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The Effect of Lean Waste Reduction Technique to Business Results: a Confirmatory Study

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Abstract
Understanding of how to implement Lean successfully and how it contributes to performance in manufacturing organizational is still relatively lacking so that Lean exploration is still needed in the management aspect. This research will examine the effect of LMS, LWRT on LBR. This research was conducted on 30 companies in industrial centers in Indonesia, and the data were processed using the Structural Equation Model method. It was found that LMS has no significant effect on LBR, but LMS has a significant effect on LWRT, while LWRT has a significant effect on LBR. In detail, LBR variation of 78.8% is simultaneously influenced by LMS and LWRT, 21.2% is influenced by other variables. While 72.7% LWRT variation is influenced by LMS variation, and 27.3% is influenced by other variables. This result confirms Bergmiller's research (2009) that LMS has a significant effect on LBR through LWRT for the manufacturing industry in Indonesia.

Keywords
Lean Management System, Lean Waste Reduction Technique, Lean Business Result.

Introduction

Lean manufacturing (LM) is an effective and popular tool in most manufacturing and service sectors to deal with non-value and waste activities (Nandakumar et al., 2020). Organizations with the help of an integrated lean management system will be able to achieve quality goals and targets with fewer documents (Jewalikar & Shelke, 2017). Lean manufacturing is an integrated socio-technical system whose main goal is to eliminate waste (Shah & Ward, 2003). Some of the problems in implementing LM in the US and Europe, is the lack of cultural insight in the implementation of Lean Management System (LMS) (Bergmiller, 2006). In the early 1990s James Womack promoted a more complete view of LM systems, by incorporating management systems that lead to a culture of waste reduction, thus developing management systems and aspects of Lean culture. Basically, LM system is an endless commitment to reduce waste, through the implementation of best practices (Womack & Jones, 1996).

Non-value-added activities in Indonesia's national manufacturing industry are still quite high, ranging from 41–70% (Hazmi & Supriyanto, 2012; Khannan, 2015). In fact, the Ministry of Industry stipulates the 2005-2025 industrial policy in Law No. 17 of 2007 concerning the National Long-Term Development Plan (RPJPN) in which the Indonesian government plans to become a new industrial country where the industrial sector becomes the driving force in the economic structure with growth by 8.6% per year with a target of reaching 40% of GDP by 2025 (Kementerian Perindustrian, 2017).

Understanding of how to implement Lean successfully and how it contributes to performance in manufacturing organizational settings is still relatively lacking so that Lean exploration in management aspects is still needed (Womack & Jones, 1996). In-depth research on the impact of Lean on the industry, which involves the role of the Human Resources (HR) function and the HR dimension in implementing Lean is the most urgent research, because often the 'soft' aspects related to people and culture, are the cause of 'failed' Lean initiatives (Radnor & Osborne, 2013; Stewart et al., 2009; Emiliani, 2011). The focus of this research is to examine the impact of implementing

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Lean from the 'soft' aspect on manufacturing performance. This research is a case study on the national manufacturing industry in Indonesia.

Literature review

Organizations will be able to achieve quality objectives by establishing an integrated lean management system, which involves identifying and removing operations that do not provide value (Jewalikar & Shelke, 2017). Everyone at every level of the business, however, will be accountable and have the authority to make real-time decisions at their own level (Palange & Pankaj, 2021). Lean manufacturing is an endeavor to eliminate waste in a production system that is connected to human effort, inventory delays at various stages of production, and other factors (Rahman et al., 2013).

Talking regarding lean transformation is talking about the complete organization, and not simply production. All individual departments and their operations inside the organization should be optimized during a coordinated manner. This coordination is that the responsibility of senior management (Alefari et al., 2017). Lean is a powerful management strategy supported by a set of important enablers. Mohammad and Oduoza (2019), Zargun and Al-Ashhab (2014) in their analysis, they discovered crucial success characteristics that they grouped into four areas, two of which are "Strategy" and Goals", "Leadership and Management". Kotter (2007) have researched the reasons for change project failure and distilled them into eight assertions, exposing leadership errors. As a result, leadership plays a critical role in the introduction and execution of lean (Alefari et al., 2017).

Salonitis and Tsinopoulos (2016) supported an intensive review of the prevailing literature, known many key success factors for lean, as well as "organizational culture and ownership", "developing structure readiness", "commitment and capability management", "providing adequate capable support amendment", "external support from consultants", "effective communication and engagement", "strategic approach to improvement", "teamwork and whole systems thinking combined", and "time to line realistic timelines for change and to form effective use of commitment and enthusiasm for change." Involvement in decision-making, human resource development and customer focus belongs to the linkage enabler category for lean success (Mohammad & Oduoza, 2019). According to Shingo philosophy, world-class business performance can be achieved by focusing on core manufacturing and business processes, with criteria based on leadership, organizational culture, empowerment, manufacturing strategy, system integration, quality, cost, delivery, and customer satisfaction (Shingo, 2003). The Shingo Prize model is the best representative model for the "Leanness" measure, according to Bergmiller and McCright (2009). Then Bergmiller and McCright (2009) summarize the Lean Manufacturing System model, and conclude that this model (Figure 1) distills the essence of the theories of Womack (Womack & Jones, 1996; SAE, 1999 and Liker, 2004) into one coherent model.

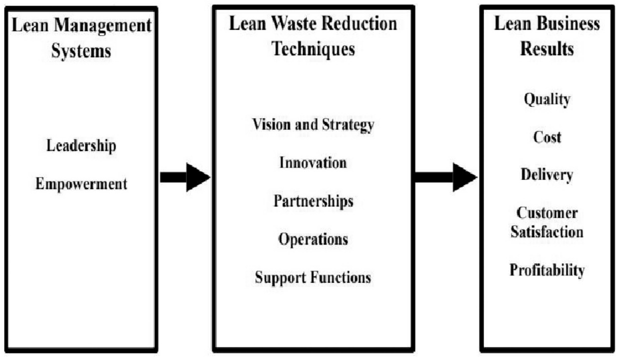

Fig. 1. Advanced Lean System Model

Bergmiller and McCright (2009) classify Lean Management Systems as policies and procedures that create an environment/culture that binds organizations to waste reduction, for each manufacturing system, and Lean Waste Reduction Techniques variables as specific business practices and production processes associated with each manufacturing system, which results in reduced wastage, while Lean Business Result as measurable improvements to each manufacturing system's stated objectives.

Furthermore, Bergmiller (2006) conducted a correlation test between these variables. The results of research by Bergmiller (2006) showed a significant correlation between the main variable Lean Management System (LMS) and the main variable Lean Waste Reducing Techniques (LWRT), and a significant correlation between LWRT and the main variable Lean Business Results (LBR). However, these results do not explain how the influence between these variables is, and how much influence the LMS and LWRT variables have on LR. This study will fill this research gap by testing the effect of LMS, LWRT on LBR, using the Structural Equation Model method.

Materials and methods

This research was conducted on 30 companies in industrial centers in various regions in Indonesia. Samples were taken from 3 industrial areas in Indonesia (Cikarang, Pulo Gadung and Tangerang). The number of respondents as many as 150 people, namely 5 respondents in each company. Respondents are staff at the upper middle managerial level. The method of collecting data is through distributing questionnaires in 30 companies that have implemented the Lean con- cept. Of the 150 questionnaires distributed, only 132 returned and only 126 were eligible for further processing using SEM method with Smart-PLS software. Detail of research methodology can be seen in Fig. 2. Indicators of each research variable taken from Bergmiller (2006) can be seen in Table 1.

Table 1
Research variable's indicators

Variable	Dimension	Indicator
Lean Management System	Leadership	Leaders have a vision, mission, strategy, planning and goals to improve production quality, increase value, and reduce waste (LD1)
		Leaders in a planned and systematic manner ensure knowledge sharing, including improvement of ideas, innovations, thoughts, competencies and expertise (LD2)
		Leaders are committed to finding and eliminating waste, youth, or non-value-added activities and costs (LD3)
	Empowerment	Employee training is always carried out to find and eliminate waste, activities and costs that are not added value (EMP1)
		Use of teams (corrective action teams, cross-functional teams, process improvement teams and/or independent teams) to achieve lean management goals (EMP2)
		There is a suggestion system that shows management's willingness to accept innovative ideas and/or improvements, and has a reward system (EMP3)
Lean Waste Reduction Technique	Vision and Strategy	The leadership implements the vision and strategy in improving the quality of production, increasing its value and reducing waste (VS1)
		The leader forms a team in an effort to achieve increased production quality, value and also reduce waste (VS2)
		Leaders empower and provide the widest opportunity in implementing lean principles (VS3)
	Innovations in market service & product	Continuous improvement (KAIZEN) and the poka-yoke system for early detection of a problem in production activities is already underway (INV1)
		Cost reduction in each department has been carried out (INV2)
		Market service innovation (comparison with competing products, expanding sales media, developing new markets) has been carried out (INV3)
	Partnerships	Integration between companies, suppliers, and customers in ensuring product quality and productivity (PRT1)
		Cooperation efforts with training institutions to improve employee skills in implementing LWRT (PRT2)
		Benchmarking project for process improvement (PRT3)
	Operation	Implementing Kanban system in production line (OP1)
		The production process has implemented the concept of a pull system and lower inventory (stock) (OP2)
		The production process has implemented the concept of pull system and successfully lowering WIP and Finish Good (OP3)
	Support function	Elimination of waste/non-value-added activities in all functional units of the organization (SF1)
		The integration of non-manufacturing and manufacturing functions has been carried out (SF2)
		Continuous commitment and/or process of changing plans in the long term, capital budgeting, training and human resource development, marketing plans and strategic planning by all functional business units (SF3)

Table 1 [cont.]

Variable	Dimension	Indicator
Lean Business Result (LBR)	Quality Improvement	Production quality is getting better (QA1)
		There is a decrease in defects (QA2)
	Cost & Productivity Improvement	There is a decrease in costs for activities that do not add value (CR1)
		Increased productivity per worker (CR2)
	Delivery Improvement	Production target achieved (DLY1)
		Accuracy of delivery of goods is achieved (DLY2)
	Customer Satisfaction	Customer satisfaction is getting better (CS1)
		There is a decrease in complaints (CS2)
	Profitability	The company's profit is getting better (PRF1) a decrease in production costs (PRF2)

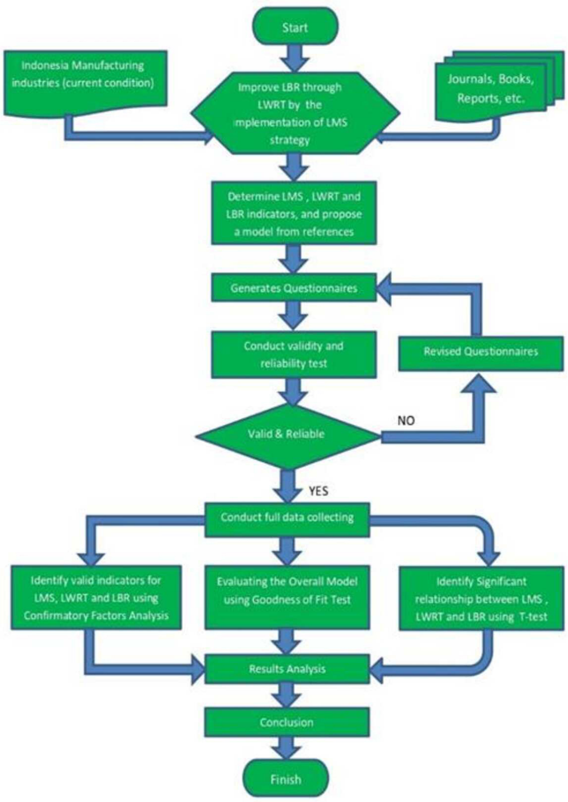

Fig. 2. Research methodology

Results

Nearly 80% of the respondents, or exactly 24 out of 30 companies, were classified as a discrete product (non-oil and chemicals) industrial group. 6 companies (at approximately 20%) were belonging to automotive and spare parts industrial group. While 3 companies (or nearly 10%) were belong to chemical/petrochemical, and oil & gas companies, which was excluded from the scope of the research and from the database and ruled out from the data analysis stage.

Approximately 60% or 18 companies were classified as large-sized companies with a total number of employees more than 100 staffs. The remaining of the companies, at approximately 40% of the respondents, have less than the said number. Most of the companies, at approximately 75% of the respondents, have been operating the business for more than 10 years. The remaining, at approximately 25% of the respondents, has less than the said lifespan.

Meanwhile, the implementation of LM with duration of less than 10 years were found from nearly 60% of the respondents, while the remaining 40% have been implementing it more than 10 years.

Description of research variables

The description of the implementation of LMS, LWRT and LBR levels that occur in the respondent companies can be seen in Figures 3, 4, and 5 below.

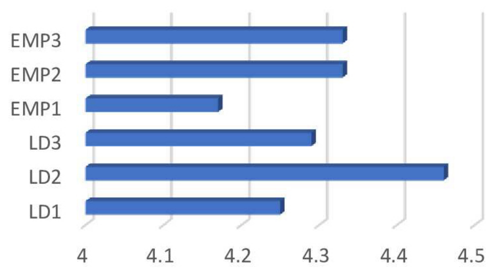

Fig. 3. Description of Lean Management System (LMS) Implementation

It can be seen from the Fig. 3, all of LMS indicators have a high perception score more than 4 with LD2 indicator has a highest perception score (4.45). It means that Leaders in a planned and systematic manner

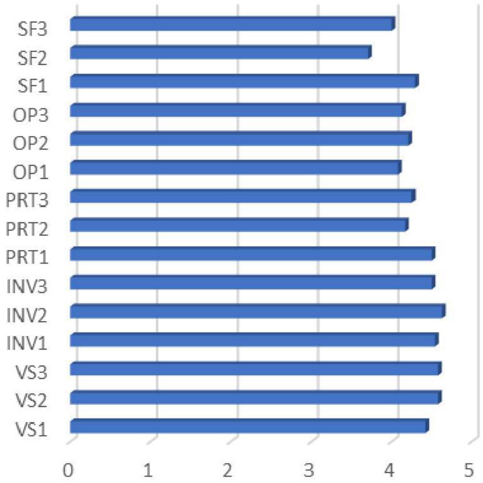

Fig. 4. Description of Implementation of Lean Waste Reduction Technique (LWRT)

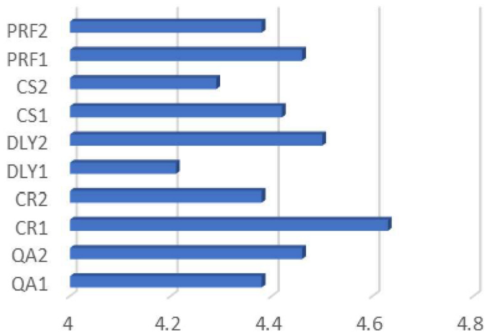

Fig. 5. Description of Lean Business Result (LBR)

ensure knowledge sharing, including improvement of ideas, innovations, thoughts, competencies and expertise. In the other hand EMP1 (Employee training is always carried out to find and eliminate waste, activities and costs that are not added value) has a lowest score which means there are an opportunity to make improvement.

The perception score for the LWRT variable indicator (15 indicators) is generally quite high and almost homogeneous in value, which is 4.0–4.5. Only one indicator which is SF2, the integration of non-manufacturing and manufacturing functions has been carried out, whose value is below 4.

From the figure above, it can be seen that the perception score for the LBR variable indicator (10 indicators) is quite homogeneous in value, which is between 4.2–4.6. There is no single indicator that is below 4. The smallest score is the DLY1 indicator (Production target achieved) which is 4.2 and the largest score is the CR1 indicator (There is a decrease in costs for activities that do not add value).

Finally, it can be concluded that all indicators of LMS, LWRT and LBR get a fairly high perception score. This means that all respondent (companies) have implemented LMS, LWRT in a "Good" manner and in the "Good" category.

Confirmatory factor analysis (outer model) and structural model evaluation (inner model)

Figure 6 shows that the indicators OP1, OP2, OP3, SF1 and SF2 are invalid to form the LWRT variable, and QA1 is not valid to form the LBR variable. This can be seen from the loading factor value of less than 0.7. In accordance with the opinion of (Hair et al., 2014) that in confirmatory research, indicators that can be said to be valid in forming research variables are those with a loading factor value of 0.7. Indicators that have a loading factor value below 0.7 are excluded from the model, so that they become model 2 (Figure 7). In model 2, all indicators have a loading factor value above 0.7.

Furthermore, the reliability and validity of the variables (constructs) were tested. If the variable (construct) has Cronbach's alpha (CA) value above 0.7, composite reliability (CR) above 0.7, and average variance extracted (AVE) above 0.5, the variable (construct) is said to be reliable and valid (Prabowo & Adesta, 2019). The following Table 2 is the value of Cronbach's alpha, composite reliability, and average variance of LMS, LWRT, and LBR.

Table 2
Validity and reliability test results

Construct	Cronbach's Alpha	Composite reliability	Average variance
LMS	0.944	0.952	0.667
LWRT	0.938	0.951	0.760
LBR	0.941	0.950	0.526

Table 2 shows that all variables have Cronbach's alpha values above 0.7, composite reliability above 0.7, and average variance above 0.5, so it can be concluded that all research variables are valid and reliable.

The significance test of the model is carried out through the evaluation of the structural model (inner model) which consists of a significance test by calculating R^2 for each exogenous variable to each endogenous variable. If the influence of exogenous variables on endogenous variables that have a t-statistic value above 1.650 means that it is significant with a 90% confidence level. On the other hand, the variable that has a t-statistic value below 1.650 is not significant

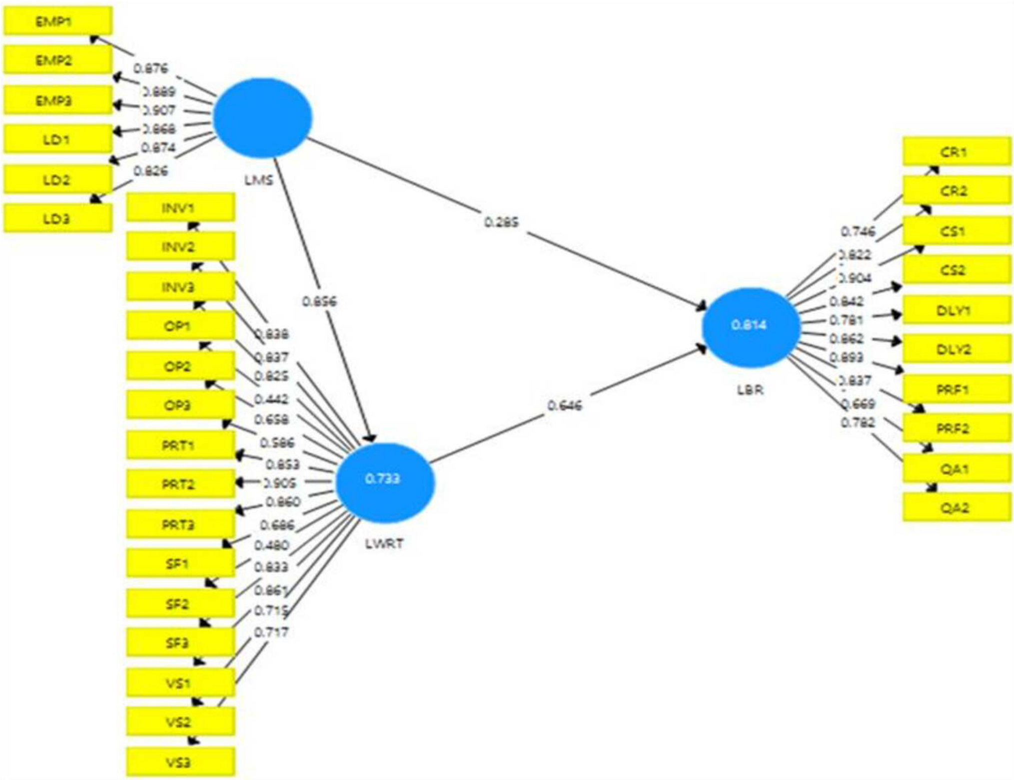

Fig. 6. Effect of LMS, LWRT Implementation on LBR (Model 1)

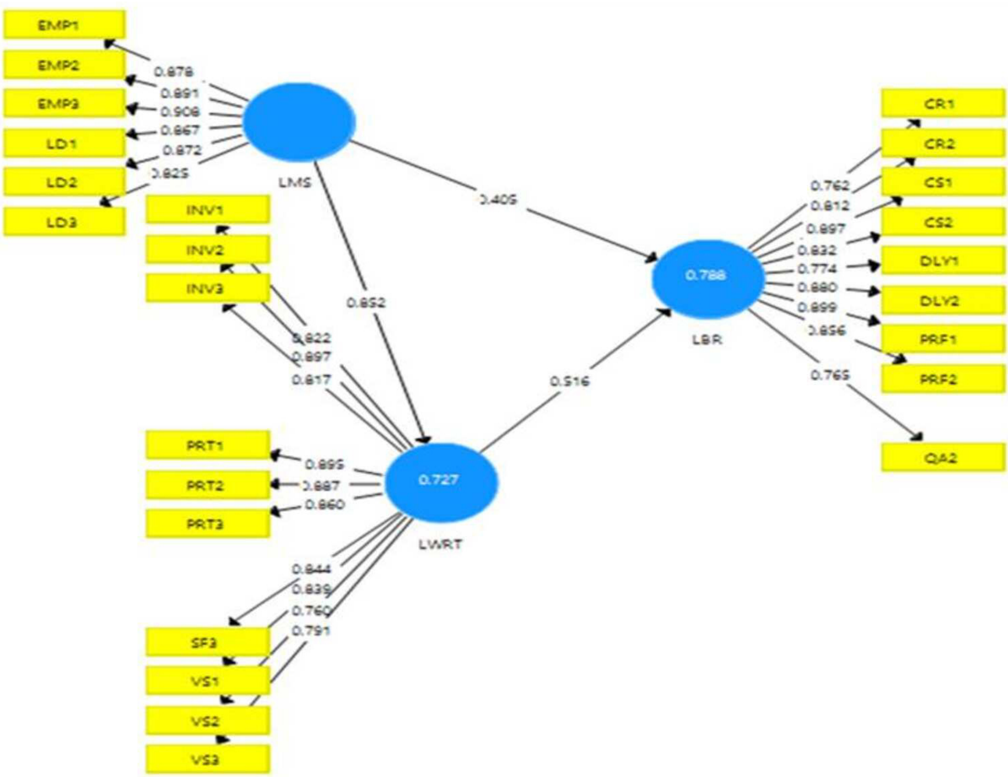

Fig. 7. Effect of LMS, LWRT Implementation on LBR (Model 2)

at the 90% confidence level and will be excluded from the model. Table 3 shows the results of the significance test of the effect of LMS, LWRT on LBR.

Table 3
Significance test results

Variable	Standard deviation	t-statistic	p-values
LMS → LBR	0.278	1.421	0.156
LMS → LWRT	0.051	16.781	0.000
LWRT → LBR	0.287	1.836	0.067

Table 3 shows that LMS has no significant effect on LBR, but LMS has a significant effect on LWRT, while LWRT has a significant effect on LBR. From Figure 7, LBR variation of 78.8% is simultaneously influenced by LMS and LWRT, 21.2% is influenced by other variables. While 72.7% LWRT variation is influenced by LMS variation, and 27.3% is influenced by other variables.

To test whether the overall model can be said to be good or not, a model fit test is carried out. To test the fit model, SRMR, d_ULS, Chi-square, and NFI values were used (Dijkstra et al., 2015). The results of the model fit test can be seen in Table 4. The table shows that the resulting model has been tested as a good model.

Table 4
The result of goodness test of fit

Goodness of Fit Index	Saturated Model	Estimated Model	Cut off value
SRMR	0.119	0.119	< 0.950
d_ULS	7.037	7.037	> 0.05
Chi-Square	8,639.542	8,639.542	high value
NFI	0.062	0.062	0.7–1.0

Discussion

Manufacturing companies that are respondents can be categorized as large companies, having been operating for approximately 10 years. Most companies have implemented Lean for quite some time. Therefore, it is natural that the average level of LMS implementation and LWRT of these companies is already in "Good" category, and has a good LBR as well. This means that the respondent companies already have policies and procedures that create an organizational environment/culture for reducing waste in each of their manufacturing systems, and the respondent companies also have business practices and production processes in their manufacturing systems that result in waste reduction.

The respondent companies have better business results in each of their manufacturing systems. However, in general the respondent companies still have not fully integrated non-manufacturing functions with manufacturing (SF2), and commitment to continuous improvement and/or process changes in long-term plans, capital budgets, training and human resource development, marketing plans and strategic review by all functional business units (SF3) has not been fully carried out properly.

The results of this study are Empowerment (EMP) and Leadership (LD) are valid indicators in building a lean management system (LMS). This fact is in accordance with the opinion of (Alefari et al., 2017) which states, employee empowerment in daily improvement is important for the success of lean implementation in manufacturing companies. Salonitis and Tsinopoulos (2016) based on an exhaustive assessment of the relevant literature, identified essential variables for the effective implementation of lean management, including developing organizational readiness and providing adequate resources to support change. This can be done through training, enabling teamwork, including increasing employee engagement by enabling innovative ideas and/or improvements from all sources, and having a reward system in place to find and eliminate waste, or activities and costs that are not added value. In accordance with the opinion of Hamid (2011) who identified the organization's internal factors and external factors as critical success factors for lean manufacturing. Leadership is also critical in overcoming the inherent resistance to change in any organization's response to cultural change (Prabowo et al., 2020).

This research also confirms the research of Bergmiller (2006) and Bergmiller & McCright (2009) which explains that a valid lean waste reduce technique (LWRT) is formed by the leadership vision and strategy (VS), partnership (PRT), support function (SF), and Innovations in Market Service & Product (INV). This finding is in line with the opinion of Zargun and Al-Ashhab (2014), who in their study identified 27 critical success factors of lean manufacturing which they classified into four groups, including "Strategy" and Goals", "Leadership and Management". Without a leader who has a vision, strategy and goals in improving the quality of production by increasing its value and also reducing waste, lean manufacturing techniques will not work as expected. Leadership does not really add value but those who manage employee activities to increase the product's value in the most effective and efficient way (Dombrowski & Mielke, 2013).

Mohammad and Oduoza (2019) argue to facilitate the transition to Lean, organizations rely on collaboration (partnership) and support from all other advocates. This collaboration and support can take the form of expert consulting, customer relations and workforce training. Prabowo et al. (2020) said that through Lean management innovation will drive continual progress by activating an analytical mindset and pursuing a systemic problem-solving approach to produce an efficient and effective learning process, ideally in a collaborative setting.

This study also proves that almost 80% of LBR variation is significantly influenced by LMS mediated by LWRT. This shows the significant role of LMS in the success of LBR through the implementation of LWRT. This means that leadership and empowerment can drive business practices and production processes in the manufacturing system through a vision and strategy in running lean, partnership or collaboration in order to find the best practice in reducing waste, which is supported by all functional units of the organization, and constantly innovating has been able to improve LBR. This is in line with previous research which says that lean is able to create quality improvement (Samuel et al., 2021), productivity improvement (Edwin et al. 2016), cost improvement (Gračanin et al., 2019), delivery improvement (Sisler et al., 2017), business performance improvement (Mohaghegh et al., 2021), and improve customer satisfaction (Emiliani, 2004). Research by Prabowo and Adesta (2019) also has a similar result that Lean tools/technique have a positive and significant impact to manufacturing performance: cost, quality, delivery and flexibility. The success of business practices and production processes in the manufacturing system (LWRT) 73% is influenced by LMS or policies and procedures in creating an environment/culture of waste reduction, which in its implementation is largely determined by leadership and empowerment. As concluded by (Alefari et al., 2017, Farida et al., 2019, Farida et al., 2021) that leadership factors are the key in almost all studies of critical success factors for lean manufacturing and human resource empowerment (Mohammad &Oduoza, 2019, Farida et al., 2021).

Conclusions

This study complements the research of Bergmiller (2006); Bergmiller and McCright (2009) by proving a significant influence between the main Lean Management System (LMS) variables on the Lean Business Result variable through the application of Lean Waste Reducing Techniques (LWRT) with T-value 16.781. The Lean Management System built by good leadership ($R = 0.852$) and human resource empowerment ($R = 0.885$) will be able to carry out the Lean Waste Reduction technique properly through the implementation of vision and strategy ($R = 0.783$), partnerships ($R = 0.860$), support functions ($R = 0.844$), and innovations ($R = 0.846$) in order to reduce waste that occurs in business and production process practices in every manufacturing system. In the end, Lean Waste Reducing Technique will be able to increase Lean Business Result ($R^2$80%). Research's respondent comes from various industrial fields, then it needs to conduct for one type of industry only to be more specific results. This research confirms Bergmiller (2006) and Bergmiller & McCright (2009) that LMS has a significant effect on LBR through LWRT for the manufacturing industry in Indonesia. So, it is expected to be a guidance for Indonesian manufacturing industry players in implementing LMS successfully.

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Abbreviation

AVE	Average Variance Extracted
CA	Cronbach's Alpha
CR	Composite Reliability
DLY	Delivery
d_ULS	Squared Euclidean distance
EMP	Empowerment
HR	Human Resources
INV	Innovations
LD	Leadership
LBR	Lean Business Results
LM	Lean Manufacturing
LMS	Lean Management System
LWRT	Lean Waste Reduction Technique
NFI	Normed Fit Index
OP	Operation
PLS	Partial Least Square
PRF	Profitability
PRT	Partnership

QA	Quality Improvement
SEM	Structural Equation Modelling
SF	Support Function
SRMR	Standardized Root Mean square Residual
VS	Vision and Strategy

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