource Manager and Administration Executive as eligible respondents (Hasan, 2021; Iteng, 2013; Mohamed Ismail, 2014), the present study stood contrariwise. In-line with international lean scholars' viewpoints that emphasised the role of human resource department to support organisation's lean transformation sustainability (Hines et al., 2011; Jørgensen et al., 2007; Marshall, 2014; Tracey & Flinchbaugh, 2009), this study considered both Human Resource Manager and Administration Executive as eligible respondents. Aligning training and development program, as well as reward and recognition scheme with lean transformation are the

examples of Human Resource Department roles in supporting organisation's lean transformation program.

In fact, their involvement may indicate that sampled organisations were truly sustainable lean organisations. This is due to the fact that, these organisations managed to integrate human resource functions to the extent of appointing their human resource managers and administration executives as the person in-charge of lean transformation program. Moreover, the present study focused on the strategic perspective of organisation's lean transformation, unlike other local context lean researches that focused more on the technical perspective (Hasan, 2021; Iteng, 2013; Mohamed Ismail, 2014). Prior researchers seek technical information regarding the extent of lean tools and techniques application in the organisation. This was another reason why they excluded non-production middle management staffs that may not entirely familiar with all lean tools and techniques adopted by their organisations. On the contrary, the extent of lean tools and techniques application was not the major concern in the present study. Therefore, all acquired respondents were considered as eligible based on legit qualification criteria mentioned.

Finally, based on the duration of working in the current position, the majority of respondents had been working between five to 10 years (43%). Meanwhile, 38% had been appointed in their present positions for less than five years, 10.9% for 11 to 15 years, and 4.3% had been serving in their current positions between 16 to 20 years. Surprisingly, 3.3% of the respondents had been in their current positions for over 20 years. Hence, there was no doubt that all respondents were knowledgeable enough to participate in this study.

4.5 Descriptive Statistics

Descriptive statistics refer to statistics such as frequencies, the mean, and the standard deviation, which provide descriptive information about a set of data (Sekaran & Bougie, 2016). It is the generic term for statistics that can be used to describe variables (Saunders et al., 2016). This study observed mean scores and standard deviation values for every latent variable to identify the level of respondents' ratings on variables being studied.

According to De Vaus (2002), survey researchers may classify a particular value of a latent variable as high or low depending on the values rated by respondents in the sample dataset. Approach to classify value of latent variables into categories is called dichotomising (i.e., divide into two categories) and trichotomising (i.e., divide into three categories). This approach has the advantage of letting the data define what is low, medium or high rather than researchers simply imposing some unrealistic definition.

In order to divide values of latent variable into two or three categories with equal-sized groups of cases, De Vaus (2002) advocated dividing the samples into third with the lowest scores, the middle third, and the top third with the highest scores and use cumulative percentage as the cutting points. . Dividing the sample rather than the scores into three equal-sized groups avoids ending up with categories that include very few cases (respondents). Therefore, to divide mean value of Sustainable Gains, Lean Tools Adoption Maturity, Lean Leadership and Lean Culture into three categories (i.e., low, medium, and high), the present study used cutting points that correspond to the 33% and 67% cumulative percentage of the total samples in the dataset.

As mentioned earlier in Chapter Three, each latent variable was measured using different scale points to prevent common method bias. Both Sustainable Gains and Lean Tools Adoption Maturity were measured on 5-points Likert scale. On the other hand, Lean Leadership was measured on 6-points Likert scale, while Lean Culture was measured on 7-points interval scale. On that account, each latent variable had different range of cutting points (see Table 4.7).

Table 4.7
Range of cutting points and levels of categories

Latent Variables	Range	Level
Sustainable Gains (SG)	1.00 to 3.85	Low
	3.86 to 4.33	Medium
	4.34 to 5.00	High
Lean Tools Adoption Maturity (LM)	1.00 to 2.99	Low
	3.00 to 3.70	Medium
	3.71 to 5.00	High
Lean Leadership (LL)	1.00 to 4.10	Low
	4.11 to 5.00	Medium
	5.01 to 6.00	High
Lean Culture (LC)	1.00 to 4.80	Low
	4.81 to 5.65	Medium
	5.66 to 7.00	High

Note. Calculated based on De Vaus (2002) formula.

Further, mean values of Sustainable Gains, Lean Tools Adoption Maturity, Lean Leadership and Lean Culture were computed and compared with the projected categories (see Table 4.8).

Table 4.8
Mean and standard deviation of latent variables

Latent Variables	Mean	Standard Deviation	Level
Sustainable Gains (SG)	4.061	.895	Medium
a. Operational performance	3.625	.721	
b. Business performance	3.562	.677	
c. Continuous improvement capability	3.997	.655	
Lean Tools Adoption Maturity (LM)	3.471	.781	Medium
Lean Leadership (LL)	4.597	.548	Medium
a. Self-development	4.558	.974	
b. Coach & develop subordinates	4.563	.855	
c. Support for daily improvement	4.708	.854	
d. Strategy deployment	4.560	.835	
Lean Culture (LC)	4.268	.665	Low
a. Positive work environment	5.287	1.055	
b. Effective communications	5.183	1.007	
c. Teamwork	5.545	.888	
d. Problem solving	5.239	.915	
e. Innovation	5.083	1.115	

Table 4.8 displayed the mean and standard deviation for all latent variables involved in hypotheses testing. The values showed that all latent variables were at medium level, only Lean Culture was at low level. This trend was expected since Lean Culture is an organisational culture that is really difficult to form because it is very subjective and intangible. In addition, the standard deviation values for all latent variables produced acceptable variability within the dataset with the ratio of the maximum standard deviation ($SD = 0.895$) to the minimum standard deviation ($SD = 0.548$) equals to 1.6:1. According to A. R. Othman, Yin, Sulaiman, Ibrahim, and Razha-Rashid (2011), standard deviations within a Likert scale should have roughly equivalent values with the rule of thumb of 2:1 (i.e., ratio of the maximum standard deviation to the minimum standard deviation) to indicate reliability and validity of a survey questionnaire. Hence, it was evident that the questionnaire used in the present study was reliable and valid.

4.6 Common Method Bias

Common method bias (CMB) or common method variance (CMV) refers to a bias that often attributed to the measurement method rather than to the construct of interest (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). Addressing the threat of CMB is compulsory when the data is collected via self-administered questionnaire (self-reported) and both the outcome measure (i.e., Sustainable Gains) and the predictor variables (i.e., Lean Tools Adoption Maturity, Lean Leadership and Lean Culture) are obtained from the same individual (single source) (Hulland et al., 2018; Podsakoff et al., 2003). Since the present study used self-reported and single source data, the threat of common method bias needs to be addressed.

CMB may produce measurement errors that threaten the validity of the constructs being measured (Tehseen, Ramayah, & Sajilan, 2017) and lead to false conclusions on the relationships between measures (Bagozzi, Yi, & Phillips, 1991; Nunnally, 1978; Podsakoff et al., 2003). Therefore, the present study had employed a procedural remedy, namely proximal separation to prevent CMB as recommended by Podsakoff et al. (2003). Proximal separation refers to physical distance between measures of the criterion and predictor variables (Podsakoff et al., 2012). Introducing proximal separation enables researcher to reduce respondent's ability and/or motivation to use previous answers (short-term memory information) to answer subsequent questions. On that account, the survey form used in this study presented questionnaire items for each variable in separate sections (Section 1 to Section 6).

Additionally, full collinearity test introduced by Kock and Lynn (2012) was performed to confirm whether CMB is still present in the research data or has been successfully

eliminated. Full collinearity test requires observation of variance inflation factors (VIFs) generated for all latent variables (i.e., independent, dependent and mediator variables) in the structural model. This study applied full collinearity test on four major latent variables; Lean Tools Adoption Maturity (independent variable), Lean Leadership and Lean Culture (mediator variables), as well as Sustainable Gains (dependent variable), since relationships that would be tested were between these variables (see Table 4.9). This test also had been employed in other recent studies (Hassan, Masron, Mohamed, & Ramayah, 2018; Krey, Chuah, Ramayah, & Rauschnabel, 2019; Shahreki, 2019).

Table 4.9
Full collinearity test results

Latent Variables	VIF
Sustainable Gains (SG)	1.154
Lean Tools Adoption Maturity (LM)	1.133
Lean Leadership (LL)	1.392
Lean Culture (LC)	1.451

Kock (2015) claimed that the CMB poses a problem in structural model relationships when any latent variables exhibit the VIF value greater than 3.3. Table 4.9 revealed none of the latent variables under study demonstrates VIF value greater than 3.3. Thus, it is evident the CMB is not a threat to this study.

4.7 Measurement Model Analysis

Measurement model is an element of a path model that contains the indicators and their relationships with the constructs. It is also called the outer model in PLS-SEM analysis (Hair, Hult, et al., 2017). In this study, measurement model assessment was performed using PLS Algorithm procedure in SmartPLS version 3.3.3 (Ringle, Wende, & Becker, 2015) to assess construct reliability and validity.

4.7.1 Measurement Model Specification

Measurement model specification refers to how constructs in a PLS-SEM path model should be measured (i.e., reflective vs. formative measures and first-order vs. second-order constructs) (Hair, Hult, et al., 2017). Since there are multidimensional latent variables (i.e., SG, LL, and LC) in the research model, the present study modelled the variables as second-order constructs. Measurement model with second-order constructs is also known as the hierarchical component model (HCM). HCM is a higher-order structure that contains several layers of constructs and involves higher level of abstraction. Although reflective-formative HCM is highly recommended in PLS-SEM literatures (Becker, Klein, & Wetzels, 2012; Cheah et al., 2019; Lee & Cadogan, 2013), the model specification primarily depends on the theoretical and empirical considerations (Hair, Hult, et al., 2017; Ramayah et al., 2018). In fact, the decision of whether to measure a construct reflectively or formatively is not a clear-cut practice.

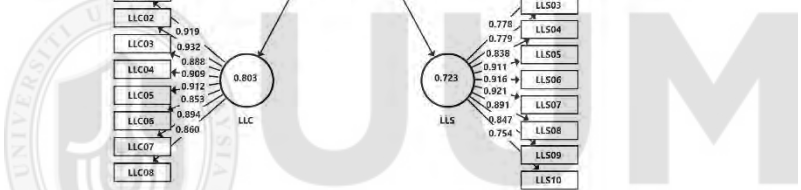
In regards to the theoretical consideration, prior researchers had relate LPS application with Complementarity Theory in modelling path relationships (Mohamed Ismail, 2014; Nawanir, 2016), Configuration Theory (Shah & Ward, 2007) and Item Response Theory (Osman et al., 2021) in modelling constructs. These theories emphasised on the synergistic relationships, inter-correlations, and dimensionality (uni- or multi-) between variables being observed (Boateng et al., 2018; Fiss, Marx, & Cambré, 2013; Furlan, Vinelli, & Dal Pont, 2011). Taking these considerations into account, the present study decided to specify Lean Transformation Sustainability measurement model as a reflective-reflective HCM. Moreover, empirical evidences from studies such as Kovács, Kö, and Demeter (2020), Mousavi et al. (2020), Valente et al. (2020) also support the use of reflective-reflective HCM in LPS researches. In addition, robustness test namely

Confirmatory Tetrad Analysis for PLS-SEM (CTA-PLS) was conducted to confirm whether the measurement model was correctly specified as reflective-reflective HCM (see 4.7.4).

Further, the present study employed the “embedded two stage approach” technique (Ringle, Sarstedt, & Straub, 2012). Embedded two stage approach is a technique to assess the reliability and validity of higher order constructs (HOC) in a PLS-SEM path model (Sarstedt et al., 2019). This technique was applied to this measurement model to overcome the shortcoming of conventional approach to analyse HOC. The conventional approach is called the “repeated indicator” technique (Wold, 1982). When using repeated indicator technique, the correct average variance extracted (AVE) and composite reliability (ρ_C) for HOC will not appear in the model output, hence researchers need to do further calculation manually (Sarstedt et al., 2019) or using self-developed MS Excel template.

As demonstrated in Sarstedt’s et al. (2019) work, embedded two-stage approach involves two stages of measurement model assessment as the following:

1. Stage One: Applying repeated indicator approach to obtain latent variable scores for the lower order constructs (LOC). LOC’s reliability and validity are also assessed during this stage (see Figure 4.2).
2. Stage Two: Using LOC latent variable scores as the indicator to establish HOC. Then, HOC’s reliability and validity are assessed (see Figure 4.3).



Measurement model stage one

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Figure 4.2 illustrated the first stage of measurement model assessment, whereby there were 16 latent variables with three HOCs; 1. SG, 2. LL, 3. LC and 13 LOCs 1. SOP, 2. SBP, 3. SCI, 4. LM, 5. LLD, 6. LLC, 7. LLI, 8. LLS, 9. LCE, 10. LCC, 11. LCT, 12. LCP and 13. LCI. LOCs represented the dimensions of HOCs.

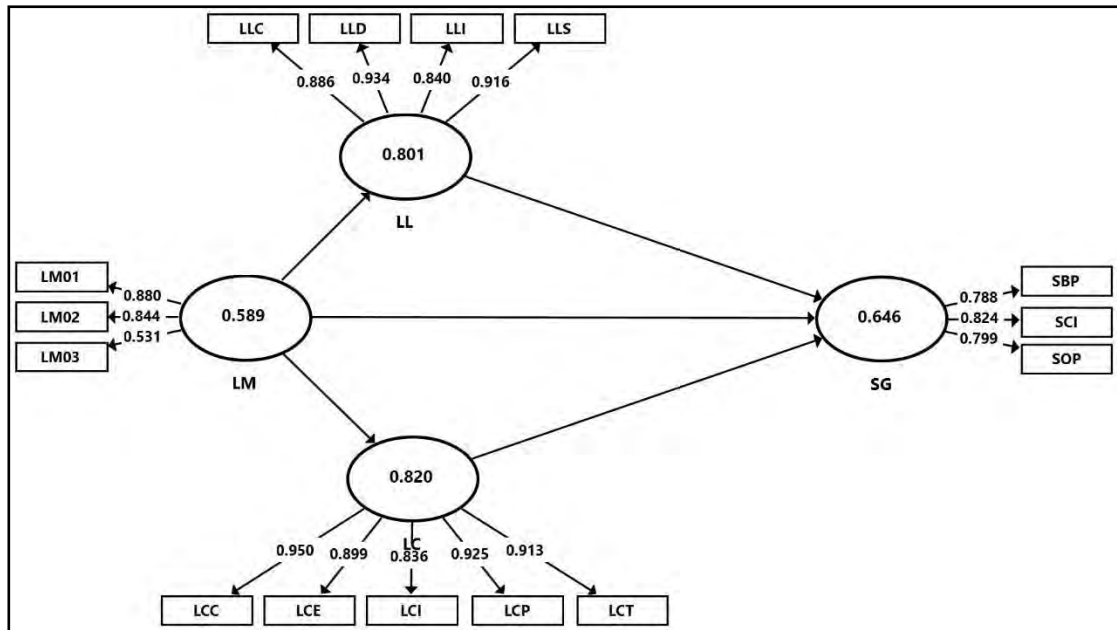


Figure 4.3

Measurement model stage two

Note. Values inside constructs = AVE. Values on arrows = factor loadings

Figure 4.3 portrayed the second stage of measurement model assessment, whereby there were only four latent variables; 1. SG, 2. LL, 3. LC and 4. LM. In this stage, the dimensions of; 1. SG (SOP, SBP, SCI), 2. LL (LLD, LLC, LLI, LLS) and 3. LC (LCE, LCC, LCT, LCP, LCI) were transformed into indicators (items) using the latent variable scores of each respective dimension. Construct reliability and validity tests provided by measurement model assessment in PLS-SEM are including; 1. internal consistency reliability, 2. convergent validity, and 3. discriminant validity (Hair, Hult, et al., 2017). Thus, this study included the reporting of these tests in the following subsections.

4.7.2 Internal Consistency Reliability and Convergent Validity Assessment

Internal consistency reliability is the degree to which the items that make up the scale are all measuring the same underlying attribute (Pallant, 2016). In this study, internal consistency reliability was measured using composite reliability coefficient (ρ_c). On the other hand, convergent validity refers to the overlap (or correlation) between

questionnaire items that have been used to measure the same construct (Saunders et al., 2016). Convergent validity is determined through average variance extracted (AVE) values. The result of internal consistency reliability and convergent validity were summarised as in Table 4.10.

Table 4.10
Internal consistency and convergent validity results

Constructs		Items	Loading	ρ_c	AVE
LOC	HOC				
Operational Performance (SOP)		SOP01	.744	.944	.679
		SOP02	.692		
		SOP03	.838		
		SOP04	.855		
		SOP05	.865		
		SOP06	.868		
		SOP07	.847		
		SOP08	.865		
Business Performance (SBP)		SBP01	.868	.932	.695
		SBP02	.814		
		SBP03	.857		
		SBP04	.895		
		SBP05	.752		
		SBP06	.809		
Continuous Improvement Capability (SCI)		SCI01	.859	.910	.595
		SCI02	.870		
		SCI03	.849		
		SCI04	.837		
		SCI05	.698		
		SCI06	.543		
		SCI07	.683		
Sustainable Gains (SG)		SOP	.799	.846	.646
		SBP	.788		
		SCI	.824		
Lean Tools Adoption Maturity (LM)	NA	LM01	.880	.805	.589
		LM02	.844		
		LM03	.531		

Table 4.10 (continue)

Constructs		Items	Loading	ρ_c	AVE
LOC	HOC				
Self-Development (LLD)		LLD01	.894	.963	.815
		LLD02	.897		
		LLD03	.912		
		LLD04	.891		
		LLD05	.910		
		LLD06	.911		
Coach & Develop Subordinates (LLC)		LLC01	.919	.970	.803
		LLC02	.932		
		LLC03	.888		
		LLC04	.909		
		LLC05	.912		
		LLC06	.853		
Support Daily Improvement (LLI)		LLC07	.894	.910	.628
		LLC08	.860		
		LLI01	.747		
		LLI02	.828		
		LLI03	.856		
		LLI04	.798		
Strategy Deployment (LLS)		LLI05	.799	.959	.723
		LLI06	.720		
		LLS01	.778		
		LLS03	.779		
		LLS04	.838		
		LLS05	.911		
Lean Leadership (LL)		LLS06	.916	.941	.801
		LLS07	.921		
		LLS08	.891		
		LLS09	.847		
		LLS10	.754		
		LLD	.934		
Positive Work Environment (LCE)		LLC	.886	.960	.774
		LLI	.840		
		LLS	.916		
		LCE01	.834		
		LCE02	.885		
		LCE03	.888		
Effective Communication (LCC)		LCE04	.847	.941	.667
		LCE05	.878		
		LCE06	.904		
		LCE07	.922		
		LCC01	.868		
		LCC02	.877		
Teamwork (LCT)		LCC03	.878	.955	.751
		LCC04	.837		
		LCC05	.790		
		LCC06	.832		
		LCC07	.750		
		LCC08	.677		
		LCT01	.866	.955	.751
		LCT02	.871		
		LCT03	.764		
		LCT04	.884		
		LCT05	.898		
		LCT06	.898		
		LCT07	.880		

Note. LSS02 was deleted to achieve discriminant validity.

Table 4.10 (continue)

Constructs		Items	Loading	ρ_c	AVE
LOC	HOC				
Problem Solving (LCP)		LCP01	.815	.941	.667
		LCP02	.756		
		LCP03	.910		
		LCP04	.795		
		LCP05	.826		
		LCP06	.796		
		LCP07	.823		
		LCP08	.804		
Innovation (LCI)		LCI01	.900	.947	.752
		LCI02	.916		
		LCI03	.909		
		LCI04	.922		
		LCI05	.762		
		LCI06	.777		
Lean Culture (LC)		LCE	.899	.958	.820
		LCC	.950		
		LCT	.913		
		LCP	.925		
		LCI	.836		

Table 4.10 presented the results of internal consistency reliability and convergent validity for all constructs. The minimum requirement of convergent validity for a construct is to have at least AVE of 0.5 (Fornell & Larcker, 1981; Hair et al., 2014), while the satisfactory level for ρ_c coefficient is equals to or more than 0.7 (Gefen, Straub, & Boudreau, 2000; Hair et al., 2014).

As a result, all constructs in this measurement model had achieved convergent validity threshold with AVE values as low as 0.589 and as high as 0.820. None of the items in the measurement model need to be removed to fulfil the convergent validity requirement. Although items such as SOP2, SCI05, SCI06, SCI07, LM03 and LCC08 demonstrated factor loadings less than the standard threshold, at $r < 0.708$ (Hair, Hult, et al., 2017), these items were retained based on other scholars' opinions. Researchers are allowed to retain items with factor loading as low as 0.50 (Byrne, 2016) or 0.40 (Hulland, 1999), as long as that particular construct has achieved its convergent validity requirement (AVE = 0.50). However, one item (LLS02) was removed to satisfy

discriminant validity requirement (detailed report is represented in 4.7.3). Furthermore, all constructs fulfilled composite reliability requirement with ρ_C coefficients were ranging from 0.846 to 0.970.

4.7.3 Discriminant Validity Assessment

The measurement model was further assessed for discriminant validity test. PLS-SEM offers three options to assess discriminant validity which include; 1. cross-loadings, 2. Fornell-Larcker criterion, and 3. heterotrait-monotrait (HTMT) ratio. However, recent criticism on the limitation of cross-loadings approach and Fornell-Larcker criterion to reliably assess discriminant validity under several circumstances motivates Henseler, Ringle, and Sarstedt (2015) to propose HTMT ratio as an alternative assessment. HTMT is the ratio between mean of all items' correlations across constructs measuring different constructs and the mean of the average items' correlations measuring the same construct (Henseler et al., 2015). On that account, the present study reported discriminant validity assessment using HTMT ratio (see Table 4.11).

Table 4.11
Discriminant validity results (HTMT Ratio)

	SG	SOP	SBP	SCI	LM	LL	LLD	LLC	LLI	LLS	LC	LCE	LCC	LCT	LCP	LCI
SG																
SOP	-															
SBP	-	.662														
SCI	-	.416	.448													
LM	.492	.423	.286	.424												
LL	.809	.482	.427	.807	.505											
LLD	.593	.395	.328	.738	.519	-										
LLC	.688	.582	.426	.657	.364	-	.795									
LLI	.622	.410	.433	.695	.343	-	.743	.698								
LLS	.616	.346	.367	.823	.583	-	.899	.762	.695							
LC	.803	.550	.472	.708	.406	.833	.685	.790	.745	.666						
LCE	.688	.536	.452	.690	.388	.729	.627	.777	.621	.601	-					
LCC	.696	.548	.475	.673	.439	.775	.674	.732	.794	.643	-	.874				
LCT	.592	.417	.395	.643	.390	.700	.606	.693	.616	.615	-	.824	.868			
LCP	.715	.559	.486	.699	.409	.790	.689	.810	.654	.687	-	.804	.886	.899		
LCI	.564	.467	.353	.548	.228	.661	.550	.620	.769	.514	-	.687	.853	.702	.780	

HTMT ratio that is greater than 0.90 indicates a problem of discriminant validity (Gold, Malhotra, & Segars, 2001). Also, Sarstedt et al. (2019) denoted several guidelines in assessing discriminant validity for second order measurement model as the following:

1. LOCs to demonstrate discriminant validity among each other and to all other constructs in the model except for their own HOC, and
2. HOCs to exhibit discriminant validity to all other constructs in the model.

Results in Table 4.11 demonstrated that all LOCs demonstrated discriminant validity among each other and to all other constructs with HTMT ratios below 0.90 after LSS02 was removed. The initial result showed that there was a discriminant validity issue between LLD and LLS (see Appendix L). In the same vein, discriminant validity was evident between HOCs and all other constructs with the same threshold. Hence, it was confirmed that there was no more discriminant validity problem between constructs in the Lean Transformation Sustainability measurement model. Since both convergent and discriminant validity for all constructs including Sustainable Gains had been proven, the second research objective was successfully accomplished.

4.7.4 CTA-PLS Robustness Test

Confirmatory tetrad analysis for PLS-SEM (CTA-PLS) is a statistical procedure for assessing the robustness of PLS-SEM measurement model results (Gudergan, Ringle, Wende, & Will, 2008). It allows researchers to empirically testing the measurement model setup so that measurement model misspecification can be avoided (Hair, Hult, et al., 2017). The CTA-PLS relies on the concept of tetrads that describe the difference of the product of one pair of covariances and the product of another pair of covariances (Bollen & Ting, 2000). In a reflective measurement model, these tetrads should vanish

(i.e., they become zero) as the indicators are assumed to stem from the same domain. If one of a construct's tetrads is significantly different from 0 (at $t > 1.96$, $p < 0.05$), one rejects the null hypothesis and assumes a formative instead of a reflective measurement model specification (Hair, Risher, Sarstedt, & Ringle, 2019). In the present study, CTA-PLS was performed to confirm whether the measurement model was correctly specified as reflective-reflective HCM (see Table 4.12).

Table 4.12
CTA-PLS results

Tetrads (τ)	Residual value	Std. Error	t -value	p -value	CI	
					Low	Up
LCP,SBP,SCI,SOP	-.221	.158	1.399	.081	-.039	.474
LCP,SBP,SOP,SCI	-.043	.046	.920	.358	-.135	.047
LM01,LM02,LM03,SCI	-.005	.029	.162	.871	-.063	.052
LM01,LM02,SCI,LM03	-.016	.029	.549	.583	-.072	.040
LLC,LLD,LLI,LLS	-.071	.041	1.731	.084	-.155	.006
LLC,LLD,LLS,LLI	-.014	.028	.498	.618	-.072	.040
LCC,LCE,LCI,LCP	.012	.049	.241	.809	-.084	.107
LCC,LCE,LCP,LCI	.070	.039	1.806	.071	-.005	.146
LCC,LCE,LCI,LCT	-.066	.046	1.424	.155	-.159	.022
LCC,LCI,LCT,LCE	-.164	.154	1.062	.144	-.461	.041
LCC,LCI,LCP,LCT	.017	.126	.139	.445	-.243	.178

Note. CI = Confidence interval

As a result, there was no significant tetrad produced by the measurement mode. Thus, the CTA-PLS test approved the specified reflective-reflective measurement model in the present study.

4.8 Structural Model Analysis

Structural model analysis or also known as the significance testing is the process of testing whether a certain relationship between two or more constructs are likely occurred by chance or not (Hair, Hult, et al., 2017; Saunders et al., 2016). In the present study, the significance testing was performed to answer all posited research questions in the first chapter. Following the recent guidelines advocated by Hair, Risher, et al.

(2019), structural model analysis involves seven assessment sequences which include the evaluation of;

1. collinearity issues,
2. model's exploratory power (R^2),
3. predictors' effect sizes (f^2),
4. model's predictive accuracy (Q^2),
5. model's predictive power (Q^2 predict),
6. significance of path model relationships, and
7. importance-performance matrix (IPMA).

Thus, the present study reported the result of structural model analysis following these sequences.

4.8.1 Collinearity Assessment

Multicollinearity or also known as collinearity issue (Hair, Hult, et al., 2017) occurs when two or more predictor variables in a multiple regression model are highly correlated (Cooper & Schindler, 2014; Sekaran & Bougie, 2016). An extreme collinearity issue is called singularity, in which a predictor variable is perfectly predicted (correlation of 1.0) by another predictor variable (Hair, Black, et al., 2019). As collinearity increases, it complicates the interpretation of the variate because it is more difficult to ascertain the effect of any single variable, owing to their interrelationships. By any means, the existence of collinearity issue could adversely affect the statistical significance of the regression coefficients. Hair, Hult, et al. (2017) suggested the evaluation of variance inflation factor (VIF) values to assess the severity of collinearity issue in a PLS-SEM path model (see Table 4.13).

Table 4.13
Collinearity assessment results

Predictor Variables	Collinearity (VIF)		
	LL	LC	SG
Lean Tools Adoption Maturity (LM)	1.000	1.000	1.216
Lean Leadership (LL)	-	-	2.722
Lean Culture (LC)	-	-	2.490

Note. SG = Sustainable Gains

VIF statistic of 5 or greater are suggesting that collinearity issue may mislead the structural model findings (Hair, Hult, et al., 2017). Table 4.13 revealed that all VIFs were less than 5. Hence, collinearity was not a severe problem in this structural model and the produced results were not misleading.

4.8.2 Model's Explanatory Power and Predictor's Effect Size

Model's explanatory power is measured by coefficient of determination, R^2 (Hair, Risher, et al., 2019; Shmueli & Koppius, 2011). R^2 interprets the combined effect of predictor variables on dependent variable (Ramayah et al., 2018), and is therefore a measure of the model's in-sample predictive power (Rigdon, 2012). Generally, R^2 values of 0.26, 0.13, and 0.02 are classified as substantial, moderate, and weak respectively (Cohen, 1988). As a result, SG demonstrated a substantial explanatory power at $R^2 = 0.552$, which implying that all predictors (i.e., Lean Tools Adoption Maturity, Lean Leadership and Lean Culture) had explained 55.2% of variance in Sustainable Gains.

On the other hand, LL and LC had smaller explanatory power compared to SG at $R^2 = 0.168$ (moderate) and $R^2 = 0.091$ (small) respectively. These numbers are implying that Lean Tools Adoption Maturity explained 16.8% of variance in Lean Leadership and 9.1% of variance in Lean Culture. However, it is common to have small R^2 value when

there is only one predictor variable connected to a certain dependent variable. The reason is because R^2 value is highly dependent on the number of predictors included in the structural model (Ramayah et al., 2018). Moreover, Lean Leadership and Lean Culture are not the key target construct (dependent variable) in the present study. The value of R^2 is primarily important for explaining variance in the dependent variable (Hair, Risher, et al., 2019; Shmueli et al., 2019) which is Sustainable Gains in the context of this study.

While R^2 interprets the combined effect of predictor variables on a dependent variable, recent PLS-SEM applications literatures (Manley, Hair, Williams, & McDowell, 2020; Ringle, Sarstedt, Mitchell, & Gudergan, 2020; Xu, Peng, & Prybutok, 2019) also suggested that substantive effect of each predictor variable on dependent variable should be reported. This substantive effect is known as effect size (f^2). In SmartPLS version 3, the values of effect size (f^2) are automatically provided by the software, unlike the previous version where analyst need to manually calculate it. Effect size (f^2) indicates the change in the R^2 value when a specified exogenous construct is omitted from the structural model. All results of R^2 and f^2 from the structural model analysis are illustrated in Figure 4.4 and summarised in Table 4.14.

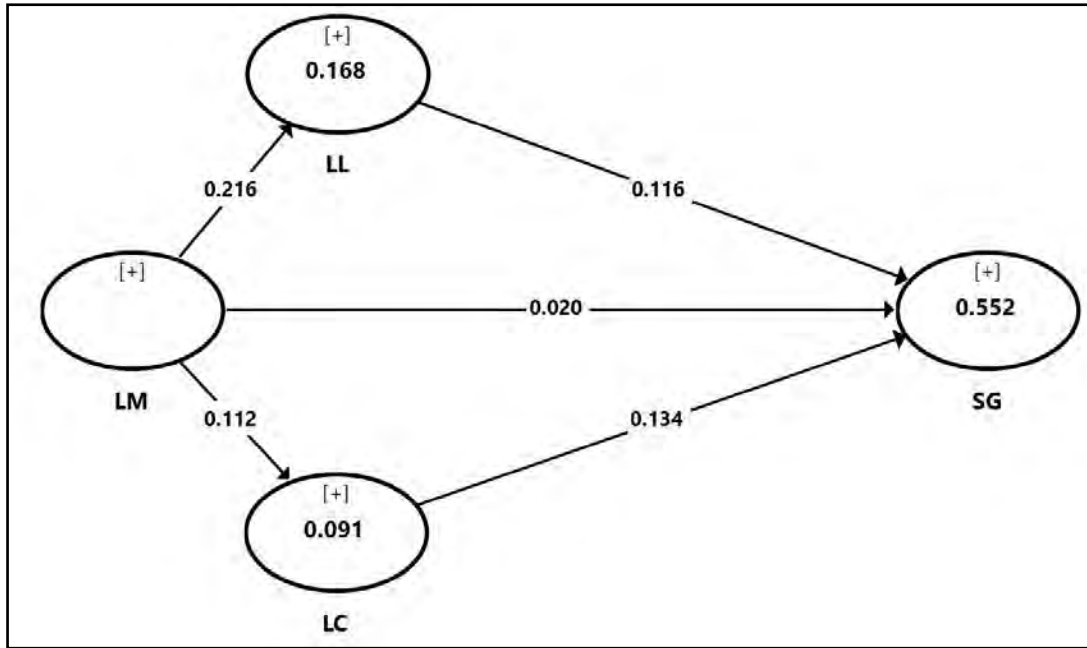


Figure 4.4

Main effect model

Note. Values on arrows = f^2 . Values inside construct = R^2

Table 4.14

Results of explanatory power (R^2) and effect sizes (f^2)

Relationships	Effect Size		Explanatory Power (R^2)
	(f^2)	Magnitude	
Lean Maturity → Sustainable Gains	.020	Small	
Lean Leadership → Sustainable Gains	.116	Small	.552 (substantial)
Lean Culture → Sustainable Gains	.134	Small	
Lean Maturity → Lean Leadership	.216	Medium	.168 (moderate)
Lean Maturity → Lean Culture	.112	Small	.091 (weak)

As recommended in recent PLS-SEM reporting guidelines (Hair, Risher, et al., 2019; Sarstedt et al., 2019), benchmark thresholds introduced by Cohen (1988) were used to determine the magnitudes of f^2 . The magnitudes are 0.02, 0.15, and 0.35, representing small, medium, and large effects respectively. Table 4.14 showed that all predictors contributed small effects on Sustainable Gains ($f^2 < 0.15$). Meanwhile, Lean Tools Adoption Maturity had a medium effect on Lean Leadership ($f^2 > 0.15$), but a small effect on Lean Culture ($f^2 < 0.02$). Thus, these results hinted that there might be significant relationships between these variables. However, confirmation regarding the

significance of the relationships between variables being studied would be discussed in detail later in 4.8.5.

4.8.3 Model's Predictive Accuracy

Structural model predictive accuracy or also known as model's predictive relevance is measured using a metric called Q^2 (Geisser, 1975; M. Stone, 1974). Q^2 is computed to assess whether a model accurately predicts data not used (out-of-sample prediction) in combination with in-sample explanatory power in the estimation of model parameters (Sarstedt, Ringle, & Hair, 2017; Shmueli, Ray, Estrada, & Chatla, 2016). In SmartPLS, Q^2 value is computed using the blindfolding procedure; a resampling technique that systematically deletes and predicts every data point of the indicators in the reflective measurement model of endogenous construct (Ramayah et al., 2018).

In general, Q^2 value should be larger than zero ($Q^2 > 0$) to indicate acceptable predictive accuracy for a certain endogenous construct (Fornell & Cha, 1994; Hair et al., 2014). Nevertheless, recent guideline introduced by Hair, Risher, et al. (2019) indicated that Q^2 values of 0.1 to 0.249 as small, 0.25 to 0.499 as medium, and 0.50 and higher as large. As a result, all endogenous constructs in this structural model demonstrated acceptable predictive accuracy at $Q^2 = 0.327$ (medium) for Sustainable Gains, $Q^2 = 0.126$ (small) for Lean Leadership and $Q^2 = 0.073 \approx 0.1$ (small) for Lean Culture (see Table 4.15). Hence, this result was implying that predicted relationships between independent variable with mediators and dependent variable were accurate and relevant.

Table 4.15
Results of predictive accuracy (Q^2)

Endogenous Constructs	Predictive Accuracy (Q^2)	Magnitude
Sustainable Gains	.327	Medium
Lean Leadership	.126	Small
Lean Culture	.073	Small

4.8.4 Model's Predictive Power

Structural model predictive power is measured based on Q^2_{predict} and root square mean error (RMSE) generated from PLSpredict procedure (Shmueli et al., 2016; Shmueli et al., 2019). Hair, Risher, et al. (2019) recommended the reporting of Q^2_{predict} to ensure that a PLS-SEM structural model has a substantiated model's predictive power. PLSpredict is a set of procedures for out-of-sample prediction that involves estimating the model on an analysis (training) sample and evaluating its predictive performance on a holdout data sample (Hair, Risher, et al., 2019; Shmueli et al., 2016). Interpretation of out-of-sample predictive power should focus on the model's key endogenous construct (Hair, Risher, et al., 2019; Shmueli et al., 2019), which is Sustainable Gains in the present study (see Table 4.16).

Table 4.16
Results of PLSpredict

Indicator	PLS-SEM			LM	PLS-SEM - LM RMSE
	RMSE	Indicator Q^2_{predict}	Latent Q^2_{predict}	RMSE	
SOP	.965	.092		.987	-.022
SBP	1.008	.008	.103	1.018	-.010
SCI	.965	.085		.995	-.025

Note. SOP = Operational Performance, SBP = Business Performance, SCI = Continuous Improvement Capability, LM = Linear regression Model, RMSE = Root Mean Square Error

Table 4.16 presented the result of out-of-sample predictive power based on Q^2_{predict} and root mean square error (RMSE). Following Shmueli's et al. (2019) guidelines, the Q^2_{predict} statistic should be evaluated first to verify that the predictions outperform

the most naïve benchmark, defined as the indicator means from the analysis sample. Similar to Q^2 values for measuring predictive accuracy, Q^2_{predict} of over zero ($Q^2_{\text{predict}} > 0$) indicates the structural model is having sufficient out-of-sample predictive power (Hair, Risher, et al., 2019). Apparently, Q^2_{predict} for all indicators of Sustainable Gains were more than zero (i.e., ranging from 0.008 to 0.092). Thus, this structural model out-of-sample predictive power was sufficient.

Then, researchers need to evaluate the prediction statistics and in most instances, researchers should assess the RMSE (Hair, Risher, et al., 2019). According to Shmueli et al. (2019), when none of the indicators of key endogenous construct in the PLS-SEM analysis has higher RMSE values compared to the naïve LM benchmark, the structural model has high predictive power. The negative values of PLS-SEM – LM RMSE for all Sustainable Gains indicators in Table 4.18 were implying that none of the PLS-SEM RMSE values were higher than the LM RMSE values. Hence, this finding indicated that Lean Transformation Sustainability model had a high predictive power.

4.8.5 Significance of Path Relationships

Bootstrapping procedure with 5000 resamples (Hair et al., 2014) was applied to examine the relationships between independent variable (i.e., Lean Tools Adoption Maturity), mediating variables (i.e., Lean Leadership and Lean Culture), and dependent variable (i.e., Sustainable Gains). Figure 4.5 illustrated the structural model established for the purpose of this study.

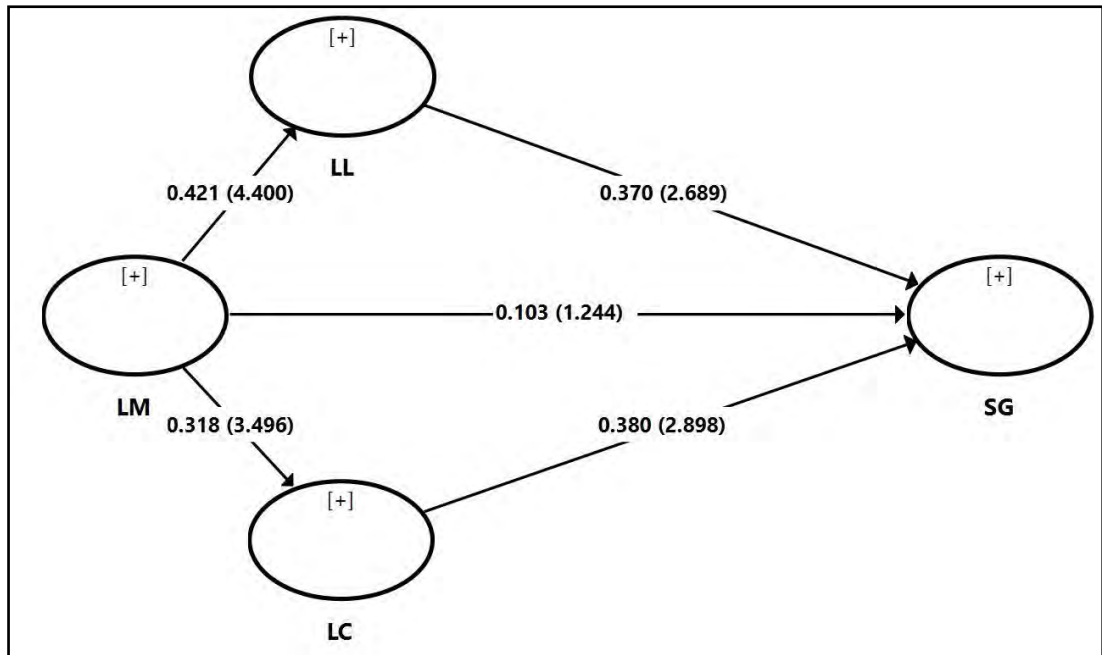


Figure 4.5
Structural model

Figure 4.5 depicted the studied constructs (i.e., LM, LL, LC and SG) and their path relationships (i.e., hypotheses). Lean Tools Adoption Maturity (LM), Lean Leadership and Lean Culture (LC) were exogenous constructs (predictor variables). LL and LC also worked as the mediators in relationships between LM and SG. Meanwhile, the arrows in the model represent relationships between constructs with path coefficients, β (outside brackets) and empirical t -values (inside brackets).

The first part of significance testing reported on the analysis performed to test the direct relationships hypothesised as the following:

1. H1: Lean Tools Adoption Maturity has a positive influence on Sustainable Gains.
2. H2: Lean Leadership has a positive influence on Sustainable Gains.
3. H3: Lean Culture has a positive influence on Sustainable Gains.
4. H4: Lean Tools Adoption Maturity has a positive influence on Lean Leadership.

5. H5: Lean Tools Adoption Maturity has a positive influence on Lean Culture.

The complete results of significance testing for this structural model were compiled as in Table 4.17.

Table 4.17

Results of significance testing (direct relationships)

Relationships	β	Std. Dev	<i>t</i> -value	<i>p</i> -value	CI (BC)		Decision
					LL	UL	
H1: LM $\rightarrow$ SG	.103	.083	1.244	.107	-.034	.238	Not accepted
H2: LL $\rightarrow$ SG	.370	.138	2.689	.004	.145	.594	Accepted
H3: LC $\rightarrow$ SG	.380	.131	2.898	.002	.160	.590	Accepted
H4: LM $\rightarrow$ LL	.421	.096	4.400	<.001	.234	.557	Accepted
H5: LM $\rightarrow$ LC	.318	.091	3.496	<.001	.149	.454	Accepted

Note. One-tailed test, significant at $t > 1.65$. CI = Confidence interval, BC = Bias corrected, LL = Lower limit, UL = Upper limit.

Lean Tools Adoption Maturity (LM). The results demonstrated in Table 4.17, revealed that Lean Tools Adoption Maturity had a non-significant relationship with Sustainable Gains ($\beta = 0.103$, $t = 1.244$, $p = 0.107$, LL = -0.034, UL = 0.238). Hence, H1 was not accepted and the finding implied; the level of Lean Tools Adoption Maturity did not affect the change in the Sustainable Gains level among the studied samples. On the contrary, Lean Tools Adoption Maturity had significant and positive relationships with both Lean Leadership ($\beta = 0.421$, $t = 4.400$, $p < 0.001$, LL = 0.234, UL = 0.557) and Lean Culture ($\beta = 0.318$, $t = 3.496$, $p < 0.001$, LL = 0.149, UL = 0.454). Therefore, H4 and H5 were accepted. These findings interpreted that; as the level of Lean Tools Adoption Maturity increased, the level of Lean Leadership and Lean Culture also increased.

Lean Leadership (LL). The significance testing results also showed that Lean Leadership had a significant and positive relationship with Sustainable Gains ($\beta = 0.370$, $t = 2.689$, $p = 0.004$, LL = 0.145, UL = 0.594). Hence, H2 was supported and this

relationship means; when the level of Lean Leadership increased, the level of Sustainable Gains also increased in the sampled organisations.

Lean Culture (LC). Similar to Lean Leadership, Lean Culture showed a significant positive relationship with Sustainable Gains ($\beta = 0.380$, $t = 2.898$, $p = 0.002$, $LL = 0.160$, $UL = 0.590$). Hence, H3 was accepted. This finding means that the change of Lean Culture level in the respondents' organisations influenced the change of their Sustainable Gains level in a positive trend.

Then, the second part of significance testing reported in the present study included the testing of two indirect relationships that were hypothesised as follow:

1. H6: Lean Leadership mediates the relationship between Lean Tools Adoption Maturity and Sustainable Gains.
2. H7: Lean Culture mediates the relationship between Lean Tools Adoption Maturity and Sustainable Gains.

According to Ramayah et al. (2018) there are three common approaches to test indirect relationship (mediation effect) in a causal relationship study, that include:

1. causal procedural method (Baron & Kenny, 1986),
2. Sobel Test (Sobel, 1986), and
3. indirect effect bootstrapping procedure (Preacher & Hayes, 2004, 2008).

The present study decided to employ the indirect effect bootstrapping procedure due to the following rationales:

1. Baron and Kenny's causal procedure method is often criticised for having very low statistical power and prone to false conclusion in interpreting the mediation effect (MacKinnon, Krull, & Lockwood, 2000; Rungtusanatham, Miller, & Boyer, 2014).
2. Sobel test is not appropriate to be used because the present study possessed a non-normal data distribution. In a study with non-normal data distribution, Sobel Test yields lower statistical power than other alternatives (Hair, Hult, et al., 2017; Ramayah et al., 2018).
3. Preacher and Hayes's (2008) indirect effect bootstrapping procedure works best for models with multiple mediators. The present study has two mediators namely Lean Leadership and Lean Culture. Thus, it is perfectly suited with the context of this study.

Taking these considerations into account, the results of tested indirect effects using bootstrapping procedure were presented as in Table 4.18.

Table 4.18

Results of significance testing (indirect relationships)

Relationships	β	Std. Dev	<i>t</i> -value	<i>p</i> -value	CI (BC)		Decision
					LL	UL	
H6: LM $\rightarrow$ LL $\rightarrow$ SG	.176	.073	2.397	.017	.052	.334	Accepted
H7: LM $\rightarrow$ LC $\rightarrow$ SG	.120	.060	2.016	.044	.031	.256	Accepted

Note. Two-tailed test, significant at $t > 1.96$. CI = Confidence interval, BC = Bias corrected, LL = Lower limit, UL = Upper limit.

As a result, both indirect relationships tested were significant. H6 was accepted at $\beta = 0.176$, $t = 2.397$, $p = 0.017$, LL = 0.052, UL = 0.334, while H7 was accepted at $\beta = 0.120$, $t = 2.016$, $p = 0.044$, LL = 0.031, UL = 0.256. Hence, it was proven that both Lean Leadership and Lean Culture bridged the critical gap between Lean Tools Adoption Maturity and Sustainable Gains.

In addition, researchers are advised to conclude mediation results by identifying types of mediation effect (Hair, Hult, et al., 2017; Nitzl, Roldan, & Cepeda, 2016). According to MacKinnon, Fairchild, and Fritz (2007) there are three types of mediation effect including; 1. full mediation, 2. competitive partial mediation, and 3. complementary partial mediation (see Figure 4.6).

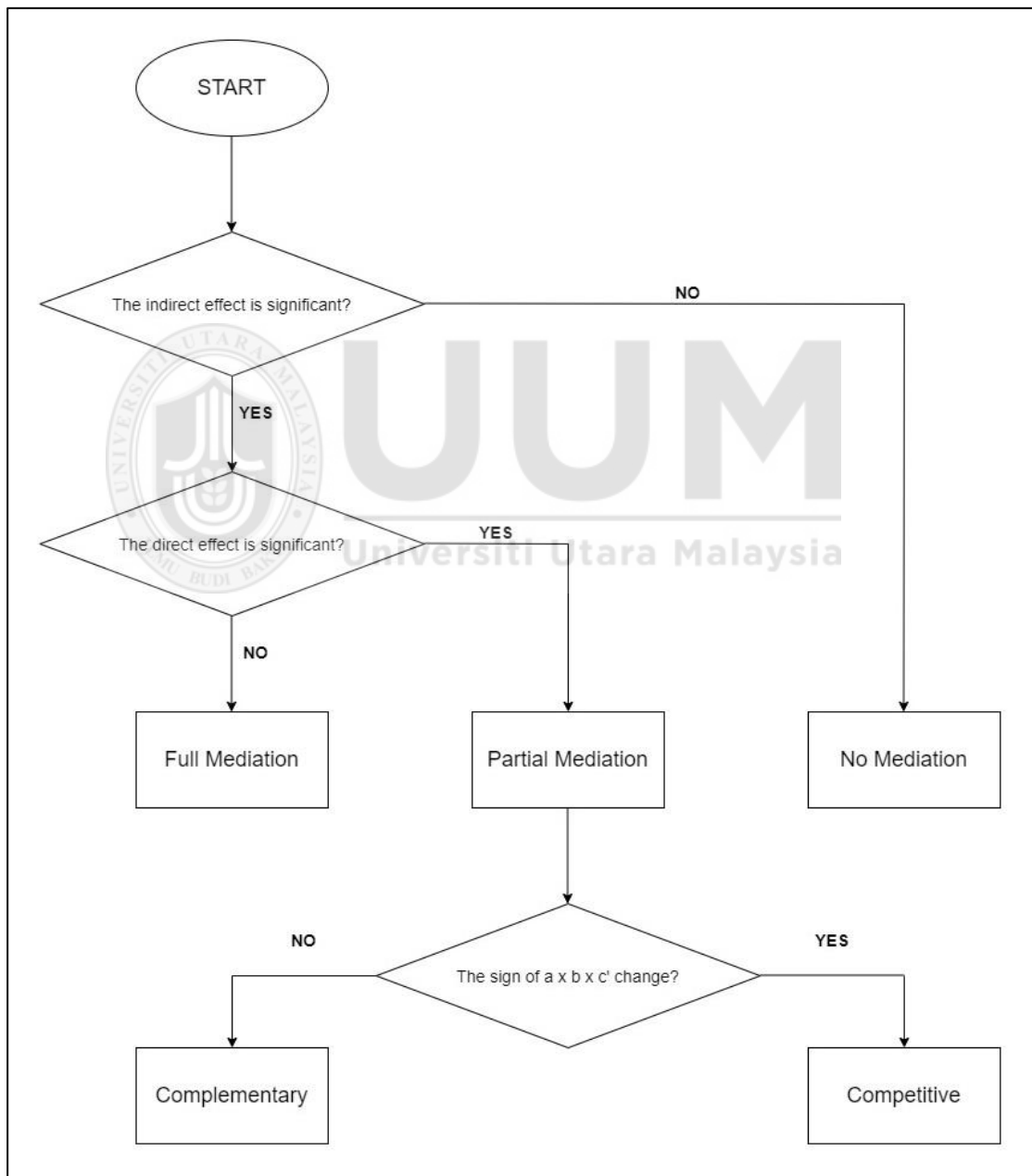


Figure 4.6

Types of mediation

Source: Adapted from Zhao, Lynch Jr., and Chen (2010)

As depicted in Figure 4.6, full mediation occurs when the indirect effect is significant but the direct effect is not significant. This description was matched with the mediation effect of Lean Leadership and Lean Culture on the relationship between Lean Tools Adoption Maturity and Sustainable Gains. In this study, it was revealed that the direct relationship between Lean Tools Adoption Maturity and Sustainable Gains (H1: LM $\rightarrow$ SG) was not significant at $t < 1.65$ and $p > 0.05$. However, the indirect relationship between Lean Tools Adoption Maturity and Sustainable Gains through Lean Leadership (H6: LM $\rightarrow$ LL $\rightarrow$ SG) was significant at $t = 2.397$ and $p = 0.017$. In the same vein, the indirect relationship between Lean Tools Adoption Maturity and Sustainable Gains through Lean Culture (H7: LM $\rightarrow$ LC $\rightarrow$ SG) also significant at $t = 2.016$ and $p = 0.044$. Thus, H7 was also recognised as a full mediation. All types of mediation identified in this study was summarised in Table 4.19.

Table 4.19
Summary of mediation types

Direct	Relationships				Types of Mediation
	<i>t</i> - value	<i>p</i> - value	Indirect	<i>t</i> - value	<i>p</i> - value
H1: LM $\rightarrow$ SG	1.244	.107	H6: LM $\rightarrow$ LL $\rightarrow$ SG	2.397	.017
			H7: LM $\rightarrow$ LC $\rightarrow$ SG	2.016	.044

Note. Direct effect not significant at $t < 1.65$. Indirect effect significant at $t > 1.96$.

4.8.6 Importance-Performance Matrix Analysis

The importance-performance matrix analysis (IPMA) or also known as importance-performance map analysis is an extra feature to extend the results presentation of the standard PLS-SEM estimations by contrasting the total effects of the latent variables on some target variable with their latent variable scores (Hair, Hult, et al., 2017). IPMA graphical representation enables researchers to easily identify critical areas that require attention (Hair, Hult, et al., 2017) and consequently assist researchers to further explain

and discuss the findings for managerial implications (Ramayah et al., 2018). On that account, the present study employed IPMA on the key target construct (i.e., Sustainable Gains) to identify critical areas that should receive high attention for further improvement action (see Table 4.20 and Figure 4.7).

Table 4.20
Result of IPMA

Predictor Variables	Importance (Total Effects)	Performances (Index Values)
Lean Culture (LC)	.335	57.660
Lean Leadership (LL)	.333	61.320
Lean Tools Adoption Maturity (LM)	.136	50.718

Note. Sorted descending based on importance levels (total effects)

Table 4.20 demonstrated the IPMA results for each predictor construct in the structural model. The results were including importance level based on predictor's total effect and predictor's performance based on latent variable index values.

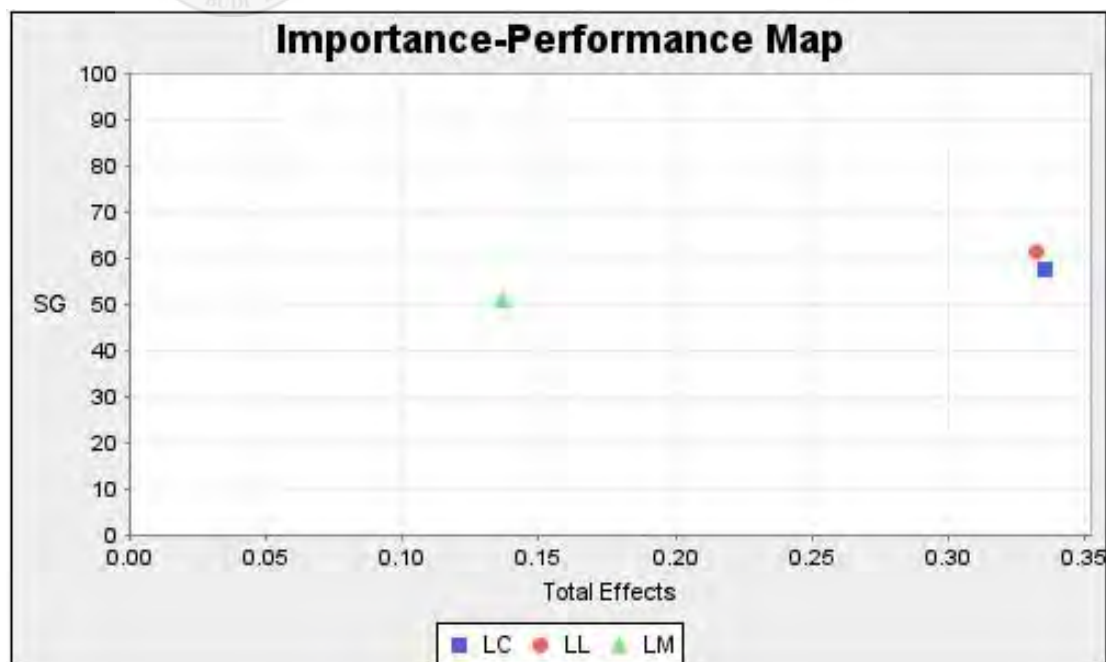


Figure 4.7

Importance-performance map

Note. Total effects-axis represents Importance. SG-axis represents Performance

The IPMA graphic in Figure 4.7 revealed that Lean Leadership showed the highest performance and it was indeed an important variable in the prediction of Sustainable Gains. However, the most important variable was Lean Culture, but it had a slightly lower performance compared to Lean Leadership. On the other hand, Lean Tools Adoption Maturity had the lowest performance and also the least important variable in the prediction of Sustainable Gains. These findings were suggesting that the performance of each predictor variable need to be improved so that lean transformation in the respondents' organisations would become more sustainable.

4.9 Robustness Tests

The final step in interpreting PLS-SEM results, therefore, involves running one or more robustness tests to support the stability of results (Hair, Risher, et al., 2019). In terms of measurement models, Gudergan et al. (2008) introduced the CTA-PLS to empirically substantiating the specification of measurement models (i.e., reflective versus formative measurements). In this study, CTA-PLS had been performed and reported in the previous sub-section. The result approved the specification of reflective-reflective higher order measurement model used in the present study (see 4.7.4).

On the other hand, for structural models' robustness, Sarstedt et al. (2020) suggested PLS-SEM users to check for endogeneity, nonlinear effects and unobserved heterogeneity. However, the test for endogeneity was omitted in the present study due to two reasons. First, only variables with non-normal distribution (univariate normality) are potentially exhibit endogeneity (Sarstedt et al., 2020). While all variables in the present study demonstrate normal distribution at univariate level (see Appendix H), endogeneity may not present in the structural model. Second, the test for endogeneity

should be conducted only when the research orientation is primarily explanatory (Sarstedt et al., 2020). As mentioned in 3.7.2, the present study was exploratory-oriented. On that account, endogeneity test was not imperative to be conducted in this study.

4.9.1 Nonlinear Effects Assessment

There are two types of test for detecting potential nonlinearities in the structural model relationships namely; 1. quadratic interaction terms, and 2. Ramsey's (1969) regression equation specification error test (RESET) (Hair, Risher, et al., 2019). Quadratic interaction terms are used for estimating individual nonlinear effect from each predictor variable, while Ramsey's (1969) RESET determines nonlinearities for the whole structural model. A significant test statistic at $p < 0.05$ in any of the RESET partial regressions indicate a potential nonlinear effect. In the same vein, statistical significance of quadratic interaction terms at $p < 0.05$ imply possible existence of nonlinear effect (Sarstedt et al., 2020; Svensson et al., 2018).

Following Svensson et al. (2018), the present study employed both tests. Hence, it was found that all partial regressions were not subjected to nonlinearities; 1. SG on LM, LL and LC ($F(2,86) = 0.253, p = 0.777$), 2. LL on LM ($F(2,88) = 1.428, p = 0.245$), and 3. LC on LM ($F(2,88) = 0.945, p = 0.393$). Next, interaction terms were included in the structural model to represent the quadratic effects between; 1. LM, LL, and LC on SG, 2. LM on LL and 3. LM on LC. The results of bootstrapping with 5000 samples and using no sign changes indicate that neither of the nonlinear effects was significant (see Table 4.21). This study therefore concluded that the linear effects model was robust.

Table 4.21
Nonlinear effects assessment

Quadratic effect	Coefficient	<i>p</i> -value	<i>f</i> ²	Ramsey's RESET
LM*Q → SG	-.106	.192	.039	F (2,86) = 0.253, <i>p</i> = 0.777
LL*Q → SG	.081	.279	.015	
LC*Q → SG	.071	.288	.011	
LM*Q → LL	-.162	.273	.059	F (2,88) = 1.428, <i>p</i> = 0.245
LM*Q → LC	-.222	.424	.079	F (2,88) = 0.945, <i>p</i> = 0.393

4.9.2 Unobserved Heterogeneity Assessment

Unobserved heterogeneity occurs when subgroups of data exist that produce substantially different model estimates. If this is the case, estimating the model based on the entire data set is very likely to produce misleading results (Becker, Rai, Ringle, & Völckner, 2013; Hair, Risher, et al., 2019). Hence, PLS-SEM users should consider unobserved heterogeneity assessment as a regular practice to verify if the analysis of the entire data set is justifiable or not.

As demonstrated by Sarstedt et al. (2020), a systematic procedure namely finite mixture PLS (FIMIX-PLS) was performed to identify and treat (if necessary) unobserved heterogeneity in the PLS-SEM model. Following Matthews, Sarstedt, Hair, and Ringle (2016), the procedure was first initiated by assuming a one-segment solution, using the default settings for the stop criterion at $10^{-10} = 1.0E - 10$, the maximum number of iterations = 5000, and the number of repetitions = 10. Then, the procedure was repeated for two and three segments, using the same settings as in the initial analysis.

The results of the fit indices for the one- to three-segment solutions paint an ambiguous picture (see Table 4.22). Sarstedt, Becker, Ringle, and Schwaiger (2011) highlighted that whenever AIC3 and CAIC indicate the same number of segments, the results likely point to the appropriate number of segments. In the present analysis, however, AIC3

indicates a three-segment solution, whereas CAIC points to a one-segment solution which was not consistent. Sarstedt et al. (2020) further asserted that AIC4 and Bayesian information criteria (BIC) generally perform well when used to determine the number of segments in FIMIX-PLS. Both criteria point to a two-segment solution, which appears to be densely clustered according to the EN criterion (i.e., $EN > 0.5$) (Hair, Sarstedt, Matthews, & Ringle, 2016).

Table 4.22
Fit indices for the one- to three-segment solutions

Criteria	Number of Segments		
	1	2	3
AIC (Akaike's Information Criterion)	694.491	669.566	656.334
AIC3 (Modified AIC with Factor 3)	702.491	686.566	682.334
CAIC (Consistent AIC)	722.665	729.436	747.901
AIC4 (Modified AIC with Factor 4)	710.491	703.566	708.334
BIC (Bayesian Information Criteria)	714.665	712.436	721.901
MDL5 (Minimum Description Length with Factor 5)	859.363	1019.918	1192.167
EN (Entropy Statistic (Normed))		0.719	0.703

Note. Highlighted columns indicate the best outcome per segment retention criterion.

Moreover, minimum description length with factor 5 (MDL5) also points to a two-segment solution. However, the two-segment solution did not meet the minimum sample size requirements for each segment (see Table 4.23). Jointly, this analysis did not clearly point to a specific segmentation solution because; 1. AIC3 and CAIC point to different segment numbers (inconsistent solution), and 2. sample proportion for consistent solution (two-segment) did not meet the minimum required sample size (i.e., $n = 20 < 77$). This study therefore concluded that unobserved heterogeneity was not at a critical level and no further treatment should be employed. Thus, the results of the entire data sets' analyses were robust.

Table 4.23
Relative segment sizes

Number of Segments	Segment 1	Segment 2	Segment 3
1	1.000		
2	0.775	0.225	
3	0.580	0.221	0.199

Note: The table shows the relative segment sizes in declining order per solution (i.e., per row); due to label switching, a specific segment can have different labels across the solutions (Sarstedt et al., 2020); the SmartPLS 3 software uses the relative segment sizes in declining order when assigning the segment numbers to the final FIMIX-PLS segments

4.10 Summary of the Chapter

In conclusion, this study managed to acquire a response rate of 50.27% which was higher than previous studies in the same research context and setting. Based on demographic characteristics comparison, there was no non-response bias evident in the present study. Further, during data screening stage, few missing data were systematically identified and imputed using Little's MCAR Test and expectation maximisation algorithm. No straight-lining response was identified in the research data since the questionnaire items were design using mixed-scale properties. There was also no significant multivariate outlier was detected from the dataset. However, the result of Mardia's multivariate data distribution still demonstrated a non-normal distribution at $\beta = 1.902, p > 0.05$ for skewness and $\beta = 25.210, p > 0.05$ for kurtosis.

Then, the measurement model assessments confirmed that all constructs being studied were valid and reliable with AVE statistics were more than 0.5 (i.e., ranging from 0.589 to 0.820), HTMT ratios were below 0.90 (i.e., ranging from 0.228 to 0.899) and ρ_c coefficients were higher than 0.7 (i.e., ranging from 0.846 to 0.970). Furthermore, both structural model's explanatory power and predictive power based on key target construct (Sustainable Gains) produced a substantial power at $R^2 = 0.552$ and Q^2 predict

statistics more than 0 with all PLS-SEM RMSE statistics lower than linear model (LM) RMSE statistics.

In addition, findings from the significance testing revealed that majority of the hypothesised relationships were statistically significant except for H1: Relationship between Lean Tools Adoption Maturity and Sustainable Gains. Nevertheless, this relationship was fully mediated by the intervention of Lean Leadership and Lean Culture. Thus, IPMA graphics plotted Lean Tools Adoption Maturity as a predictor variable with the least effect on Sustainable Gains and Lean Culture as the most important predictor in the model. Common method bias was also examined through full collinearity test, and the result suggested that the bias posed no significant threat on the results of structural model assessments.

Finally, robustness tests of measurement model specification (CTA-PLS), nonlinear effects (Ramsey's RESET and quadratic interaction terms) and unobserved heterogeneity (FIMIX-PLS) were also successfully conducted to approve the stability of all produced results. Findings from all conducted tests suggested that the results of the whole data analyses were truly robust.

CHAPTER FIVE

DISCUSSIONS & CONCLUSION

5.1 Introduction

This chapter primarily discussed and elaborated the findings of the present study in-lined with the proposed research objectives and posited hypotheses. Besides that, a complete recap of the entire study and implications of the present study on theoretical, practical and methodological aspects were also included. To end the chapter, limitations of the present study were also addressed and several opportunities for future research were recommended.

5.2 Recapitulation of the Study

The present study was conducted to empirically address the issue of lean transformation sustainability among Malaysian manufacturing organisations. Specifically, this study assessed the role of Lean Tools Adoption Maturity, Lean Leadership and Lean Culture towards achieving Sustainable Gains. Thus, three research objectives were formulated to guide the study in a systematic and scientific directions. The research objectives were:

1. To analyse the relationship between lean tools adoption maturity and sustainable lean transformation gains.
2. To investigate the mediating effect of lean leadership on the relationship between lean tools adoption maturity and sustainable lean transformation gains.
3. To investigate the mediating effect of lean culture on the relationship between lean tools adoption maturity and sustainable lean transformation gains.

Further, the research model of this study was developed based on the integration of two change management theories namely; Theory E and Theory O (Beer & Nohria, 2000b). Theory E focussed on economic value (hard approach), while Theory O emphasised organisation's capability (soft approach). As both theories have distinct and contradict core objectives, combined adaptation (integration) of these theories creates the best and most effective change strategy for organisational transformation (Beer & Nohria, 2000b; Hodges & Gill, 2015; Luecke, 2003). This is the effective way to enact rapid economic value improvement while also building organisational capability which are essential for gaining sustainable advantage. Specific to the context of this study, sustainable advantage was manifested as Sustainable Gains variable. On the other hand, strategies to enhance economic value and organisational capability were operationalised into three predictor variables that include Lean Tools Adoption Maturity, Lean Leadership and Lean Culture.

A self-administered questionnaire survey form was designed as the instrument to gather the research data from the target population. The questionnaire items were adapted from several previous studies such as Osman et al. (2021), Mousavi et al. (2020), Beraldin et al. (2019) and Gaiardelli et al. (2019). The target population of the present study was manufacturing organisations in Malaysia that are currently practising lean principles in their operations system. However, due to some constraints, the researcher only had access to lean manufacturing organisations listed in MPC's lean transformation program directory. Based on G*power calculation, a total of 77 lean manufacturing organisations were determined as the minimum number of samples required for producing results with sufficient statistical power. Nevertheless, the questionnaire

forms were distributed to the entire accessible population units ($N = 213$) to make up for respondents' reluctance, ineligibility or unengaged responses.

After three months, this study managed to acquire a total of 92 samples ($n = 92$) which accounted for 50.27% of response rate. Based on demographic characteristics comparison using chi-square test of association, the absence of non-response bias was confirmed. In addition, post-hoc power analysis result supported that the acquired number of samples were good enough in producing statistical results with optimum statistical power ($1 - \beta = 87.6\%$). These 92 eligible samples belong to 92 manufacturing organisations who had initiated lean transformation journey for at least two years. 20.7% of the respondent organisations produced food and beverages products, 18.5% were wood-based products manufacturers, 15.2% produced electrical and electronics devices, 9.8% were automotive parts producers, and 8.7% equal proportion of chemical and petrochemical, iron and steel as well as pharmaceutical products manufacturers separately. Meanwhile, the remaining few proportions were belonged to machinery and equipment (5.4%), rubber (2.2%), textile (2.2%) and aerospace components (1.1%) manufacturing. All sampled organisations were represented by the most knowledgeable personnel with major decision-making roles in lean transformation activities in their respective organisations. They were among managing directors, general managers, operation managers, administration executives and production supervisor.

All data obtained was then systematically screened to ensure only reliable and quality reporting units were retained for statistical analyses. During this stage, few missing data were systematically identified and imputed using Little's MCAR Test and expectation maximisation algorithm. No straight-lining response and significant multivariate outlier

were detected from the collected research data. However, the result of data distribution still demonstrated a non-normal distribution based on Mardia's multivariate skewness and kurtosis statistics.

Next, the main statistical analysis namely PLS-SEM running on SmartPLS software version 3.3.3 was performed to fulfil the proposed research objectives. PLS-SEM analysis consists of two types of assessments which include measurement model and structural model. The measurement model assessment was employed to test the validity and reliability of the constructs being studied and subsequently accomplished the second research objective. Meanwhile, structural model assessments were employed to test seven hypotheses that had been posited and together accomplished the remaining research objectives. Table 5.1 described how the conducted statistical analyses and findings were matched with the formulated research hypotheses to accomplish the proposed research objectives.

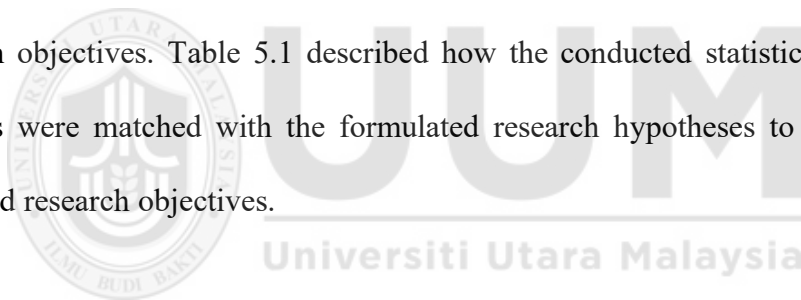


Table 5.1

Alignment of research objectives with statistical analyses and research hypotheses

Research Objectives	Statistical Analyses		Hypotheses	Results
To analyse the relationship between lean tools adoption maturity and sustainable lean transformation gains.	Structural model assessment: Path analysis via direct effect bootstrapping procedure (Hair, Hult, et al., 2017).	H1	Lean Tools Adoption Maturity has a positive influence on Sustainable Gains.	H1 was not accepted: $t = 1.244 < 1.65$ $p = 0.107 > 0.05$
To investigate the mediating effect of lean leadership on the relationship between lean tools adoption maturity and sustainable lean transformation gains.	Structural model assessment: Path analysis via direct effect bootstrapping procedure (Hair, Hult, et al., 2017).	H2	Lean Leadership has a positive influence on Sustainable Gains.	H2 was accepted: $\beta = 0.370, t = 2.689, p = 0.004$
		H4	Lean Tools Adoption Maturity has a positive influence on Lean Leadership.	H4 was accepted: $\beta = 0.421, t = 4.400, p < 0.001$
	Structural model assessment: Path analysis via indirect effects bootstrapping procedure (Preacher & Hayes, 2008).	H6	Lean Leadership mediates the relationship between Lean Tools Adoption Maturity and Sustainable Gains.	H6 was accepted: $\beta = 0.176, t = 2.397, p = 0.017$ Full mediation
To investigate the mediating effect of lean culture on the relationship between lean tools adoption maturity and sustainable lean transformation gains.	Structural model assessment: Path analysis via direct effect bootstrapping procedure (Hair, Hult, et al., 2017).	H3	Lean Culture has a positive influence on Sustainable Gains.	H3 was accepted: $\beta = 0.380, t = 2.898, p = 0.002$
		H5	Lean Tools Adoption Maturity has a positive influence on Lean Culture.	H5 was accepted: $\beta = 0.318, t = 3.496, p < 0.001$
	Structural model assessment: Path analysis via indirect effects bootstrapping procedure (Preacher & Hayes, 2008).	H7	Lean Culture mediates the relationship between Lean Tools Adoption Maturity and Sustainable Gains.	H7 was accepted: $\beta = 0.120, t = 2.016, p = 0.044$ Full mediation

5.3 Discussion of the Research Findings

Based on the formulated problem statement, three research questions were posited as guidelines to ensure the objectives of the present study would be achieved. Answers for these research questions were taken from verified hypotheses in the earlier chapter. By successfully answering each of the research question, every proposed research objective in the present study was considered as successfully accomplished. Therefore, findings obtained from the present study were systematically discussed according to the research questions order.

5.3.1 Answers for Research Question 1

To answer the first research question, RQ1: *Is there a positive relationship between lean tools adoption maturity and sustainable lean transformation gains?* the relationship between Lean Tools Adoption Maturity and Sustainable Gains (H1) was examined. Until recently, the relationship between Lean Tools Adoption Maturity and Sustainable Gains is remained unexplained in the operations management literature. Existing evidences had found significant effects of lean tools adoption on either operational performance (Hardcopf et al., 2021; Sahoo, 2021), financial performance (Galeazzo, 2019; Shashi et al., 2019), business performance (Iteng et al., 2017; Nawanir et al., 2016) or sustainable performance (Iranmanesh et al., 2019; Sajan et al., 2017).

Unlike existing evidences, the present study produced a new evidence that portrayed the effect of maturity of lean tools adoption on the integration of organisations' operational performance, business performance and continuous improvement capability, known as Sustainable Gains. Results in the present study did not support the hypothesis of a significant positive effect of Lean Tools Adoption Maturity on

Sustainable Gains. The value of the empirical t -statistics equals to 1.244 ($t = 1.244 < 1.65$) suggested a non-significant influence of Lean Tools Adoption Maturity on Sustainable Gains. Thus, H1 was not accepted.

Although H1 was not supported, the result contributed a new insight by expanding the way lean transformation is conceptualised and measured. Compared to studies that only used magnitude of lean tools and techniques adoption as a proxy for measuring lean transformation, this study approached lean transformation from the maturity angle, thus considering it as a combination of fidelity, extensiveness and experience in lean tools and techniques adoption. To characterise the lean transformation, the present study focused on the level of lean maturity that help scholars and practitioners to understand how much, how wide and for how long an organisation had adopted lean thinking in its operations system.

Besides that, this finding verified statistics from real scenarios in industry and case studies of lean transformation failure that were reported in the literature. It was speculated that up to 70% of business organisations failed to make lean transformation as an effective strategy for achieving sustainable productivity improvements (Van Landeghem et al., 2013). Other sources recorded that nearly two-thirds of the lean transformation ended in failures, only an estimated 2 to 3% had achieved the desired level of success and sustained results (Jadhav et al., 2014; Sisson & Elshennawy, 2015). The reputation of lean adoption in various types of industries was damaged by many failed transformations with reports of 60 to 90% of improvement program failures (Pearce & Pons, 2019) and manufacturers that failed in the transformation returned back producing according to their traditional means (Costa et al., 2019).

Murti (2009) studied nine manufacturers who were participants of New Zealand Trade and Enterprise (NZTE) Lean Programmes. He concluded that NZTE's Lean Programmes were successful in promoting lean but proved poor in ensuring sustainable improvements. Only one manufacturing organisation looked likely to sustain improvements made. Turesky and Connell (2010) also reported that lean transformation at a manufacturing organisation in Northern New England failed to produce sustained results. Another example of lean transformation failure is evident in the case of Colorado's small and medium-sized manufacturing (SMM) organisations conducted by Pentlicki (2014). Three SMMs with experience in implementing lean manufacturing for a period of at least two years were barely sustained their lean transformation gains due to several leadership and management-related issues.

Therefore, it is true that lean transformation does not necessarily affect organisation's achievement in sustaining performance gains. There are plenty of evidences that suggest lean transformation attempts are subjected to failure and lead to organisation's setback. Such evidences also implying that the current result presented in this study did make sense and might be more accurate than recently published studies. Several recent studies that found a significant effect of lean transformation on performance gains adopted a narrow focus in conceptualising and measuring lean transformation. These studies only focused on the magnitude to which an organisation utilised lean practices, tools or techniques as a proxy to measure lean transformation (Hardcopf et al., 2021; Hernandez-Matias et al., 2020; Sahoo, 2021; Susanty, Sumiyati, Syaiful, & Nihlah, 2021; V. Wickramasinghe & Wickramasinghe, 2020). Thus, the assessment of organisations' lean transformation level might be misleading as alleged by Galeazzo

(2019), which resulting in a significant direct relationship with performance gains that contradicted to the actual scenario and current findings obtained in this study.

5.3.2 Answers for Research Question 2

Going beyond prior studies, the second research question of the present study related to the investigation of possible indirect effects of Lean Maturity on Sustainable Gains via Lean Leadership. Three hypotheses (H2, H4 and H6) was formulated to satisfy the rules of mediation test according to Preacher and Hayes (2004; 2008). In order to investigate the mediating effect of Lean Leadership (H6), direct relationships between Lean Leadership and Sustainable Gains (H2) as well as Lean Maturity and Lean Leadership (H4) need to be determined first. The test statistics and probability estimate for H2 and H4 were all exceeded the threshold benchmark at $t > 1.65$ and $p < 0.05$, signifying that both hypothesised relationships were significant. Therefore, the investigation on the mediating effect of Lean Leadership can be proceeded. Further, the result of Lean Leadership mediating effect was statistically significant at $t = 2.397, p = 0.017$. Hence, H6 was supported.

To the best of researcher's knowledge, a statistically significant result that verifies the intervention of lean leadership in sustaining gains from lean transformation efforts is reported for the first time in the present study. The findings from the analyses showed a positive impact of practising lean leadership principles to sustain performance gains acquired from lean transformation (H2). It was also clear that without lean leadership, there was no significant relationship between lean maturity and sustainable gains (H1). Path analysis using PLS-SEM technique revealed that the relationship between lean maturity and sustainable gains was fully mediated by the existence of lean leadership

(H6). This finding suggested that lean leadership was indeed a missing link that bridge the critical gap between the applications of lean tools and techniques with the ability to persistently acquire benefits and improvements from lean transformation efforts.

Though direct comparisons with previous studies (Dombrowski & Mielke, 2013; Larteb et al., 2015; Mulders, 2016; Nooraei Ashtiani, 2016) were not possible due to differences in measurement of the construct and types of statistical analysis being employed, current findings gained a new empirical evidence by measuring lean leadership as a four-dimensional construct; 1. self-development, 2. coach and develop subordinates, 3. support for daily improvement, and 4. strategy deployment and examining its combined effect on sustainable gains. These four dimensions defined lean leadership aligned with The Toyota Way (Liker, 2004; Liker & Convis, 2012), the original philosophy of lean transformation. Previous studies revealed that only self-development (Mulders, 2016) and strategy deployment (Nooraei Ashtiani, 2016) principles had a statistically significant effect on sustainable gains. By leveraging the advantage of the second-generation statistical technique (i.e., PLS-SEM), this study managed to measure all four dimensions simultaneously which not only enhanced the comprehensiveness (content validity) of the lean leadership measurement, but also creates a synergy in predicting the outcome variable.

Finally, the findings also agreed with previously conducted qualitative studies (Lucey et al., 2005; Murti, 2009; Pentlicki, 2014), where lean leadership is generally important to sustain lean transformation gains, but this study further explained that by increasing the level of lean leadership practices, the level of sustainable gains would also increase at the magnitude of $\beta = 0.370$ and $f^2 = 0.116$. Particularly, one-unit change in Lean

Leadership, causing 0.37-unit change in Sustainable Gains. Although in regards to f^2 value the effect size was considered as small, the confidence level was especially high at 99.96% ($p = 0.004$), suggesting a meaningful finding. Concisely, the comparison with previous qualitative findings revealed a similar conclusion, even the present study was using a different research design (quantitative method). Hence, a new evidence based on different nature of data enriched the body of knowledge on this phenomenon.

5.3.3 Answers for Research Question 3

The final research question, RQ3: *Does lean culture mediate the relationship between lean tools adoption maturity and sustainable lean transformation gains?* was also answered by testing three hypotheses (i.e., H3, H5 and H7). H3 stated the positive direct relationship between Lean Culture and Sustainable Gains and was supported at $\beta = 0.380$, $t = 2.898$ and $p = 0.002$. This result supports notion made by many lean scholars (Atkinson, 2013; Bhasin, 2013; Mann, 2003; Pakdil & Leonard, 2015; Zarbo, 2012) and previous qualitative findings (Association for Manufacturing Excellence, 2009; Sisson & Elshennawy, 2015; Vance, 2017) stating that culture affects the sustainability of lean transformation. While this might not seem like a breaking news, prior to this study no statistically validated research finding that support such notion could be found. Thus, lean culture had been statistically proven as an enabler of lean transformation sustainability.

Next, H5: *Lean Tools Adoption Maturity has a positive influence on Lean Culture* was tested to fulfil the rules of testing mediation effect (Preacher & Hayes, 2004, 2008) and the result revealed a significant positive relationship between the two variables ($\beta = 0.318$, $t = 3.496$, $p < 0.001$). Thus, the results of path analysis supported assumptions

by lean scholars (Hines et al., 2011; Liker, 2004; Novac & Mihalcea, 2014; Urban, 2015) and some qualitative findings (Vance, 2017; Walentynowicz, 2014) highlighting that lean culture can also be an outcome of lean transformation sustainability.

The final part of investigating Lean Culture mediation effect involved testing the significance of indirect relationship between Lean Tools Adoption Maturity and Sustainable Gains via Lean Culture (H7). The test result revealed that there was a significant mediation effect of Lean Culture on the relationship between Lean Tools Adoption Maturity and Sustainable Gains ($\beta = 0.120$, $t = 2.016$, $p = 0.044$). This suggests that lean culture was indeed a bridge that linked a critical divide between the applications of lean tools and techniques with the ability to persistently acquire improvements from lean transformation efforts. Similar to Lean Leadership, it was evident that Lean Culture also fully mediated the relationship between Lean Tools Adoption Maturity and Sustainable Gains, as the direct relationship between the two variables (H1) was not significant. In other words, without forming a lean culture in the organisation, the gains made from lean transformation are unlikely to sustain. The result also truly reflects Toyota Motor Manufacturing (TMM) catchphrase “We build people before we build cars”. The existence of lean culture in the sampled organisations intervened the efficacy of lean transformation to acquire sustainable gains.

Moreover, the results of the present analysis revealed to what degree the existence of lean culture influences a lean transformation initiative in achieving its sustainable gains. The effect size of lean culture on sustainable gains was categorised as small at $f^2 = 0.134$, but close to medium level ($f^2 = 0.15$). Although small, such effect remains

meaningful in the prediction of sustainable gains as the confidence level was very high at 99.98% ($p = 0.002$).

Unlike most previous studies, the present study had observed lean culture effect with more precise measurement by indicating how far the actual organisational culture deviates from the ideal culture that aligned with lean thinking. Studies published by Bortolotti et al. (2015), Pakdil and Leonard (2015), Losonci et al. (2017), Paro and Gerolamo (2017), Taherimashhadi and Ribas (2018), Antomarioni et al. (2019), Cadden et al. (2020), and Hardcopf et al. (2021) had examined types of cultural profile that influence lean transformation success. Assessing types of cultural profile based on traditional organisational culture models (Hofstede et al., 1990; Schein, 1985) were not able to fully capture the concept of “ideal lean culture” (Jenei et al., 2014; Urban, 2015). This is because, building such culture requires a balance by combining several cultural profiles that valued both flexibility and uniformity (Pakdil & Leonard, 2015).

Five dimensions of lean culture introduced in the present study; 1. positive work environment, 2. effective communications, 3. teamwork, 4. problem solving, and 5. innovation, acknowledged both flexibility and uniformity. Specifically, flexibility was measured in communication (i.e., top-down and bottom-up communications work in parallel), teamwork (i.e., production work teams are empowered to decide on most issues) and innovation (i.e., production work teams are permitted to experiment with new ways of working) dimensions. On the other hand, uniformity was accounted in positive work environment (i.e., standardised process-driven focus, daily search for new improvements and stable inter-department cooperation) and problem solving (i.e., using systematic format for problem resolution, and decisions are made based on facts

and data) dimensions. Thus, it can be concluded that successful and lasting lean transformations cannot happen without the alignment of an organisation's existing culture with lean thinking that promotes the balance between flexibility and uniformity.

5.4 Research Implications and Contributions

Based on previously discussed research findings, the present study offered several implications to lean management body of knowledge in the form of theoretical, practical and methodological contributions. Theoretical contribution explained how this study shed some light especially for lean researchers and operations management scholars in general to further understand the concept of lean transformation sustainability. Meanwhile, practical contribution highlighted how this study might assist organisational leaders to make the right decisions regarding lean transformation endeavour in their respective organisations. Lastly, methodological contribution demonstrated how the adopted research design and techniques of data analysis in this study were able to produce more generalisable and robust research findings compared to prior studies.

5.4.1 Theoretical Contributions

Theoretical contributions of an academic research are established when its findings have successfully addressed theoretical research gaps found in the literature of a particular research area. According to Quoquab and Mohammad (2018), typical theoretical research gaps may include;

1. conceptualising a variable from different perspective,
2. introducing different facets of a variable, and
3. searching for new relationships in a phenomenon of interest.

In this sense, all three forms of theoretical gaps were successfully addressed in the present study.

Conceptualising Lean Transformation Sustainability from Different Perspective.

This theoretical contribution was established by introducing an all-inclusive conceptual definition of lean transformation sustainability (LTS). This newly introduced definition resolved confusion and ambiguous interpretations of this concept. As a result of providing a clear and comprehensive meaning on LTS, the present study shed some light on how to operationalise and objectively measure the concept. Most previous studies had measured this concept in a subjective manner (using qualitative data) through episodes of reviews, observations and interviews. Hence, factors or themes generated from their findings were mostly either too broad or too narrow to measure and sometimes overlapped because no exact operational definition was introduced to uniquely distinguish each factor. On that account, the present study had remapped and reconceptualised factors and themes extracted from qualitative findings and proposed four unique variables namely; 1. Sustainable Gains, 2. Lean Tools Adoption Maturity, 3. Lean Leadership and 4. Lean Culture to objectively assess LTS concept. Each variable was also conceptualised differently from majority of previous studies to suit the context of the present study and overcome some limitations in the existing measurement. For instance, while most existing studies only included the magnitude of lean tools and techniques adoption as a proxy to measure lean transformation level, the present study combined magnitude, extensiveness, and experience of organisations in lean adoption for that purpose. Magnitude, extensiveness, and experience of organisations in lean adoption formed a new variable called Lean Tools Adoption Maturity. This study therefore seems to be one of the pioneer quantitative studies that

translated lean transformation into lean maturity level, besides Galeazzo (2019), Santos Bento and Tontini (2019) and Mousavi et al. (2020). Moreover, after a vast literature search it seemed that this was the earliest study to operationalised The Toyota Way of Lean Leadership (Liker & Convis, 2012) into set of measurement items and empirically validated it. Other prior studies either adopted Dombrowski and Mielke's (2014) Lean Leadership rules to generate measurement items (Mulders, 2016) or developed their own items (Nooraei Ashtiani, 2016). This study also was one of very few quantitative studies that viewed Lean Culture as a gap of current organisational culture from the culture that is truly aligned with lean thinking. Others had perceived Lean Culture as certain types of cultural profile that influence organisations to successfully adopt lean transformation (Antomarioni et al., 2019; Bortolotti et al., 2015; Cadden et al., 2020; Hardcopf et al., 2021; Pakdil & Leonard, 2015).

Introducing Different Facets of Lean Transformation Gains. The second theoretical contribution was established by validating the measurement of sustainable lean transformation gains that used both tangible and intangible indicators. Majority of prior studies measured lean transformation gains solely based on tangible indicators such as operational performance, financial performance or business performance. On the contrary, the present study added a new facet namely continuous improvement capability to represent intangible indicator in measuring lean transformation gains. Combining continuous improvement capability with operational and business performance to form a new higher order construct named as Sustainable Gains creates a balance and synergy in assessing the sustainability of lean transformation initiatives. The results of statistical validation through convergent and discriminant validity tests confirmed the balance and synergy between tangible and intangible indicators as

hypothetically assumed. A balanced and synergised lean assessment tool is deemed practical and holistic to evaluate its sustainability (Burch, 2008; Jørgensen et al., 2007). The combination of tangible and intangible indicators for measuring lean transformation gains was also backed up by the concept of sustainable organisational change (Buchanan et al., 2005) and integration of Theory E and Theory O (Beer & Nohria, 2000b). To the best of the researcher's knowledge and supported with extensive literature reviews, this study was among one of the first studies that integrates both tangible and intangible indicators to measure the gains made from lean transformation initiatives in the context of manufacturing sector, particularly in Malaysia.

Established New Relationships to Further Explain LTS Concept. The third theoretical contribution of this study lies in its success to explain relationships between persistent gains made from lean transformation initiatives (Sustainable Gains) and its contributing factors (Lean Tools Adoption Maturity, Lean Leadership and Lean Culture) which remain uncertain in previous studies. A total of four variables were assigned into respective roles as the following; dependent (Sustainable Gains), independent (Lean Tools Adoption Maturity) and mediator (Lean Leadership and Lean Culture). The present study then produced empirical evidences that verified every role assigned to each variable based on statistical estimation. The inconsistent impact of lean transformation (measured by Lean Tools Adoption Maturity) on persistent performance levels (measured by Sustainable Gains) were successfully explained by the intervention (indirect effect) of human roles. Human roles (i.e., Lean Leadership and Lean Culture) intervene and become bridges that connect applications of lean tools and techniques with organisation's ability to persistently achieve performance gains. Together, these variables and their inter-relations formed a conceptual model that

serves as a foundation for future researchers to determine the sustainability of lean transformation in other context such as healthcare, education or construction. In this regard, the present study had exposed an interesting theoretical linkage by proving the mediating role of Lean Leadership and Lean Culture with the integration of tangible and intangible gains as the dependent variable. The contribution of this present study offers particular theoretical implications for lean researchers who have so far, overlooked the intangible gains and the mediating role of human factors, and for lean practitioners wherein have ignored the important components (intangible gains) and necessary resources (human interventions) to establish a sustainable lean system. Finally, this study also contributed to the literature on lean transformation sustainability by providing Malaysia's perspective on this phenomenon of interest which addressed the contextual gap.

5.4.2 Practical Contributions

The findings of this study also contributed to lean practitioners in manufacturing sector, particularly for organisational leaders who are in-charge of leading lean transformation projects. This study provides a meaningful insight for lean leaders to acquire a better understanding and learn the best practices on how to sustain lean transformation. Accordingly, the practical contributions of this study were presented and explained in the following points.

Alert the Importance of Measuring Intangible Gains. The output of this study is expected to alert lean practitioners on the importance of measuring intangible gains to evaluate the outcome of lean transformation. By presenting valid and reliable results produced using a series of robust statistical tests, it is legit to advise lean practitioners

to not just concentrate on tangible gains but also seriously consider intangible gains. Monitoring intangible gains such as continuous improvement capability encourages lean organisations to always search for new opportunities for improvement (Burch, 2008; Jørgensen et al., 2007). The continuous search for improvement opportunities ignites sense of urgency that directs lean organisations to move out from comfort zone to learning zone (Flinchbaugh et al., 2008; Hines et al., 2011). As quoted by P.T. Barnum, an American business figure, comfort is the enemy of progress.

Highlight the Role of Human Interventions in Sustaining Lean Transformation.

The present study also provided hard evidences to lean practitioners that it requires more than just intensive applications of lean tools and techniques to acquire continuous and sustainable gains from lean transformation. They should consider human interventions by practising lean leadership principles and building a lean organisational culture to stay lean and keep harvesting its benefits. Hence, by proving that adoption of lean leadership principles and formation of lean culture truly contribute towards achieving sustainable gains, this study might assist lean practitioners to verify their strategies and resource allocations in steering the lean transformation initiatives in their organisations. Such positive evidences might also make lean practitioners more confidence in their decision to further advance their lean transformation journey.

Prevent False Assessment of Lean Transformation Progress. Another practical contribution of this study stems for providing a valid and reliable empirical evidence on how to properly measure lean transformation progress. While majority of previous studies solely focused on measuring the magnitude (completeness) of lean tools and techniques application to indicate lean transformation progress, the present study

promotes a broader alternative. Two additional criteria namely; extensiveness (variety) and experience (duration) need to be included to establish accurate measures of lean transformation progress or lean adoption level. Together, magnitude (completeness), extensiveness (variety) and experience (duration) criteria form a construct called Lean Tools Adoption Maturity. This alternative is consistent to Galeazzo's (2019) notion that claimed focus on narrow (single) criteria to measure organisation's lean adoption level leads to false assessment. This notion is further supported by lean transformation failure statistics reported from real scenario in manufacturing industries (Costa et al., 2019; Madsen et al., 2019; Pearce & Pons, 2019). Therefore, by exposing lean practitioners with lean maturity criteria, it would prevent them from making false assessments regarding lean transformation progress in their organisations.

Identify Critical Factor that Needs Attention. Based on Importance-Performance Analysis (IPMA) as reported in 4.8.6, every variable being studied demonstrated a fair importance in the prediction of Sustainable Gains acquired from lean transformation initiatives. Formation of Lean Culture contributed the most in the prediction of Sustainable Gains (34%). Adoption of Lean Leadership principles also plays an important role with only a slightly lower percentage (33%) than Lean Culture. A low total effect demonstrated by Lean Tools Adoption Maturity (14%) implying that the impact of Lean Tools Adoption Maturity on Sustainable Gains totally relied on the formation of Lean Culture and adoption of Lean Leadership principles. Without the existence of these two variables, lean transformation initiatives hardly achieve a persistent performance level. In addition, each variable was yet to reach its maximum performance, suggesting that there are still rooms for improvement. Over 100% performance, Lean Leadership was at 61%, followed by Lean Culture (58%) and Lean

Tools Adoption Maturity (51%). These performance levels represent to what extent the sample organisations had invested or focusing their efforts on practising these variables. By increasing the performance of each respective variable, the effectiveness of these variables in sustaining gains acquired from lean transformation are also expected to increase. On that account, lean practitioners should consider improving the performance of all three variables (i.e., Lean Tools Adoption Maturity, Lean Leadership and Lean Culture) in order to achieve Sustainable Gains (i.e., persistent performance level).

Promote the Survival of Local Manufacturing Business. Finally, it is hoped that the output from this study is able to assist local manufacturing organisations to stay in business especially during tough times like recent COVID-19 global outbreak. The successful and sustainable lean transformation will eventually lead to the survival of a manufacturing company (Pentlicki, 2014). This is due to the fact that lean transformation initiative was the reason behind Toyota Motor Manufacturing (TMM) revival post WWII and its survival during 1973 global oil crisis (Shah & Ward, 2007). During these hard times, TMM had managed to reduce waste and sustain in the environment of limited resources by truly embracing the lean thinking. Therefore, the same implication is anticipated for local manufacturing business by taking lessons from this study research findings.

5.4.3 Methodological Contributions

Methodological contributions of an academic research are established when its findings have managed to address methodological gaps found in the literature of a specific phenomenon of interest. Common methodological gaps are including;

1. using different methods (research design) to investigate the phenomenon of interest,
2. validating a measurement scale (questionnaire items), and
3. gathering research data from multiple sources (Quoquab & Mohammad, 2018).

Thus, this section discussed methodological contributions accordingly.

Using Survey Design and Quantitative Data to Investigate LTS Concept. While most conducted studies on LTS used case study design and qualitative data, this study managed to investigate LTS using mass survey that produced quantitative data. In comparison to qualitative data, quantitative data enhanced generalisation of research findings to larger samples (Creswell & Creswell, 2018; Zikmund et al., 2013). By enhancing generalisation of the research findings, the present study fulfilled one of the eight hallmarks of a scientific research. Hallmarks are distinguishing characteristics that certified a research has been conducted following scientific procedures (Sekaran & Bougie, 2016). Moreover, quantitative data provides tangible statistical evidence needed for consulting lean practitioners and addressing their critiques. The tangible evidences that are generated based on significant data sets would also aid in adjusting any misunderstandings related to lean transformation benefits and impact or how it should be employed (Pearce & Pons, 2019).

Validating Measurement Scales for Higher Order Constructs. Albeit all variables being studied were measured using existing measurement scales, the present study contributed to the methodological advancement by combining and validating the variables as higher order constructs. Specifically, the dependent variable namely Sustainable Gains is the combination of operational performance, business performance

and continuous improvement capability. The measurement scales for operational and business performance were adapted from Jayaraman et al. (2012), while continuous improvement capability items were adapted from Gaiardelli et al. (2019). Together, the three variables were combined to form a higher order construct called Sustainable Gains. The same concept combination was applied to Lean Leadership construct. Lean Leadership measurement scales were formed from the combination of four separate scales namely strategy deployment, self-development, support for daily improvement and coach and develop subordinates. Strategy deployment measurement scales were adapted from strategic alignment items (Galeazzo et al., 2017) and manufacturing strategy integration items (Narasimhan et al., 2006). Meanwhile, self-development measurement scales were adapted from K. B. Stone (2012b) and van Assen (2016a), support for daily improvement were adapted from top management support items by Beraldin et al. (2019). Finally, coach and develop subordinates measurement scales were also adapted from Beraldin et al. (2019). Combining several variables into a single variable that reflects a more abstract higher-level concept is called Hierarchical Component Modelling (HCM) (Becker et al., 2012). The used of HCM help to reduce the number of path model relationships, thereby achieving model parsimony (Sarstedt et al., 2019). On that account, the present study satisfied another hallmark of a scientific research known as parsimony. Parsimony is simplicity in explaining the phenomenon of interest or in generating solutions for the problems. A parsimony research model is always preferred over a complex one with unmanageable number of variables (Sekaran & Bougie, 2016).

Gathering Research Data from Multiple Sources. Although research data used in this study was obtained from a single source (i.e., person in charge of lean

transformation projects in manufacturing organisations), some precautions in dealing with its drawbacks were taken. One of the major drawbacks of single source data is the possibility of producing a bias called common method variance (CMV) (Podsakoff & Organ, 1986). Controlling and reducing CMV can also be regarded as a part of methodological contribution because many recent survey studies in the lean transformation literature still neglected it (Cadden et al., 2020; De La Vega et al., 2020; El Khalil, 2018; Hernandez-Matias et al., 2020; Khalfallah & Lakhal, 2021; Mahmoudi & Bagheri Majd, 2021; Mousavi et al., 2020; Ruben, Vinodh, & Asokan, 2020; Shafiq & Soratana, 2020; Susanty et al., 2021; Valente et al., 2020). Procedural remedies including proximal separation and mixed-scale properties as reported in 3.6.1 were employed to control CMV. In addition, a statistical remedy namely full collinearity test was also performed and reported to confirm that CMV had been successfully controlled (refer sub-chapter 4.6). Besides CMV, a series of robustness tests embedded in SmartPLS were conducted to deal with other statistical modelling issues that include measurement misspecification, nonlinearity effect and unobserved heterogeneity as reported in 4.7.4, 4.9.1 and 4.9.2 respectively. Thus, it can be concluded that instead of gathering data from multiple resources, the present study contributes to the methodological advancement by applying underutilised statistical techniques to ensure the robustness and stability of the research findings.

5.5 Limitations and Recommendations for Future Research

Despite various contributions from multiple aspects (i.e., theoretical, practical and methodological), the present study still subjected to some limitations. Nevertheless, the limitations of this study allowed the identification of interesting future research opportunities.

No Official and Complete Sampling Frame is Currently Available. The primary limitation realised in the present study is the absence of complete sampling frame that harbouring the list of all lean manufacturers in Malaysia. This sampling frame limitation led to other consequence setbacks. Unlike ISO certified organisations, there is no official lean-certified organisations' list that can be found for Malaysia population. Even the largest and most reputed business organisation contacts known as FMM directory also does not certainly specify whether the listed organisations are lean practitioners or not. Alternatively, a self-compiled directory based on the list of participants in MPC's LEAN Transformation Program and Assessment was used in this study. Unfortunately, only 213 manufacturing organisations are listed in this directory. Hence, the size of accessible population was relatively small ($N = 213$). As a consequence, the number of samples that the researcher managed to obtain were also limited.

Small Sample Size. The samples in this study composed of 92 organisations with the statistical power of 87.6%. Therefore, larger samples are needed to reach higher statistical power. The researcher experienced difficulty in convincing a larger number of organisations to participate and could not cover the entire manufacturing sector in Malaysia due to a lack of time and interest from many organisations, plus the fact that some organisations did not fit the criteria (i.e., no longer pursuing lean transformation journey). Their lack of interest to participate mostly due to after-effects of COVID-19 outbreak and long episodes of MCO. Nevertheless, small sample size is one of the common limitations found in the lean transformation survey studies (Al Najem, Garza-Reyes, & El Melegy, 2019; Galeazzo, 2019; Jenei et al., 2014; K. B. Stone, 2012b).

Limited Generalisability. The small sampling frame also limits the generalisation of the research findings. The generalisability of the current findings was limited only to MPC's LEAN Transformation Program and Assessment participating organisations. Despite there are possible commonalities between all lean practitioners in Malaysia, caution must be exercised in generalising the results beyond the accessible population. Although the findings are not meant to be generalised nationwide, the present study still serves as a good pioneer attempt to empirically investigate LTS concept from the Malaysian manufacturers' perspectives. In fact, the self-compiled directory used in the present study does include manufacturing organisations from all states across the country including Sabah and Sarawak. Hence, future studies could attempt to enlarge the sampling frame by combining lean manufacturer's directory from multiple sources (e.g., MPC, MARii, Jobstreet vacancy ads, PROTON and PERODUA suppliers' lists), increasing the number of organisations in the accessible population. Still, the present study offered a better theory generalisation on LTS when compared to previous studies that are mostly reported qualitative findings. This study also could be a stepping stone for researchers in coping with the limited quantitative studies on LTS globally. Taking this fact into consideration, future research could test the proposed research model of this study in different countries. Replicating the study in different countries would support the inference of more generalisable results (Iranmanesh et al., 2019; Khaw, Zailani, Iranmanesh, & Heidari, 2019; Shashi et al., 2019; Tortorella, Giglio, & van Dun, 2019) and allow future researchers to examine similarities and distinctions between different settings (Beraldin et al., 2019).

Cross-sectional Evidence. As the study was cross-sectional, caution is required in interpreting the causal findings, especially for mediating effects. Even so, the majority

of recent lean transformation studies still report cross-sectional data (Cadden et al., 2020; Habidin et al., 2020; Khalfallah & Lakhal, 2021; Mousavi et al., 2020; Sahoo, 2021; Susanty et al., 2021). In fact, survey methodologists also support the causal reasoning of cross-sectional evidence for mediating effects (Preacher & Hayes, 2004; Salthouse, 2011). Yet, future longitudinal study would add interesting findings on this phenomenon of interest. A longitudinal study may capture the dynamic nature of lean maturity and provide a better picture of how it will affect sustainable gains after certain extended period. Although this approach was not feasible in the present study, the researcher invites others to determine the speculated outcomes based on longitudinal data collection.

Imbalanced Distribution of Organisation's Characteristics. Finally, because the present study did not have a balance distribution of all characteristics in the sampled organisations, the analysis of demographic effects was not possible. For instance, most respondents were representing locally-owned business. Less than 10% represented multinational or joint-venture businesses. Thus, analysing the effect of business ownership was not feasible. Regarding the size of organisations, a similar situation was observed. Approximately 61% of the valid samples were small-sized businesses, while there was only 11 % of large-sized businesses. Hence, any inferential statistical procedure could not be performed. The same limitation applies to other organisational characteristics, such as industry classifications and types of production processes. Unfortunately, due to sample limitations, there were not enough degrees of freedom for any additional analysis of these variables. Thus, future studies could enlarge the study sample to provide a wider variety of respondents' characteristics, allowing the

identification of the investigated relationships in a broader spectrum of organisational contexts.

Other Recommendations. As the present study had examined lean leadership and lean culture as higher order constructs with multiple dimensions, further studies could analyse the individual effect of each of these dimensions on sustainable gains. This further investigation is important to understand how exactly lean leadership or lean culture affect organisation's ability to persistently achieve desired performance level. For instance, does lean leader's self-development has the most effect on sustainable gain, or sustainable gains are highly influenced by strategy deployment? Another positive avenue for future research involves investigating the role of reward system in sustaining gains acquired from lean transformation. Reward system was often highlighted as a mechanism that support the establishment of lean culture that is necessary for sustaining lean transformation in previous qualitative studies (Hines et al., 2011; Jørgensen et al., 2007; Nooraei Ashtiani, 2016; Rentes et al., 2009; Sisson & Elshennawy, 2015). In fact, the role of reward system to reinforce organisational change was also supported by change management theories (Beer & Nohria, 2000a). Thus, this preliminary information is adequate to develop a testable hypothesis for further investigation.

5.6 Summary of the Chapter

In summary, this chapter reported that all proposed research objectives were successfully accomplished and further highlighted the following important findings (see Table 5.2).

Table 5.2
Summary of research findings

Items	Statements	Remarks
RQ1	Is there a positive relationship between lean tools adoption maturity and sustainable lean transformation gains?	Answered
RO1	To determine the relationship between lean tools adoption maturity and sustainable lean transformation gains.	Achieved
H1	Lean tools adoption maturity has a positive influence on sustainable gains.	Not accepted
Findings	lean tools adoption maturity does not influence sustainable gains.	No direct relationship
RQ2	Does lean leadership mediate the relationship between lean tools adoption maturity and sustainable lean transformation gains?	Answered
RO2	To investigate the mediating effect of lean leadership on the relationship between lean tools adoption maturity and sustainable lean transformation gains.	Achieved
H2	Lean leadership has a positive influence on sustainable gains.	Accepted
H4	Lean tools adoption maturity has a positive influence on lean leadership.	Accepted
H6	Lean leadership mediates the relationship between lean tools adoption maturity and sustainable gains.	Accepted
Findings	Lean leadership fully mediated the relationship between lean tools adoption maturity and sustainable gains.	Full mediating relationship
RQ3	Does lean culture mediate the relationship between lean tools adoption maturity and sustainable lean transformation gains?	Answered
RO3	To investigate the mediating effect of lean culture on the relationship between lean tools adoption maturity and sustainable lean transformation gains.	Achieved
H3	Lean culture has a positive influence on sustainable gains.	Accepted
H5	Lean tools adoption maturity has a positive influence on lean culture.	Accepted
H7	Lean culture mediates the relationship between lean tools adoption maturity and sustainable gains.	Accepted
Findings	Lean leadership fully mediated the relationship between lean tools adoption maturity and sustainable gains.	Full mediating relationship

In addition, this chapter highlighted three contributions from theoretical perspectives, five contributions towards lean practitioners and three implications that contributed to methodological advancement (see Table 5.3).

Table 5.3
Summary of research implications

Area	Contribution
Theory	1. Conceptualised lean transformation sustainability into four inter-related variables: i. Dependent variable: Sustainable gains ii. Independent variable: Lean tools adoption maturity iii. Mediator variable: Lean leadership iv. Mediator variable: Lean culture 2. Introduced different facets of lean transformation gains by combining operational and business performance (tangible gains) with continuous improvement capability (intangible gain). 3. Established indirect relationships between lean tools adoption maturity and sustainable gains through lean leadership and lean culture.
Practice	1. Alert lean practitioners on the importance of measuring intangible gains to evaluate the outcome of lean transformation. 2. Highlight the role of human interventions (practising lean leadership principles and forming lean organisational culture) in sustaining lean transformation. 3. Prevent false assessment of lean transformation progress by concurrently evaluate completeness (magnitude), extensiveness (variety) and experience (duration) of lean organisations in applying lean tools and techniques. 4. Identify lean tools adoption maturity, lean culture and lean leadership as critical factors to achieve sustainable lean transformation gains. 5. Promote the survival of local manufacturing business by embracing lean thinking and sustaining lean transformation initiative.
Methodology	1. Using survey design and quantitative data to investigate the concept of lean transformation sustainability. 2. Validating measurement scales of sustainable gains and lean leadership as higher order constructs. 3. Addressing the issue of common method variance and applying underutilised statistical techniques to ensure the robustness and stability of the research findings.

This chapter also discussed five limitations that were realised in the present study and paired the limitations with opportunities to improve the study in the future (see Table 5.4).

Table 5.4

Summary of limitations and future research opportunities

No.	Limitations	Future research opportunities
1	The absence of complete sampling frame that harbouring the list of all lean manufacturers in Malaysia	Expand the current sampling frame by combining directories from multiple sources such as MPC, MARii, Jobstreet vacancy ads, PROTON and PERODUA suppliers' lists.
2	Small sample size	
3	Limited generalisability	Conduct replication studies: Test the proposed Lean Transformation Sustainability Model in different countries.
4	Cross-sectional evidence	Conduct longitudinal study
5	Imbalanced distribution of organisation's characteristics in the samples obtained.	Enlarge the study sample to provide a wider variety of respondents' characteristics, allowing the identification of the investigated relationships in a broader spectrum of organisational contexts.

Finally, two additional research opportunities were recommended in an effort to encourage future researchers to extend current knowledge on lean transformation sustainability. The recommendations were including:

1. Analyse the individual effect of lean leadership dimensions or lean culture dimensions on sustainable gains.
2. Investigate the role of reward system in sustaining gains acquired from lean transformation.

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APPENDICES

Appendix A: Lean Transformation Sustainability publications

SOURCE	RESEARCH OBJECTIVES				RESEARCH DESIGNS				
	Contributing Factors	Models / Frameworks Development	Relationship between Variables	Sustainability / Maturity Assessment	Single-Case Study	Multiple-Case Study	Survey Studies	Conceptual Papers	Experts' Viewpoint / Experience
1		X			X				
2		X			X				
3		X						X	
4		X			X				
5	X				X				
6		X	X					X	
7	X								X
8	X								X
9	X								X
10		X						X	
11		X				X			
12	X	X	X			X	X		
13	X				X				
14	X					X			
15	X				X				
16	X					X			
17	X	X				X			
18	X				X				
19	X				X				
20	X						X		
21	X				X				
22				X	X				
23	X	X	X		X				
24	X	X	X		X				
25	X				X				
26				X	X				
27	X				X				
28	X								X
29		X	X					X	
30		X			X				

SOURCE	RESEARCH OBJECTIVES				RESEARCH DESIGNS				
	Contributing Factors	Models / Frameworks Development	Relationship between Variables	Sustainability / Maturity Assessment	Single-Case Study	Multiple-Case Study	Survey Studies	Conceptual Papers	Experts' Viewpoint / Experience
31	X					X			
32	X					X			
33									X
34		X	X				X		
35		X		X	X				
36								X	
37	X	X	X				X		
38			X					X	
39	X				X				
40		X	X					X	
41	X	X			X				
42		X		X		X			
43		X		X	X				
44	X			X				X	
45					X				
46			X	X			X		
47		X					X		
48	X	X			X				
49	X	X	X				X		
50				X				X	
51	X					X			
52	X								X
53	X							X	
54	X			X	X				
55			X				X		
56		X				X			
57		X	X					X	
58				X				X	
59	X					X			
60				X				X	

SOURCE	RESEARCH OBJECTIVES				RESEARCH DESIGNS			
	Contributing Factors	Models / Frameworks Development	Relationship between Variables	Sustainability / Maturity Assessment	Single-Case Study	Survey Studies	Conceptual Papers	Experts' Viewpoint / Experience
61		X		X	X			
62	X		X					X
63		X	X			X		
64		X	X	X	X			
65		X	X				X	
66	X		X			X		
67		X					X	
68	X					X		
69		X	X				X	
70	X				X			
71	X	X	X			X		
72		X	X	X		X		
73	X					X		
74	X	X	X			X		
75			X					X
76			X			X		
77	X						X	
78						X		
79	X	X			X			
80		X	X			X		
81				X	X			
82							X	
83		X				X		
84	X	X			X			
85	X					X		
86		X	X			X		
87		X	X			X		
88		X		X	X			
89				X				X
90		X		X	X			
Σ	43	42	27	19	31	15 18	18	9

Source: 1. Popoola (2000), 2. Nightingale and Mize (2002), 3. Mann (2003), 4. Drew et al. (2004), 5. Lucey et al. (2004), 6. Veech (2004), 7. Lucey et al. (2005), 8. Wood (2005), 9. Alukal (2006b), 10. Found et al. (2006), 11. Jørgensen et al. (2007), 12. Burch (2008), 13. Connell

(2008), 14. Lean Learning Center (2008), 15. Hogan (2009), 16. Mann (2009), 17. Murti (2009), 18. Rentes et al. (2009), 19. Schlichting (2009), 20. Tracey and Flinchbaugh (2009), 21. Hines (2010), 22. Lyonnet et al. (2010), 23. Ramakrishnan and Testani (2010), 24. Testani and Ramakrishnan (2010), 25. Turesky and Connell (2010), 26. Bhasin (2011), 27. Hines et al. (2011), 28. Miller (2011), 29. Mohd-Zainal et al. (2011), 30. Nightingale and Srinivasan (2011), 31. Roth (2011), 32. Ruffa (2011), 33. Gregory (2012), 34. K. B. Stone (2012b), 35. W. P. Wong et al. (2012), 36. Ahmed Soliman (2013), 37. Glover et al. (2013), 38. L. G. Jones (2013), 39. Maalouf (2013), 40. Habidin et al. (2013), 41. Taylor et al. (2013), 42. Van Landeghem et al. (2013), 43. Ahmed Soliman and Gadalla (2014), 44. Dombrowski and Mielke (2014), 45. Hallam and Keating (2014), 46. Iris and Cebeci (2014), 47. Jadhav et al. (2014), 48. Marchwinski (2014), 49. Marshall (2014), 50. Pakdil and Leonard (2014), 51. Pentlicki (2014), 52. Remy (2014), 53. Tenescu and Teodorescu (2014), 54. Tortorella and Fogliatto (2014), 55. Larteb et al. (2015), 56. Mann (2015), 57. Pakdil and Leonard (2015), 58. Schröders and Cruz-Machado (2015), 59. Sisson and Elshennawy (2015), 60. Urban (2015), 61. Maasouman and Demirli (2016), 62. Mohd Yusof and Aoki (2016), 63. Nooraei Ashtiani (2016), 64. Setianto and Haddud (2016), 65. Pakdil and Leonard (2017), 66. Vance (2017), 67. Al Manei et al. (2018), 68. Grigg et al. (2018), 69. Hallam et al. (2018), 70. Poksinska and Swartling (2018), 71. Sahoo and Yadav (2018), 72. Santos Bento and Tontini (2018), 73. Van Landeghem et al. (2018), 74. Chiarini and Brunetti (2019), 75. Costa et al. (2019), 76. Galeazzo (2019), 77. Kok et al. (2019), 78. Madsen et al. (2019), 79. Maginnis et al. (2019), 80. Santos Bento and Tontini (2019), 81. Sisson (2019), 82. Bhasin and Found (2020), 83. Devine and Bicheno (2020), 84. Gaspar and Leal (2020), 85. Gavilán and Consolación (2020), 86. Habidin et al. (2020), 87. Mousavi et al. (2020), 88. Rossini et al. (2020), 89. Silvério et al. (2020), 90. Zanon et al. (2020).



Appendix B: Content Validation Rubric

CONTENT VALIDATION RUBRIC

Name of researcher: AZIM AZUAN BIN OSMAN

Institute: School of Technology and Logistics Management, Universiti Utara Malaysia

Research topic: Lean Transformation Sustainability in Malaysia Manufacturing Sector

Name of reviewer:	
Title (if any):	
Position:	
Organisation & Department:	
Industrial/ Academia experience (years):	
Date of review:	

INTRODUCTION

This content validation rubric is employed according to the standard provided by The American Educational Research Association, American Psychological Association, and National Council on Measurement in Education (2014) for content validation purpose. The survey questionnaire comprises set of items for measuring FOUR main variables, namely (1) Sustainable Gains, (2) Lean Maturity, (3) Lean Leadership, and (4) Lean Culture. In addition, a checklist of Lean Building Blocks is included as auxiliary questions to guide respondents for answering Lean Maturity questions. There is also ONE section of general information about the respondents' companies.

All variables are measured as MULTIDIMENSIONAL constructs (except Lean Maturity), according to respective dimensions as the following:

Main Variables	Dimensions
Sustainable Gains	1. Operational Performance (SOP) 2. Business Performance (SBP) 3. Continuous Improvement (SCI)
Lean Maturity	NA
Lean Leadership	1. Self-Development (LLD) 2. Support for Daily Improvement (LLI) 3. Coach and Develop Subordinates (LLC) 4. Strategy Deployment (LLS)
Lean Culture	1. Positive Working Environment (LCE) 2. Effective Communications (LCC) 3. Teamwork (LCT) 4. Problem Solving (LCP) 5. Innovation (LCI)

CONTENT VALIDATION RUBRIC

Different scale properties (5-point Likert, 6-point Likert, and 7 interval scales) are proposed as a way to prevent common method bias in the measurement scales (Podsakoff, MacKenzie, & Podsakoff, 2012). Besides that, this survey instrument is organised by placing items for measuring each construct in different pages to provide proximal separation which is another way to prevent common method bias.

Single item questions (GLOBAL ITEM) are also included in this survey instrument to prepare for REDUNDANCY ANALYSIS (i.e., LM04, GLT, GLL, and GLC). Redundancy analysis is a statistical technique to test convergent validity of FORMATIVE constructs (Hair, Hult, Ringle, & Sarstedt, 2017). In this study, all main variables are designed as multidimensional constructs (hierarchical component model - HCM). Most structural model scholars (Ringle, Sarstedt, & Straub, 2012; Sarstedt, Hair, Cheah, Becker, & Ringle, 2019) recommend researchers to design a REFLECTIVE-FORMATIVE (Type II) HCM. Thus, global item measures need to be included in the survey questionnaire as a precaution.



CONTENT VALIDATION RUBRIC

Instruction: Please rate the level of **representativeness** and **clarity** of item in measuring the aligned overarching construct on a scale of 1 to 4 as the following:

Representativeness scale:

NOT representative	Needs MAJOR revision	Needs MINOR revision	MOST representative
1	2	3	4

Clarity scale:

NOT clear	Needs MAJOR revision	Needs MINOR revision	VERY clear
1	2	3	4

Note. Please refer the related **list of items** attached in the separate pages.

Construct: Lean Building Blocks

Items	Representativeness				Clarity			
	1	2	3	4	1	2	3	4
LBB01								
LBB02								
LBB03								
LBB04								
LBB05								
LBB06								
LBB07								
LBB08								
LBB09								
LBB10								
LBB11								
LBB12								
LBB13								
LBB14								

Additional comments: _____

CONTENT VALIDATION RUBRIC

Construct: Lean Maturity

Items	Representativeness				Clarity			
	1	2	3	4	1	2	3	4
LM01								
LM02								
LM03								
LMG								

Additional comments:

Construct: Sustainable Gains (Operational Performance)

Items	Representativeness				Clarity			
	1	2	3	4	1	2	3	4
SOP01								
SOP02								
SOP03								
SOP04								
SOP05								
SOP06								
SOP07								
SOP08								

Additional comments:

CONTENT VALIDATION RUBRIC

Construct: Sustainable Gains (Business Performance)

Items	Representativeness				Clarity			
	1	2	3	4	1	2	3	4
SBP01								
SBP02								
SBP03								
SBP04								
SBP05								
SBP06								

Additional comments:

Construct: Sustainable Gains (Continuous Improvement)

Items	Representativeness				Clarity			
	1	2	3	4	1	2	3	4
SCI01								
SCI02								
SCI03								
SCI04								
SCI05								
SCI06								
SCI07								
SGG								

Additional comments:

CONTENT VALIDATION RUBRIC

Construct: Lean Leadership (Self-Development)

Items	Representativeness				Clarity			
	1	2	3	4	1	2	3	4
LLD01								
LLD02								
LLD03								
LLD04								
LLD05								
LLD06								

Additional comments:

Construct: Lean Leadership (Coach and Develop Subordinates)

Items	Representativeness				Clarity			
	1	2	3	4	1	2	3	4
LLC01								
LLC02								
LLC03								
LLC04								
LLC05								
LLC06								
LLC07								
LLC08								
LLG								

Additional comments:

CONTENT VALIDATION RUBRIC

Construct: Lean Leadership (Support for Daily Improvement)

Items	Representativeness				Clarity			
	1	2	3	4	1	2	3	4
LLI01								
LLI02								
LLI03								
LLI04								
LLI05								
LLI06								
LLI07								

Additional comments:

Construct: Lean Leadership (Strategy Deployment)

Items	Representativeness				Clarity			
	1	2	3	4	1	2	3	4
LLS01								
LLS02								
LLS03								
LLS04								
LLS05								
LLS06								
LLS07								
LLS08								
LLS09								
LLS10								

Additional comments:

CONTENT VALIDATION RUBRIC

Construct: Lean Culture (Positive Work Environment)

Items	Representativeness				Clarity			
	1	2	3	4	1	2	3	4
LCE01								
LCE02								
LCE03								
LCE04								
LCE05								
LCE06								
LCE07								

Additional comments:

Construct: Lean Culture (Effective Communications)

Items	Representativeness				Clarity			
	1	2	3	4	1	2	3	4
LCC01								
LCC02								
LCC03								
LCC04								
LCC05								
LCC06								
LCC07								
LCC08								

Additional comments:

CONTENT VALIDATION RUBRIC

Construct: Lean Culture (Teamwork)

Items	Representativeness				Clarity			
	1	2	3	4	1	2	3	4
LCT01								
LCT02								
LCT03								
LCT04								
LCT05								
LCT06								
LCT07								

Additional comments:

Construct: Lean Culture (Problem Solving)

Items	Representativeness				Clarity			
	1	2	3	4	1	2	3	4
LCP01								
LCP02								
LCP03								
LCP04								
LCP05								
LCP06								
LCP07								
LCP08								

Additional comments:

CONTENT VALIDATION RUBRIC

Construct: Lean Culture (Innovation)

Items	Representativeness				Clarity			
	1	2	3	4	1	2	3	4
LCI01								
LCI02								
LCI03								
LCI04								
LCI05								
LCI06								
LCG								

Additional comments:



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CONTENT VALIDATION RUBRIC

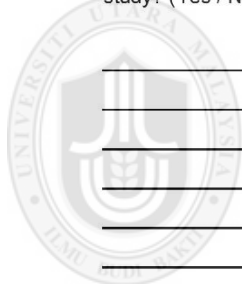
Concept of Lean Transformation Sustainability

1. How do you perceive lean transformation sustainability?
 - a. Organisation's ability to maintain the momentum of lean transformation over time or in the long-run. ☐
 - b. Organisation's ability to leverage lean principles to reduce waste of raw materials and energy consumption, and subsequently achieve triple bottom-line (i.e., environment, social, and economy sustainability) ☐

2. This study operationally defines **Lean Transformation Sustainability** as:

*Maintaining the momentum of lean transformation in organisation's production system while achieving persistent performance goals and having consistent direction towards continuous improvement. The **sustaining phase** begins once the lean pilot project is completed. **Lean pilot project** refers to the process of installing basic lean elements into the manufacturing system of an organisation. **Basic lean elements** are referring to lean practices, tools or techniques that require less investment and feasible to implement, even for SMEs.*

Do you agree with the definition of lean transformation sustainability used in this study? (Yes / No). If No, please share your opinion.



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CONTENT VALIDATION RUBRIC

3. There are two types of gains that can be considered as the results of lean transformation program (Burch, 2008; Jørgensen, Matthiesen, Nielsen, & Johansen, 2007):

- i. **Tangible gains:** Improvement in terms of technical perspective which reflects performance in relationship to organisation's strategic scope.
- ii. **Intangible gains:** Improvement in terms of human capabilities and organisational development.

Do you agree both tangible and intangible indicators should be considered to measure gains acquired from lean transformation program? (Yes / No). If No, please share your opinion.

4. What are the appropriate aspects to indicate sustainable gains acquired from the lean transformation? (Please select all that you think appropriate)

a. Operational Performance	Gains from internal operation of the company in terms of cost reduction, product quality improvement, flexibility enhancement, delivery performance, and productivity increment.	☐
b. Business Performance	Gains from financial aspects, such as revenue growth, net profits, return on assets and non-financial aspects, such as capacity to develop a competitive profile, new products, and market share.	☐
c. Continuous Improvement Capability	Competitive abilities that allow organisations to learn, innovate and renew.	☐

CONTENT VALIDATION RUBRIC

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Appendix C: Ratings of Questionnaire Items by Panel of Experts

Items for Lean Building Blocks

Item Code	Expert #1	Expert #2	Expert #3	Expert #4	Expert #5	Expert #6	Expert #7	n_r	Σn_a
LBB01	4	4	4	4	4	4	4	7	7
LBB02	4	4	4	4	4	4	4	7	7
LBB03	4	4	4	4	4	4	4	7	7
LBB04	4	4	4	4	4	4	4	7	7
LBB05	4	4	4	1	4	4	4	6	6
LBB06	4	4	4	4	4	4	4	7	7
LBB07	4	4	4	4	4	4	4	7	7
LBB08	4	4	4	4	4	4	4	7	7
LBB09	4	4	4	4	4	4	4	7	7
LBB10	4	4	4	3	4	4	4	6	7
LBB11	4	4	4	4	4	4	4	7	7
LBB12	4	4	4	4	4	4	4	7	7
LBB13	4	4	4	4	4	4	4	7	7
LBB14	4	4	4	2	4	4	4	6	6

Note. n_r = number of experts rated the item as “representative” (score 3 and 4). Σn_a = sum of individual item’s agreement

Items for Lean Tools Adoption Maturity

Item Code	Expert #1	Expert #2	Expert #3	Expert #4	Expert #5	Expert #6	Expert #7	n_r	Σn_a
LM01	4	4	4	4	4	3	4	7	6
LM02	4	4	3	4	4	4	4	7	6
LM03	4	4	4	4	4	4	4	7	7
LMG	4	4	4	4	4	3	4	7	6

Note. n_r = number of experts rated the item as “representative” (score 3 and 4). Σn_a = sum of individual item’s agreement

Items for Sustainable Gains

Item Code	Expert #1	Expert #2	Expert #3	Expert #4	Expert #5	Expert #6	Expert #7	n_r	Σn_a
SOP01	4	4	4	4	4	4	4	7	7
SOP02	4	4	3	2	4	4	4	6	6
SOP03	4	4	4	4	4	4	4	7	7
SOP04	4	4	4	4	4	4	4	7	7
SOP05	4	4	4	4	4	4	4	7	7
SOP06	4	4	4	4	4	4	4	7	7
SOP07	4	3	4	4	4	4	4	7	6
SOP08	4	4	4	4	4	4	4	7	7
SBP01	4	4	4	4	4	3	4	7	6
SBP02	4	4	4	4	4	3	4	7	6
SBP03	4	4	4	4	4	3	4	7	6
SBP04	4	4	4	4	4	3	4	7	6
SBP05	4	4	4	4	4	3	4	7	6
SBP06	4	4	4	4	4	3	4	7	6
SCI01	4	4	4	4	4	4	4	7	7
SCI02	4	4	4	4	2	4	4	6	6
SCI03	4	4	4	4	4	4	4	7	7
SCI04	4	4	4	3	2	4	4	6	5
SCI05	4	4	4	4	2	4	4	6	6
SCI06	4	4	4	3	2	4	4	6	5
SCI07	4	4	4	4	4	4	4	7	6

Note. n_r = number of experts rated the item as “representative” (score 3 and 4). Σn_a = sum of individual item’s agreement

Items for Lean Leadership

Item Code	Expert #1	Expert #2	Expert #3	Expert #4	Expert #5	Expert #6	Expert #7	n_r	Σn_a
LLS01	4	4	4	4	4	4	4	7	7
LLS02	4	4	4	4	4	4	4	7	7
LLS03	4	4	4	4	4	4	4	7	7
LLS04	4	4	4	4	4	4	4	7	7
LLS05	4	4	4	4	2	4	4	6	6
LLS06	4	4	4	4	2	4	4	6	6
LLS07	4	4	4	4	2	4	4	6	6
LLS08	4	4	4	4	4	4	4	7	7
LLS09	4	4	4	4	4	4	4	7	7
LLS10	4	4	4	4	4	4	4	7	7
LLD01	4	4	4	3	4	4	4	7	7
LLD02	4	3	4	4	4	4	4	6	7
LLD03	4	4	4	4	4	4	4	7	7
LLD04	4	4	4	4	4	4	4	7	7
LLD05	4	3	4	4	4	4	4	6	7
LLD06	4	4	4	4	4	4	4	7	7
LLI01	4	4	4	4	4	4	4	7	7
LLI02	4	4	4	4	2	4	4	6	6
LLI03	4	4	4	4	2	4	4	6	6
LLI04	4	4	4	4	2	4	4	6	6
LLI05	4	4	4	4	4	4	4	7	7
LLI06	4	4	4	4	2	3	4	6	5
LLI07	4	4	4	2	4	4	4	6	6
LLC01	4	4	4	4	4	4	4	7	7
LLC02	4	4	4	4	4	4	4	7	7
LLC03	4	4	4	4	4	4	4	7	7
LLC04	4	4	4	4	4	4	4	7	7
LLC05	4	4	4	4	4	4	4	7	7
LLC06	4	4	4	4	4	4	4	7	7
LLC07	4	4	4	4	4	4	4	7	7
LLC08	4	4	4	4	4	4	4	7	7

Note. n_r = number of experts rated the item as “representative” (score 3 and 4). Σn_a = sum of individual item’s agreement

Items for Lean Culture

Item Code	Expert #1	Expert #2	Expert #3	Expert #4	Expert #5	Expert #6	Expert #7	n_r	Σn_a
LCE01	4	4	4	4	4	4	4	7	7
LCE02	4	4	4	4	4	4	4	7	7
LCE03	4	4	4	3	4	4	4	7	6
LCE04	4	4	4	3	4	4	4	7	6
LCE05	4	4	4	4	4	4	4	7	7
LCE06	4	4	4	4	4	4	4	7	7
LCE07	4	4	4	4	4	4	4	7	7
LCC01	4	4	3	4	4	4	4	7	6
LCC02	4	4	4	4	4	4	4	7	7
LCC03	4	4	4	4	4	4	4	7	7
LCC04	4	4	4	4	4	4	4	7	7
LCC05	4	4	4	4	4	4	4	7	7
LCC06	4	4	4	4	4	4	4	7	7
LCC07	4	4	4	4	4	4	4	7	7
LCC08	4	4	4	4	4	4	4	7	7
LCT01	4	4	4	4	4	4	4	7	7
LCT02	4	4	4	4	4	4	4	7	7
LCT03	4	4	4	4	4	4	4	7	7
LCT04	4	4	4	4	4	4	4	7	7
LCT05	4	4	4	4	4	4	4	7	7
LCT06	4	4	4	3	4	4	4	7	6
LCT07	4	4	4	4	4	4	4	7	7
LCP01	4	4	4	4	4	4	4	7	7
LCP02	4	4	4	4	3	4	4	7	6
LCP03	4	4	4	4	4	4	4	7	7
LCP04	4	4	4	4	4	4	4	7	7
LCP05	4	4	4	4	4	4	4	7	7
LCP06	4	4	4	4	4	4	4	7	7
LCP07	4	4	4	3	4	4	4	7	6
LCP08	4	4	4	3	4	4	4	7	6
LCI01	4	4	4	3	2	4	4	6	5
LCI02	4	4	4	3	4	4	4	7	6
LCI03	4	4	4	4	2	4	4	6	6
LCI04	4	4	4	4	2	4	4	6	6
LCI05	4	4	4	4	2	4	4	6	6
LCI06	4	4	4	4	4	4	4	7	7

Note. n_r = number of experts rated the item as “representative” (score 3 and 4). Σn_a = sum of individual item’s agreement

Appendix D: Survey Questionnaire



Pusat Pengajian Pengurusan Teknologi dan Logistik

SCHOOL OF TECHNOLOGY MANAGEMENT AND LOGISTICS

Universiti Utara Malaysia

RESEARCH ON DETERMINANTS OF LEAN TRANSFORMATION SUSTAINABILITY IN MALAYSIA MANUFACTURING SECTOR

General Information:

This survey is a PhD research to identify the determinants of Lean Transformation Sustainability in Malaysia manufacturing sector. The researchers believe that the outcome of this research will be of immense benefit to sustain Lean Transformation effort among manufacturing companies in Malaysia. Your effort in filling the questionnaire is highly appreciated in order to produce a quality research. Your answer plays an important role in the success of this study and you are assured that such information will be treated with utmost confidentiality. The results will be used only for research purposes and no attempt will be made to identify any individuals or organizations in any publications.

General Instruction:

The questionnaire consists of five (5) sections. Please read the items carefully before answering. There is no right or wrong answer. Your answers are expected to be the best answer that represents your opinion. Where appropriate, tick in the box, circle the appropriate answer or complete the answer in the space provided. If there is any issue related to the questions, please do not hesitate to contact us. Thank you for your participation.

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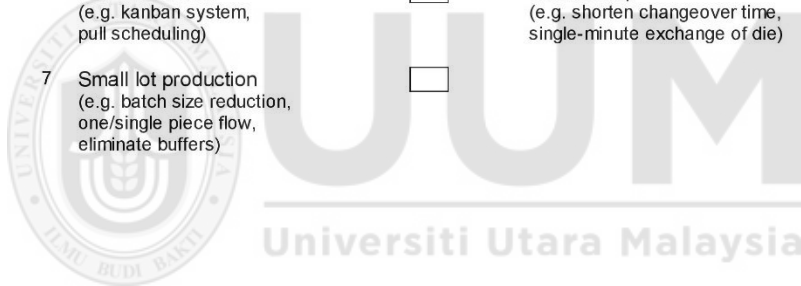
SECTION 1: LEAN MATURITY

LEAN BUILDING BLOCKS

Definition: LEAN building blocks refers to a set of LEAN tools and techniques which can be used by practitioners to introduce, improve and sustain the LEAN system in their organisation.

Instructions: What are the LEAN tools and techniques used in your organization? (Please tick all that apply)

1 Cross-functional teams	☐	8 5S / Workplace organisation	☐
2 <i>Heijunka</i> / Production Smoothing (e.g. line balancing, workload levelling, mixed-model manufacturing)	☐	9 Streamlined layout (e.g. U-shaped cells, group cellular manufacturing focused factory group technology)	☐
3 Visual control / Visual management (e.g. warning lights, notice boards)	☐	10 Standard work / Work standardisation	☐
4 Value Stream Mapping	☐	11 Total Productive Maintenance	☐
5 <i>Jidoka</i> / Autonomation (i.e. authority to halt / stop production)	☐	12 <i>Poka yoke</i> / mistake proofing / fool-proof techniques & tools	☐
6 Pull Production (e.g. kanban system, pull scheduling)	☐	13 Quick setup (e.g. shorten changeover time, single-minute exchange of die)	☐
7 Small lot production (e.g. batch size reduction, one/single piece flow, eliminate buffers)	☐		



SECTION 1: LEAN MATURITY

LEAN MATURITY

Definition: Lean maturity refers to how widely, how thoroughly, and how long LEAN is implemented in the organisation.

LM01: Please rate the current ADOPTION LEVEL of lean tools and techniques in your MANUFACTURING PLANT. Tick (✓) the appropriate box based on the following scale:

No implementation	Few implementation	Some implementation	Extensive implementation	Full implementation

LM02: Please rate HOW EXTENSIVE lean tools and techniques have been implemented in your MANUFACTURING PLANT. Tick (✓) the appropriate box based on the following scale:

In few manufacturing processes	In some manufacturing processes	In all manufacturing processes	In the entire manufacturing / production department	In the entire business functions (e.g. manufacturing, supply chain, human resource)

LM03: Please rate for HOW LONG lean tools and techniques have been implemented in your MANUFACTURING PLANT. Tick (✓) the appropriate box based on the following scale:

Less than 2 years	2 to 3 years	3 to 4 years	4 to 5 years	More than 5 years

LM04: Overall, how do you rate the level of LEAN maturity in your manufacturing plant?

Low Maturity	1	2	3	4	5	6	7	High Maturity

*Circle/ highlight the appropriate score

SECTION 2: SUSTAINABLE GAINS

OPERATIONAL PERFORMANCE

Definition: Reflects the performance of internal operation of the company in terms of cost reduction, product quality improvement, flexibility enhancement, delivery performance, and productivity increment.

Instruction: Please indicate below how the following operational performance indicators evolved in the last THREE YEARS in your MANUFACTURING PLANT. Tick (/) the appropriate box based on the following scale:

Significant decrease	Moderate decrease	Little or No change	Moderate increase	Significant increase
1	2	3	4	5

No	Indicators	Scale				
		1	2	3	4	5
1	Cost saving					
2	Space minimisation					
3	Product quality					
4	Employee productivity					
5	Machine/ equipment productivity					
6	Volume flexibility					
7	Product flexibility					
8	Delivery performance					

BUSINESS PERFORMANCE

Definition: Reflects the financial aspects, such as revenue growth, net profits, profit to revenue ratio and return on assets, and non-financial aspects, such as capacity to develop a competitive profile, new products and market share.

Instruction: Please indicate below how the following business performance indicators evolved in the last THREE YEARS in your MANUFACTURING PLANT. Tick (/) the appropriate box based on the following scale:

Significant decrease	Moderate decrease	Little or No change	Moderate increase	Significant increase
1	2	3	4	5

No	Indicators	Scale				
		1	2	3	4	5
1	Revenue growth					
2	Net profits					
3	Return on assets					
4	Competitive profile					
5	New product development					
6	Market development					

SECTION 2: SUSTAINABLE GAINS

CONTINUOUS IMPROVEMENT CAPABILITIES

Definition: Reflects competitive abilities that allow the organisation to learn, innovate and renew.

Instruction: Please indicate to what extent you agree/disagree with the following statements about continuous improvement in your MANUFACTURING PLANT. Tick (✓) the appropriate box based on the following scale:

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	2	3	4	5

No	Statements	Scale					
		1	2	3	4	5	6
1	Our organisation engages in dynamically changing itself to better serve its customers						
2	We keep improving production processes even there is no pressing problem occurs						
3	We periodically evaluate whether the improvement projects follow according to the agreed approach						
4	We strive to continually improve all aspects of products and processes						
5	We believe that the improvement of a production process is never complete; there is always a room for more incremental improvement						
6	We believe that organisation's performance will deteriorate sooner or later if we do not constantly improve and learn						
7	Consistent process improvement makes our organisation's performance a moving target, which is difficult for competitors to challenge						

LEAN transformation sustainability refers to the maturity of LEAN implementation in an organisation's manufacturing system while achieving persistent performance goals and having consistent direction towards continuous improvement.

LTS01: Overall, do you think LEAN transformation in your manufacturing plant is SUSTAINABLE?

Least Likely → Most Likely						
1	2	3	4	5	6	7

*Circle/ highlight the appropriate score

SECTION 3: LEAN LEADERSHIP PRINCIPLES

STRATEGY DEPLOYMENT

Definition: The extent to which top management adopt long-term thinking and align LEAN transformation with corporate strategic orientation.

Instruction: Please indicate to what extent you agree/disagree with the following statements about LEAN strategy deployment in your MANUFACTURING PLANT. Tick (/) the appropriate box based on the following scale:

Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree
1	2	3	4	5	6

Top management...

No	Statements	Scale					
		1	2	3	4	5	6
1	...has established a long-term LEAN transformation plan						
2	...never abandon LEAN principles in favour of short-term operating objectives						
3	...pursues long-term stable performance instead of short-term temporary gains						
4	...adopt LEAN principles to drive manufacturing decisions						
5	...regularly revise consistency between LEAN transformation and our corporate strategy						
6	...keep LEAN transformation in step with our corporate strategy						
7	...align LEAN transformation action plans with our corporate strategy						
8	...reformulates any rules (policies) that obstruct LEAN transformations						
9	...spread/ promote LEAN principles to entire business functions (e.g. human resource, product development, sales and marketing, procurement)						
10	...extend LEAN transformation to a majority of our suppliers/ vendors						

SECTION 3: LEAN LEADERSHIP PRINCIPLES

SELF-DEVELOPMENT

Definition: The extent to which top management is aware to make self-improvement and personally lead subordinates in a LEAN transformation.

Instruction: Please indicate to what extent you agree/disagree with the following statements about self-development of top management personnel (e.g., CEO, Managing Director, President, Chairman, etc.) in your MANUFACTURING PLANT. Tick (✓) the appropriate box based on the following scale:

Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree
1	2	3	4	5	6

Top management...

No	Statements	Scale					
		1	2	3	4	5	6
1	...have both in-depth understandings about LEAN and legit ability to lead people						
2	...always make self-reflection to keep improving themselves (e.g. seek own limitations, current potential, and further improvement)						
3	...continuously apply LEAN knowledge in daily operational management (consistency)						
4	...dedicate time to acquire LEAN knowledge from experts (e.g. lean sensei, lean coach, external consultants)						
5	...are the true champions (role model) in your organisation's LEAN transformation						
6	...nurture/ mentor potential subordinates to become LEAN change agent (e.g. internal LEAN coach, new LEAN champion)						

SECTION 3: LEAN LEADERSHIP PRINCIPLES

SUPPORT FOR DAILY IMPROVEMENT

Definition: The extent to which managers at all levels demonstrate commitment and support by interacting with employees on a daily/ regular basis.

Instruction: Please indicate to what extent you agree/disagree with the following statements about daily support for LEAN (kaizen) activities by management personnel (e.g., top managers, department managers, and supervisors) in your MANUFACTURING PLANT. Tick (✓) the appropriate box based on the following scale:

	Strongly disagree 1	Disagree 2	Slightly disagree 3	Slightly agree 4	Agree 5	Strongly agree 6
No	Statements					
1	Top management provides the necessary resources for improvement programmes (e.g., funding, time, physical space, information)					
2	All managers (including top management) in this plant:					
	a. make a lot of face-to-face contact with production employees					
	b. are readily available on the production floor when they are needed					
	c. frequently go around in the production floor to understand the current situation					
3	Functional / departmental managers coordinates daily process improvement activities					
4	Engineers' offices are located near the production floor, to provide quick assistance whenever needed					

SECTION 3: LEAN LEADERSHIP PRINCIPLES

COACH & DEVELOP SUBORDINATES

Definition: The extent to which production managers/ supervisors use coaching as a means of facilitating learning, growth and development of their subordinates.

Instruction: Please indicate to what extent you agree/disagree with the following statements about LEAN coaching session/ program in your MANUFACTURING PLANT. Tick (✓) the appropriate box based on the following scale:

Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree
1	2	3	4	5	6

Managers/supervisors...

No	Statements	Scale					
		1	2	3	4	5	6
1	... use examples (e.g., analogies, scenarios) to help subordinates learn about LEAN						
2	... assist subordinates to see the LEAN application in broader perspectives						
3	... conduct role-play with subordinates to help them see LEAN from different perspectives						
4	... provide subordinates with constructive feedback						
5	... solicit feedback from subordinates to ensure that interactions given are truly helpful to them						
6	... ask probing questions to encourage subordinates to think through issues						
7	... are not dictating how things should be done						
8	... support subordinates to meet constantly evolving targets						

LEAN leadership refers to four principles that guide organisation managers/ leaders' beliefs, behaviours, and practices to lead subordinates towards a sustainable and continuously improve LEAN transformation. The four principles are; strategic deployment, self-development, supporting daily improvement, as well as coaching and developing subordinates.

LL01: Overall, to what extent managers (including top management) in your manufacturing plant are practising LEAN leadership principles?

Not at all	To a GREAT extent					
1	2	3	4	5	6	7

*Circle/ highlight the appropriate score

SECTION 4: GENERAL INFORMATION

Instruction: This section seeks general information about your company. Where appropriate, please tick (✓) or fill in the blank

1 Years in operation?		_____ years	
2 Types of ownership?	4 Number of full-time employees?	7 Your current position level?	
Local ☐	5 to 74 ☐	Top manager ☐	
Foreign/ MNC ☐	75 to 199 ☐	Middle manager ☐	
Joint-venture ☐	200 and more ☐	Front-line manager ☐	
3 Types of industry?	5 Annual sales turnover (in MYR)?	8 Please state your full job title?	
Aerospace composite ☐	Less than 15 millions ☐	_____	
Automotive ☐	15 to 50 millions ☐	9 How long have you been in the current position?	
Chemical & Petrochemicals ☐	More than 50 millions ☐	_____ years	
Electrical & Electronics ☐		10 How long has your company adopted LEAN manufacturing?	
Food & Beverages ☐	6 Types of production process?	_____ years	
Iron & Steel ☐	Job shop ☐	_____	
Machinery & Equipment ☐	Batch ☐	_____	
Pharmaceutical ☐	Repetitive ☐	_____	
Textile ☐	Continuous flow ☐	_____	
Wood & Furnitures ☐	Mass customisation ☐	_____	
Others (please specify): _____	Others (please specify): _____	_____	

SECTION 5: LEAN CULTURE

POSITIVE WORK ENVIRONMENT

Definition: The extent to which a non-blaming and process-driven organisational atmosphere inspire mutual trust and respect for people.

Instruction: Please indicate to what extent you agree/disagree with the following statements about working atmosphere in your MANUFACTURING PLANT. Circle/ highlight the appropriate box based on the following scale:

In our organisation...

No	Indicators	Strongly Disagree Strongly Agree						
1	...nobody hides faults; spotted errors are treated as opportunity to improve	1	2	3	4	5	6	7
2	...employees at all positions report errors/ faults without fear of blame	1	2	3	4	5	6	7
3	...when error happens, manufacturing process(s) is to be improved (rather than finding who to blame)	1	2	3	4	5	6	7
4	...priority is given to gradual improvements (rather than drastic changes in manufacturing processes)	1	2	3	4	5	6	7
5	...continuous searching for possible improvements is part of the daily routine	1	2	3	4	5	6	7
6	...all functional departments/ units demonstrate a high commitment on eliminating waste	1	2	3	4	5	6	7
7	...there is a stable inter-functional cooperation to eliminate waste	1	2	3	4	5	6	7

SECTION 5: LEAN CULTURE

EFFECTIVE COMMUNICATIONS

Definition: The extent to which important information on LEAN transformation is effectively transferred between organisation members.

Instruction: Please indicate to what extent you agree/disagree with the following statements about effectiveness of communication in your MANUFACTURING PLANT. Circle/ highlight the appropriate box based on the following scale:

MANUFACTURING PLANT. Circle might in the appropriate box based on the following scale:									
No	Indicators	Strongly Disagree					Strongly Agree		
1	There are effective two-way communications in this plant; top-down and bottom-up communications work in parallel	1	2	3	4	5	6	7	
2	There are good communications between different functional departments in conducting LEAN transformation projects	1	2	3	4	5	6	7	
3	Organisational position is not a barrier to communicate on process improvement	1	2	3	4	5	6	7	
4	Employees at all positions are constantly provided with information of LEAN strategic direction (e.g. transformation plans, objectives, vision)	1	2	3	4	5	6	7	
5	Top management clearly communicated: a. the need(s) for pursuing LEAN transformation (e.g., why, when, and how LEAN would be implemented) b. both individual and work teams responsibilities for reducing waste c. regular updates on relevant operational information/ status (e.g., quality, delivery, safety problems, and achievements)	1	2	3	4	5	6	7	
6	Our plant emphasises on communicating in a visual way (e.g., notice boards, photos, charts, signal lights)	1	2	3	4	5	6	7	

SECTION 5: LEAN CULTURE

TEAMWORK

Definition: The extent to which LEAN transformation and problem resolution activities are handled in teams.

Instruction: Please indicate to what extent you agree/disagree with the following statements about team working in your MANUFACTURING PLANT. Circle/ highlight the appropriate box based on the following scale:

No	Indicators	Strongly Disagree → Strongly Agree						
1	Dedicated (full-time) lean teams (or kaizen teams) are formed to drive LEAN transformation activities	1	2	3	4	5	6	7
2	Working in teams means everyone is willing to help out and hold each other accountable	1	2	3	4	5	6	7
3	Team goals dominate individual goals	1	2	3	4	5	6	7
4	Production problems are solved in teams (rather than by individuals)	1	2	3	4	5	6	7
5	There is an effort to get all team members' opinions and ideas before making a decision	1	2	3	4	5	6	7
6	Considering inputs from many functional areas in decision-making processes is a common practice in this plant	1	2	3	4	5	6	7
7	Production work teams are empowered to decide on most issues happening in their own work areas (e.g., problem resolutions, process improvement, new working methods)	1	2	3	4	5	6	7

SECTION 5: LEAN CULTURE

PROBLEM SOLVING

Definition: The extent of problem-solving efforts are carried out based on LEAN philosophy.

Instruction: Please indicate to what extent you agree/disagree with the following statements about solving problems related to WASTE in your MANUFACTURING PLANT. Circle/ highlight the appropriate box based on the following scale:

No	Indicators	Strongly Disagree → Strongly Agree						
		1	2	3	4	5	6	7
1	Production employees dare to face conflicts instead of hiding problems	1	2	3	4	5	6	7
2	Identifying root causes rather than applying any quick fix as temporary solutions	1	2	3	4	5	6	7
3	Considering various alternatives (potential solutions) to seek consensus	1	2	3	4	5	6	7
4	Using systematic format (e.g., PDCA cycle, DMAIC sequence, 5 Whys)	1	2	3	4	5	6	7
5	Rely on scientific methods (rather than simple guess) for diagnosing production problems	1	2	3	4	5	6	7
6	Discussion / debate on conflicting opinions to find the best solution is a common practice	1	2	3	4	5	6	7
7	Solutions are long thought, but implemented immediately (rapid implementation)	1	2	3	4	5	6	7
8	Solutions are implemented based on facts and data (rather than assumptions)	1	2	3	4	5	6	7

SECTION 5: LEAN CULTURE

INNOVATION

Definition: The extent to which new ideas are welcomed and innovations are made through experimentation and risk-taking.

Instruction: Please indicate to what extent you agree/disagree with the following statements about innovation efforts in your MANUFACTURING PLANT. Circle/highlight the appropriate box based on the following scale:

No	Indicators	Strongly Disagree	Strongly Agree
1.	Employees at all positions are:		
	a. open to new ideas that may make work easier or better	1	2
	b. really interested in new ideas to eliminate waste	1	2
2.	Production work teams are continuously experimenting with the new ways of working to:		
	a. improve work process	1	2
	b. eliminate waste	1	2
3.	Production work teams are permitted to undertake calculated risk while experimenting with the new ways of working	1	2
4.	Fail experiments are not penalized, production work teams are encouraged to learn from mistakes instead	1	2

LEAN culture is a type of organisational culture that can be distinguished through several attributes including; positive working atmosphere, effective communication, team-oriented, careful problem resolution, and innovative.

LC01: Overall, do you think your manufacturing plant's organisation culture has become truly LEAN?

Least Likely	1	2	3	4	5	6	Most Likely

*Circle/ highlight the appropriate score

SECTION 6: COMMENT

Please kindly send this completed survey file to azimazuan.osman@gmail.com before _____.

- ☐ Please provide your email if you wish to have a copy of the research report.
Your email address:

Comments (optional):

Thank you for your participation...



Appendix E: Chi-square Test Output for Non-Response Bias Assessment

		Crosstab		
		Respond		
		No	Yes	Total
Region	North	21	25	46
	South	11	14	25
	East	8	8	16
	West	9	8	17
	Centre	21	37	58
Total		70	92	162

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	2.234 ^a	4	.693
Likelihood Ratio	2.243	4	.691
Linear-by-Linear Association	.705	1	.401
N of Valid Cases	162		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 6.91.

Crosstab

		Respond		Total
		No	Yes	
Types of industry	Aerospace Components	0	1	1
	Automotive	5	9	14
	Chemical & Petrochemicals	16	8	24
	Electrical & Electronics	4	14	18
	Food & Beverages	19	20	39
	Iron & Steel	3	8	11
	Machinery & Equipment	6	5	11
	Pharmaceuticals	4	8	12
	Rubber	2	2	4
	Textile Apparel and Footwear	2	1	3
	Wood Based	9	16	25
Total		70	92	162

Chi-Square Tests

	Value	df	Asymptotic Significance (2- sided)
Pearson Chi-Square	13.645 ^a	10	.190
Likelihood Ratio	14.311	10	.159
Linear-by-Linear Association	.409	1	.523
N of Valid Cases	162		

a. 8 cells (36.4%) have expected count less than 5. The minimum expected count is .43.

Appendix F: EM and MCAR Test Output for Missing Data Replacement

Univariate Statistics

	N	Mean	Std. Deviation	Missing		No. of Extremes ^a	
				Count	Percent	Low	High
SOP07	91	3.58	.776	1	1.1	0	0
LCI01	91	5.09	1.355	1	1.1	0	0
LCI02	91	4.93	1.323	1	1.1	0	0

a. Number of cases outside the range (Q1 - 1.5*IQR, Q3 + 1.5*IQR).

EM Correlations^a

	SOP07	LCI01	LCI02
SOP07	1		
LCI01	.372	1	
LCI02	.369	.920	1

a. Little's MCAR test: Chi-Square = 5.518, DF = 3, Sig. = .138



Appendix G: Chi-square Table for Multivariate Outliers Detection

Critical values of the Chi-square distribution with d degrees of freedom							
Probability of exceeding the critical value							
d	0.05	0.01	0.001	d	0.05	0.01	0.001
1	3.841	6.635	10.828	11	19.675	24.725	31.264
2	5.991	9.210	13.816	12	21.026	26.217	32.910
3	7.815	11.345	16.266	13	22.362	27.688	34.528
4	9.488	13.277	18.467	14	23.685	29.141	36.123
5	11.070	15.086	20.515	15	24.996	30.578	37.697
6	12.592	16.812	22.458	16	26.296	32.000	39.252
7	14.067	18.475	24.322	17	27.587	33.409	40.790
8	15.507	20.090	26.125	18	28.869	34.805	42.312
9	16.919	21.666	27.877	19	30.144	36.191	43.820
10	18.307	23.209	29.588	20	31.410	37.566	45.315

INTRODUCTION TO POPULATION GENETICS, Table D.1

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Appendix H: WebPower Output for Multivariate Data Normality Test

WebPower
Statistical power analysis online

New AnalysisLoginRegister

ENHANCED BY Google

Navigation

- WebPower
- Ask Power
- My Analyses
- New Analysis
- Tools
- Manual
- References
- What's new
- Workshop
- FAQ

Output of skewness and kurtosis calculation

Sample size: 92
Number of variables: 4

Univariate skewness and kurtosis

	Skewness	SE_skew	Kurtosis	SE_kurt
SG	-0.2772198	0.2513424	-0.2920692	0.4977107
IM	0.3196133	0.2513424	-0.8686542	0.4977107
LL	-0.1669568	0.2513424	-0.6281769	0.4977107
LC	0.1247261	0.2513424	-0.8514347	0.4977107

Mardia's multivariate skewness and kurtosis

	b	z	p-value
Skewness	1.902146	29.1662382	0.08453732
Kurtosis	25.209529	0.8372582	0.40244745

Last modified: April 18 2019 13:22:04.



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Universiti Utara Malaysia

Appendix I: Frequency Analysis Output for Demographic Information

		Years in operation			Cumulative Percent
		Frequency	Percent	Valid Percent	
Valid	Below 10 years	13	14.1	14.1	14.1
	10 to 20 years	39	42.4	42.4	56.5
	21 to 30 years	25	27.2	27.2	83.7
	31 to 40 years	11	12.0	12.0	95.7
	41 to 50 years	2	2.2	2.2	97.8
	Over 50 years	2	2.2	2.2	100.0
	Total	92	100.0	100.0	

		Types of ownership			Cumulative Percent
		Frequency	Percent	Valid Percent	
Valid	Local	83	90.2	90.2	90.2
	Foreign / MNC	6	6.5	6.5	96.7
	Joint-venture	3	3.3	3.3	100.0
	Total	92	100.0	100.0	

		Types of industry			Cumulative Percent
		Frequency	Percent	Valid Percent	
Valid	Food & Beverages	19	20.7	20.7	20.7
	Wood Based	17	18.5	18.5	39.1
	Electrical & Electronics	14	15.2	15.2	54.3
	Automotive	9	9.8	9.8	64.1
	Iron & Steel	8	8.7	8.7	72.8
	Pharmaceuticals	8	8.7	8.7	81.5
	Chemical & Petrochemicals	7	7.6	7.6	89.1
	Machinery & Equipment	5	5.4	5.4	94.6
	Rubber	2	2.2	2.2	96.7
	Textile Apparel and Footwear	2	2.2	2.2	98.9
	Aerospace Components	1	1.1	1.1	100.0
	Total	92	100.0	100.0	

Number of full-time employees?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	5 to 74	56	60.9	60.9	60.9
	75 to 199	26	28.3	28.3	89.1
	200 and more	10	10.9	10.9	100.0
	Total	92	100.0	100.0	

Annual sales turnover (in MYR)?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than 15 millions	55	59.8	59.8	59.8
	15 to 50 millions	21	22.8	22.8	82.6
	More than 50 millions	16	17.4	17.4	100.0
	Total	92	100.0	100.0	

Types of production process?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Batch	31	33.7	33.7	33.7
	Continuous flow	26	28.3	28.3	62.0
	Mass customisation	21	22.8	22.8	84.8
	Job shop	7	7.6	7.6	92.4
	Repetitive	7	7.6	7.6	100.0
	Total	92	100.0	100.0	

Your current position level?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Middle manager	63	68.5	68.5	68.5
	Top manager	27	29.3	29.3	97.8
	First-line manager	2	2.2	2.2	100.0
	Total	92	100.0	100.0	

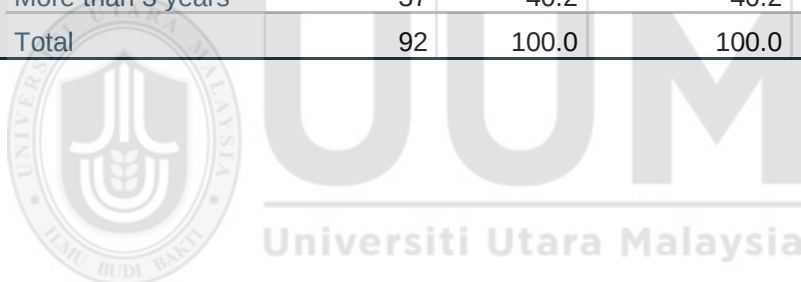
		Job Title			Cumulative Percent
		Frequency	Percent	Valid Percent	
Valid	Admin Executive	10	10.9	10.9	10.9
	Director	10	10.9	10.9	21.7
	Managing Director	8	8.7	8.7	30.4
	Others	8	8.7	8.7	39.1
	General Manager	7	7.6	7.6	46.7
	Human Resource Executive / Manager	5	5.4	5.4	52.2
	Manager	5	5.4	5.4	57.6
	Operations Manager	5	5.4	5.4	63.0
	Production Manager	4	4.3	4.3	67.4
	Quality Manager	4	4.3	4.3	71.7
	Assistant Production Manager	3	3.3	3.3	75.0
	Executive Director	3	3.3	3.3	78.3
	Factory Manager	3	3.3	3.3	81.5
	Head of Department	3	3.3	3.3	84.8
	Personal Assistant / Special Officer	3	3.3	3.3	88.0
	Senior Manager	3	3.3	3.3	91.3
	Chief Executive Officer	2	2.2	2.2	93.5
	Lean Manager	2	2.2	2.2	95.7
	Plant Manager	2	2.2	2.2	97.8
	Production Supervisor	2	2.2	2.2	100.0
	Total	92	100.0	100.0	

Tenure in current position

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Below 5 years	35	38.0	38.0	38.0
	5 to 10 years	40	43.5	43.5	81.5
	11 to 15 years	10	10.9	10.9	92.4
	16 to 20 years	4	4.3	4.3	96.7
	Over 20 years	3	3.3	3.3	100.0
	Total	92	100.0	100.0	

Duration of lean transformation journey

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Never adopted	1	1.1	1.1	1.1
	Less than a year	3	3.3	3.3	4.3
	1 to 3 years	51	55.4	55.4	59.8
	More than 3 years	37	40.2	40.2	100.0
	Total	92	100.0	100.0	



Appendix J: Descriptive Analysis Output

Descriptive Statistics (Main Variables)

	N	Mean	Std. Deviation
Lean Culture	92	4.26764	.894750
Lean Leadership	92	4.59730	.781432
Sustainable Gains	92	4.06116	.548038
Lean Maturity	92	3.47101	.665112
Valid N (listwise)	92		

Descriptive Statistics (Dimensions of Sustainable Gains)

	N	Minimum	Maximum	Mean	Std. Deviation
Sustainable Gains	92	2.619	5.119	4.06116	.548038
Operational Performance	92	1.500	5.000	3.62500	.720577
Business Performance	92	1.667	5.000	3.56159	.677439
Continuous Improvement Capability	92	3.286	6.000	3.99689	.654817
Valid N (listwise)	92				

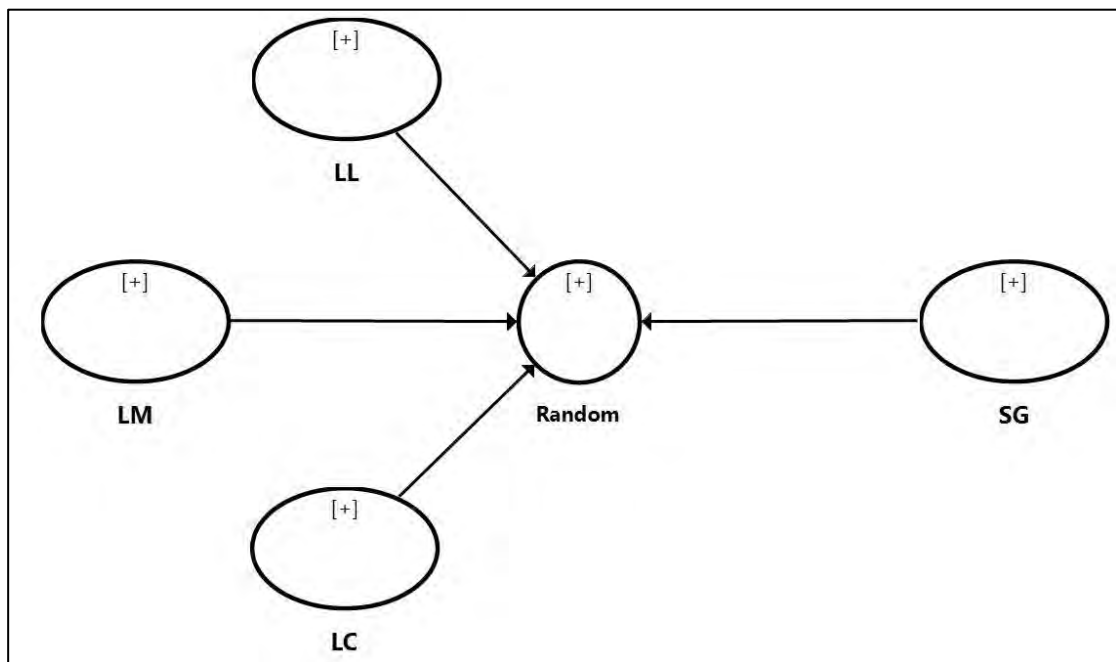
Descriptive Statistics (Dimensions of Lean Leadership)

	N	Minimum	Maximum	Mean	Std. Deviation
Lean Leadership	92	2.604	6.000	4.59730	.781432
Self-Development	92	2.333	6.000	4.55797	.974158
Coach & Develop Subordinates	92	2.250	6.000	4.56250	.854951
Support Daily Improvement	92	2.833	6.000	4.70833	.854359
Strategy Deployment	92	2.111	6.000	4.56039	.834885
Valid N (listwise)	92				

Descriptive Statistics (Dimensions of Lean Culture)

	N	Minimum	Maximum	Mean	Std. Deviation
Lean Culture	92	3.365	7.000	5.26764	.894750
Positive Work Environment	92	2.714	7.000	5.28727	1.054576
Effective Communications	92	3.000	7.000	5.18342	1.007433
Teamwork	92	3.571	7.000	5.54503	.888472
Problem Solving	92	3.000	7.000	5.23913	.914747
Innovation	92	2.167	7.000	5.08333	1.115027
Valid N (listwise)	92				

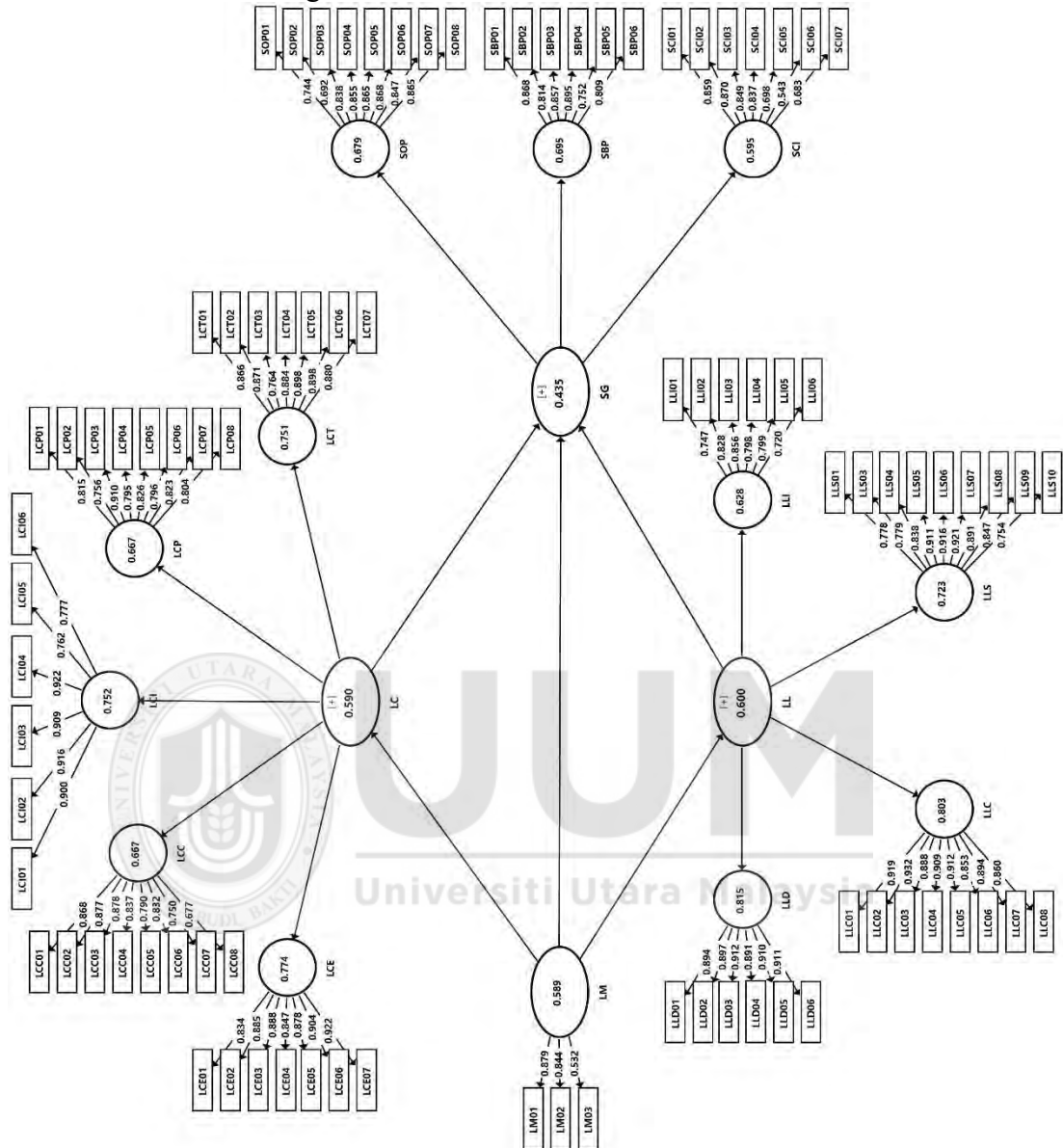
Appendix K: Full Collinearity Test Output for CMB



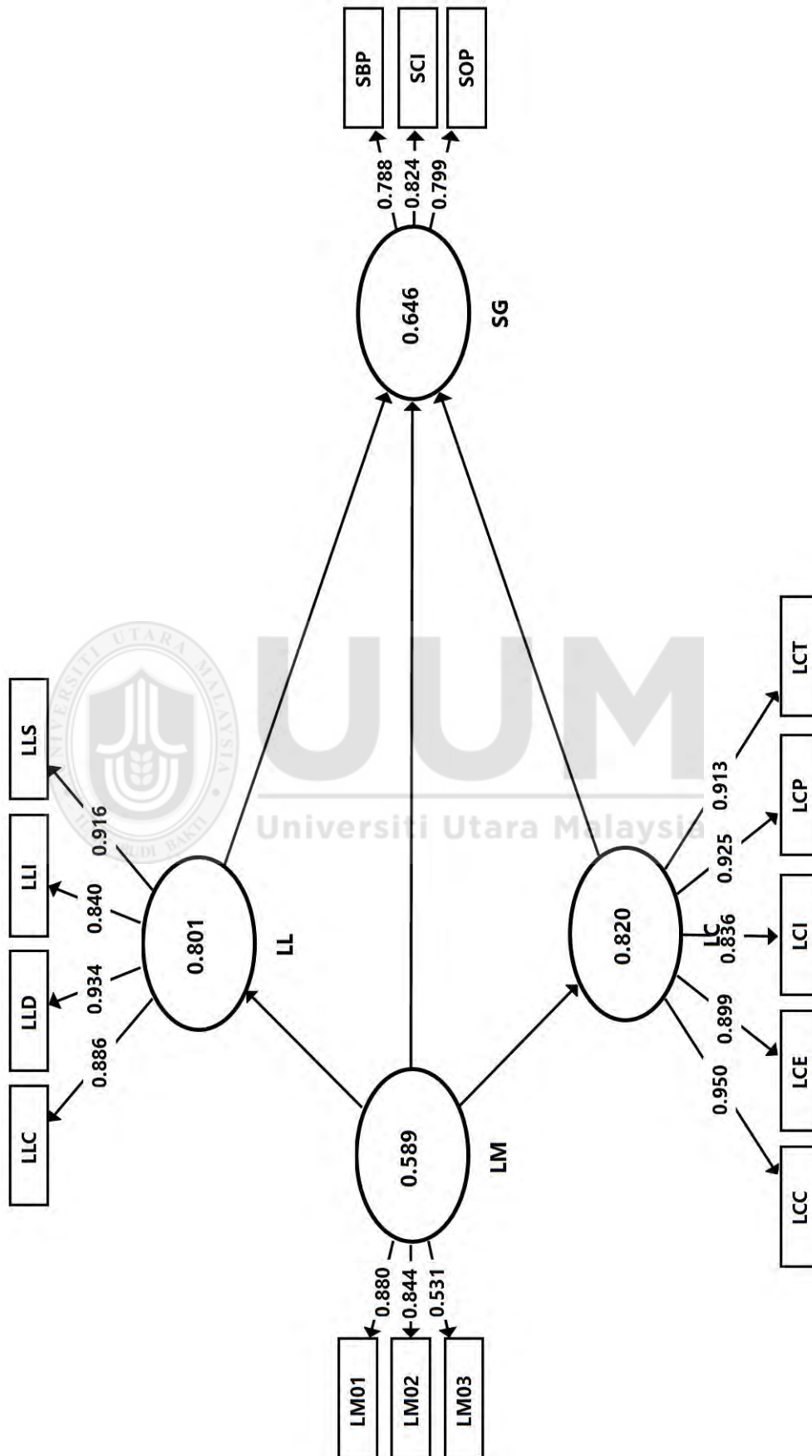
Latent Variables	Variance Inflation Factor (VIF)
LC	1.451
LL	1.392
LM	1.133
Random	
SG	1.154

Appendix L: PLS Algorithm Output for Construct Reliability and Validity Tests

Measurement Model Stage 1



Measurement Model Stage 2



Stage 1: Construct reliability and convergent validity

	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)
LC	0.980	0.981	0.590
LCC	0.928	0.941	0.667
LCE	0.951	0.960	0.774
LCI	0.932	0.947	0.752
LCP	0.928	0.941	0.667
LCT	0.944	0.955	0.751
LL	0.975	0.977	0.600
LLC	0.965	0.970	0.803
LLD	0.954	0.963	0.815
LLI	0.882	0.910	0.628
LLS	0.951	0.959	0.723
LM	0.648	0.805	0.589
SBP	0.912	0.932	0.695
SCI	0.884	0.910	0.595
SG	0.931	0.940	0.435
SOP	0.932	0.944	0.679

Stage 2: Construct reliability and convergent validity

	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)
LC	0.945	0.958	0.820
LL	0.917	0.941	0.801
LM	0.648	0.805	0.589
SG	0.737	0.846	0.646

Stage 1: Discriminant validity - HTMT ratio (before LLS02 deletion)

	LC	LCC	LCE	LCI	LCP	LCT	LL	LLC	LLD	LLI	LLS	LM	SBP	SCI	SG	SOP
LC																
LCC	0.990															
LCE	0.923	0.874														
LCI	0.877	0.853	0.687													
LCP	0.968	0.886	0.804	0.780												
LCT	0.947	0.868	0.824	0.702	0.899											
LL	0.797	0.777	0.730	0.663	0.790	0.707										
LLC	0.790	0.732	0.777	0.620	0.810	0.693	0.917									
LLD	0.685	0.674	0.627	0.550	0.689	0.606	0.962	0.795								
LLI	0.745	0.794	0.621	0.769	0.654	0.616	0.866	0.698	0.743							
LLS	0.684	0.660	0.616	0.532	0.694	0.638	0.963	0.762	0.904	0.705						
LM	0.407	0.439	0.388	0.228	0.409	0.390	0.504	0.364	0.519	0.343	0.564					
SBP	0.472	0.475	0.452	0.353	0.486	0.395	0.427	0.426	0.328	0.433	0.370	0.286				
SCI	0.708	0.673	0.690	0.548	0.699	0.643	0.809	0.657	0.738	0.695	0.826	0.424	0.448			
SG	0.709	0.696	0.688	0.564	0.715	0.592	0.696	0.688	0.593	0.622	0.617	0.471	0.890	0.798		
SOP	0.550	0.548	0.536	0.467	0.559	0.417	0.476	0.582	0.395	0.410	0.342	0.423	0.662	0.416	0.919	

Stage 1: Discriminant validity - HTMT ratio (after LLS02 deletion)

	LC	LCC	LCE	LCI	LCP	LCT	LL	LLC	LLD	LLI	LLS	LM	SBP	SCI	SG	SOP
LC																
LCC	0.990															
LCE	0.923	0.874														
LCI	0.877	0.853	0.687													
LCP	0.968	0.886	0.804	0.780												
LCT	0.947	0.868	0.824	0.702	0.899											
LL	0.794	0.775	0.729	0.661	0.790	0.700										
LLC	0.790	0.732	0.777	0.620	0.810	0.693	0.922									
LLD	0.685	0.674	0.627	0.550	0.689	0.606	0.961	0.795								
LLI	0.745	0.794	0.621	0.769	0.654	0.616	0.867	0.698	0.743							
LLS	0.666	0.643	0.601	0.514	0.687	0.615	0.956	0.762	0.899	0.695						
LM	0.407	0.439	0.388	0.228	0.409	0.390	0.508	0.364	0.519	0.343	0.583					
SBP	0.472	0.475	0.452	0.353	0.486	0.395	0.427	0.426	0.328	0.433	0.367	0.286				
SCI	0.708	0.673	0.690	0.548	0.699	0.643	0.807	0.657	0.738	0.695	0.823	0.424	0.448			
SG	0.709	0.696	0.688	0.564	0.715	0.592	0.698	0.688	0.593	0.622	0.616	0.471	0.890	0.798		
SOP	0.550	0.548	0.536	0.467	0.559	0.417	0.482	0.582	0.395	0.410	0.346	0.423	0.662	0.416	0.919	

Stage 2: Discriminant validity - HTMT ratio

	LC	LL	LM	SG
LC				
LL	0.833			
LM	0.406	0.505		
SG	0.803	0.809	0.492	

Inner VIF (collinearity assessment)

	LC	LL	LM	SG
LC				2.490
LL				2.722
LM	1.000	1.000		1.216
SG				

R square (model's explanatory power)

	R Square	R Square Adjusted
LC	0.101	0.091
LL	0.178	0.168
SG	0.567	0.552

f square (predictors' effect size)

	LC	LL	LM	SG
LC				0.134
LL				0.116
LM	0.112	0.216		0.020
SG				

Appendix M: CTA-PLS Output for Measurement Model Robustness Test

SG	Original Sample	STDEV	T Statistics	P Values	CI Low	CI Up
1: LCP,SBP,SCI,SOP	0.221	0.158	1.399	0.081	-0.039	0.474
2: LCP,SBP,SOP,SCI	-0.043	0.046	0.920	0.358	-0.135	0.047

LM	Original Sample	STDEV	T Statistics	P Values	CI Low	CI Up
1: LM01,LM02,LM03,SCI	-0.005	0.029	0.162	0.871	-0.063	0.052
2: LM01,LM02,SCI,LM03	-0.016	0.029	0.549	0.583	-0.072	0.040

LL	Original Sample	STDEV	T Statistics	P Values	CI Low	CI Up
1: LLC,LLD,LLI,LLS	-0.071	0.041	1.731	0.084	-0.155	0.006
2: LLC,LLD,LLS,LLI	-0.014	0.028	0.498	0.618	-0.072	0.040

LC	Original Sample	STDEV	T Statistics	P Values	CI Low	CI Up
1: LCC,LCE,LCI,LCP	0.012	0.049	0.241	0.809	-0.084	0.107
2: LCC,LCE,LCP,LCI	0.070	0.039	1.806	0.071	-0.005	0.146
4: LCC,LCE,LCI,LCT	-0.066	0.046	1.424	0.155	-0.159	0.022
6: LCC,LCI,LCT,LCE	-0.164	0.154	1.062	0.144	-0.461	0.041
10: LCC,LCI,LCP,LCT	0.017	0.126	0.139	0.445	-0.243	0.178



Appendix N: Blindfolding and PLSpredict Output for Model Predictive Power

Q square

	SSO	SSE	Q ² (=1-SSE/SSO)
LC	460.000	426.471	0.073
LL	368.000	321.789	0.126
LM	276.000	276.000	
SG	276.000	185.867	0.327

PLSpredict: Latent Variable Q square predict

	RMSE	MAE	Q ² _predict
LC	0.993	0.827	0.065
LL	0.960	0.786	0.127
SG	0.972	0.785	0.103

PLSpredict: Manifest Variable Q square predict (PLS Model)

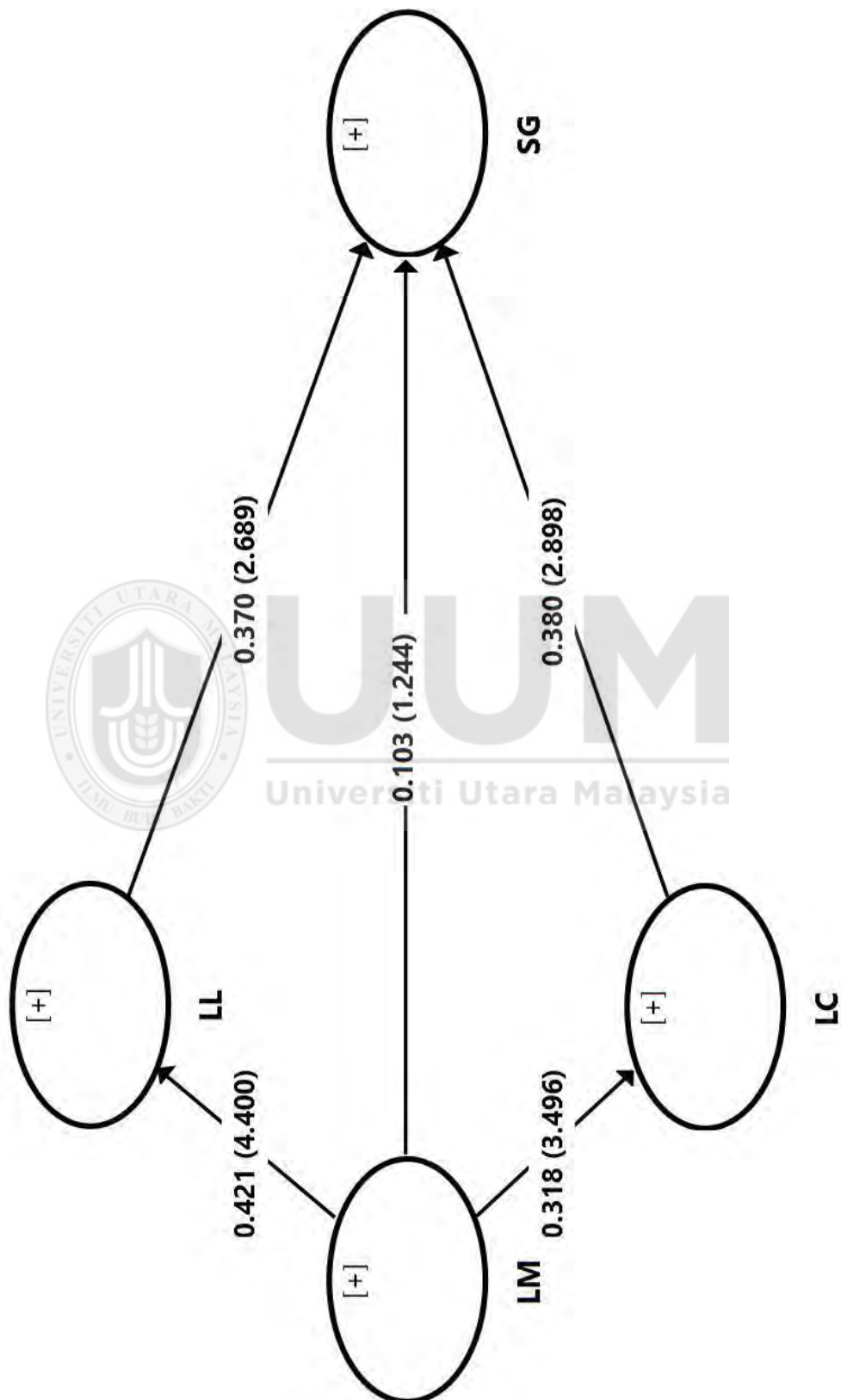
	RMSE	MAE	MAPE	Q ² _predict
LCC	0.982	0.822	106.165	0.071
LCP	0.983	0.811	426.826	0.061
LCE	0.980	0.802	107.912	0.069
LCI	1.021	0.880	136.186	-0.013
LCT	0.985	0.819	204.526	0.056
LLC	0.991	0.815	130.211	0.044
LLS	0.927	0.741	593.131	0.171
LLD	0.948	0.761	118.676	0.132
LLI	1.000	0.833	146.031	0.035
SBP	1.008	0.761	128.347	0.008
SCI	0.970	0.794	137.466	0.085
SOP	0.965	0.681	142.952	0.092

PLSpredict: Manifest Variable Q square predict (LM Model)

	RMSE	MAE	MAPE	Q ² _predict
LCC	1.018	0.848	114.440	0.002
LCP	1.008	0.834	692.673	0.013
LCE	1.005	0.820	117.445	0.021
LCI	1.029	0.880	129.684	-0.029
LCT	1.027	0.846	222.634	-0.027
LLC	1.002	0.811	125.442	0.023
LLS	0.937	0.730	420.232	0.153
LLD	0.956	0.765	128.026	0.118
LLI	1.015	0.853	141.114	0.005
SBP	1.018	0.774	120.885	-0.011
SCI	0.995	0.810	153.007	0.037
SOP	0.987	0.693	150.542	0.049

Appendix O: Bootstrapping Output for Significance Testing

Structural Model



Path coefficients with *t* statistics (direct effects)

	Original Sample (O)	Standard Deviation (STDEV)	T Statistics (O/STDEV)	P Values
LC → SG	0.380	0.131	2.898	0.002
LL → SG	0.370	0.138	2.689	0.004
LM → LC	0.318	0.091	3.496	0.000
LM → LL	0.421	0.096	4.400	0.000
LM → SG	0.103	0.083	1.244	0.107

Path coefficients with confidence interval (direct effects)

	Original Sample (O)	Bias	5.0%	95.0%
LC → SG	0.380	0.012	0.160	0.590
LL → SG	0.370	-0.011	0.145	0.594
LM → LC	0.318	0.013	0.149	0.454
LM → LL	0.421	0.013	0.234	0.557
LM → SG	0.103	0.002	-0.034	0.238

Path coefficients with *t* statistics (indirect effects)

	Original Sample (O)	Standard Deviation (STDEV)	T Statistics (O/STDEV)	P Values
LM → LC → SG	0.120	0.060	2.016	0.044
LM → LL → SG	0.176	0.073	2.397	0.017

Path coefficients with confidence interval (indirect effects)

	Original Sample (O)	Bias	2.5%	97.5%
LM → LC → SG	0.120	0.009	0.031	0.256
LM → LL → SG	0.176	0.007	0.052	0.334

Appendix P: IPMA Output

Construct Total Effects for [SG]

	SG
LC	0.335
LL	0.333
LM	0.136

Construct Performances for [SG]

	Performances
LC	57.660
LL	61.320
LM	50.718



Appendix Q: Output Quadratic Effects for Nonlinearity Robustness Test

Lean Tools Adoption Maturity Quadratic Effect on Sustainable Gains

	Original Sample (O)	Standard Deviation (STDEV)	T Statistics (O/STDEV)	P Values
LM*Q -> SG	-0.106	0.122	0.872	0.192

Lean Leadership Quadratic Effect on Sustainable Gains

	Original Sample (O)	Standard Deviation (STDEV)	T Statistics (O/STDEV)	P Values
LL*Q -> SG	0.081	0.138	0.588	0.279

Lean Culture Quadratic Effect on Sustainable Gains

	Original Sample (O)	Standard Deviation (STDEV)	T Statistics (O/STDEV)	P Values
LC*Q -> SG	0.071	0.127	0.559	0.288

Lean Tools Adoption Maturity Quadratic Effect on Lean Leadership

	Original Sample (O)	Standard Deviation (STDEV)	T Statistics (O/STDEV)	P Values
LM*Q -> LL	-0.162	0.268	0.605	0.273

Lean Tools Adoption Maturity Quadratic Effect on Lean Culture

	Original Sample (O)	Standard Deviation (STDEV)	T Statistics (O/STDEV)	P Values
LC*Q -> LC	-0.222	0.277	0.800	0.424

Appendix R: Output Ramsey's RESET for Nonlinearity Robustness Test

Partial Regression: LM, LL, and LC on SG

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.753 ^a	.567	.552	.672894	.567	38.392	3	88	.000
2	.755 ^b	.569	.544	.678683	.003	.253	2	86	.777

a. Predictors: (Constant), LC, LM, LL

b. Predictors: (Constant), LC, LM, LL, PRE_2, PRE_Q

Partial Regression: LM on LL

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.421 ^a	.178	.168	.916919	.178	19.434	1	90	.000
2	.451 ^b	.203	.176	.912594	.026	1.428	2	88	.245

a. Predictors: (Constant), LM

b. Predictors: (Constant), LM, PRE_5, PRE_6

Partial Regression: LM on LC

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.318 ^a	.101	.091	.958644	.101	10.109	1	90	.002
2	.346 ^b	.120	.090	.959232	.019	.945	2	88	.393

a. Predictors: (Constant), LM

b. Predictors: (Constant), LM, PRE_8, PRE_9

Appendix S: Output FIMIX-PLS for Unobserved Heterogeneity Robustness Test

Fit indices for three-segment solution

AIC (Akaike's Information Criterion)	656.334
AIC3 (Modified AIC with Factor 3)	682.334
AIC4 (Modified AIC with Factor 4)	708.334
BIC (Bayesian Information Criteria)	721.901
CAIC (Consistent AIC)	747.901
HQ (Hannan Quinn Criterion)	682.797
MDL5 (Minimum Description Length with Factor 5)	1192.167
LnL (LogLikelihood)	-302.167
EN (Entropy Statistic (Normed))	0.703
NFI (Non-Fuzzy Index)	0.688
NEC (Normalized Entropy Criterion)	27.293

Fit indices for two-segment solution

AIC (Akaike's Information Criterion)	669.566
AIC3 (Modified AIC with Factor 3)	686.566
AIC4 (Modified AIC with Factor 4)	703.566
BIC (Bayesian Information Criteria)	712.436
CAIC (Consistent AIC)	729.436
HQ (Hannan Quinn Criterion)	686.868
MDL5 (Minimum Description Length with Factor 5)	1019.918
LnL (LogLikelihood)	-317.783
EN (Entropy Statistic (Normed))	0.719
NFI (Non-Fuzzy Index)	0.742
NEC (Normalized Entropy Criterion)	25.828

Fit indices for one-segment solution

AIC (Akaike's Information Criterion)	694.491
AIC3 (Modified AIC with Factor 3)	702.491
AIC4 (Modified AIC with Factor 4)	710.491
BIC (Bayesian Information Criteria)	714.665
CAIC (Consistent AIC)	722.665
HQ (Hannan Quinn Criterion)	702.634
MDL5 (Minimum Description Length with Factor 5)	859.363
LnL (LogLikelihood)	-339.246
EN (Entropy Statistic (Normed))	
NFI (Non-Fuzzy Index)	
NEC (Normalized Entropy Criterion)	

Segment size

	Segment 1	Segment 2	Segment 3
%	0.580	0.221	0.199