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Abstract

Purpose – The purpose of this paper is to increase productivity through smart maintenance planning by including productivity as one of the objectives of the maintenance organization. Therefore, the goals of the paper are to investigate existing machine criticality assessment and identify components of the criticality assessment tool to increase productivity.

Design/methodology/approach – An embedded multiple case study research design was adopted in this paper. Six different cases were chosen from six different production sites operated by three multi-national manufacturing companies. Data collection was carried out in the form of interviews, focus groups and archival records. More than one source of data was collected in each of the cases. The cases included different production layouts such as machining, assembly and foundry, which ensured data variety.

Findings – The main finding of the paper is a deeper understanding of how manufacturing companies assess machine criticality and plan maintenance activities. The empirical findings showed that there is a lack of trust regarding existing criticality assessment tools. As a result, necessary changes within the maintenance organizations in order to increase productivity were identified. These are technological advancements, i.e. a dynamic and data-driven approach and organizational changes, i.e. approaching with a systems perspective when performing maintenance prioritization.

Originality/value – Machine criticality assessment studies are rare, especially empirical research. The originality of this paper lies in the empirical research conducted on smart maintenance planning for productivity improvement. In addition, identifying the components for machine criticality assessment is equally important for research and industries to efficient planning of maintenance activities.

Keywords Productivity, Bottleneck

Paper type Research paper

1. Introduction

The modern manufacturing sector is extremely competitive, particularly given increased demands for quality, variety and shorter lead times. This competition has fueled the fourth revolution in the manufacturing industry, especially through initiatives such as Industry 4.0.
and Smart Manufacturing (Thoben et al., 2017). The initiatives are characterized by cyber-physical systems, where physical and engineering systems are connected through the Internet of Things (IoT), i.e. digitalized manufacturing (Hermann et al., 2016). Digitalized manufacturing has placed extremely high expectations on manufacturing systems to deliver substantial increases in productivity, automation and resource efficiency (Monostori et al., 2016). As a result, these places increased requirements for plant-level reliability and availability. In order to realize these expectations, maintenance organization needs to keep pace with the rapid advances in digitalized manufacturing. Dominant themes have been identified that could have great influence on the internal environment of maintenance organizations in the future: fact-based maintenance planning and maintenance planning with a systems perspective are two of them (Bokrantz et al., 2017). Hence, traditional maintenance must transform into smart maintenance, which is intelligent and ready for these challenges (Acatech, 2015). However, traditional industrial maintenance practices are well behind the theory, which is reflected in the poor performance of machines. For example, overall equipment effectiveness (OEE) figures average 50–60 percent in manufacturing companies (Ljungberg, 1998; Ylipää et al., 2017), whereas world-class OEE is expected to be 85 percent. Traditionally, maintenance aims at maximizing only the availability component of OEE, thereby increasing machine-level productivity. This situation is prevalent in maintenance research as well, where single-machine problems have been the primary focus of improvements for maintenance organizations (Helu and Weiss, 2016; Li et al., 2009). However important this may be, the effects of single-machine failures on the system as a whole, i.e. ripple effects, are also a major concern. Ripple effects cause blocked and starved machine states on other machines (idling losses), thereby compromising system-level productivity and causing energy losses (Skoogh et al., 2011). The effect is compounded further when multiple machine failures occur. The variability caused by the idling losses needs to be mitigated through achieving a swift and even production flow, which can increase productivity without reducing flexibility in production (Schmenner and Swink, 1998). Therefore, simultaneously maintaining more than one machine in a system (maintenance prioritization) is an important research problem that needs to be addressed (Roy et al., 2016).

The prioritization of maintenance operations is an important task for achieving production system efficiency (Levitt, 1997; Ni and Jin, 2012). However, there is a lack of robust decision support tools for identifying critical machines for prioritizing maintenance. A previous study showed that although manufacturing companies prioritize maintenance operations, they do so without properly setting machine criticalities (Gopalakrishnan and Skoogh, 2018). Additionally, the maintenance decisions at the shop-floor level were operator-influenced or based on experiences of maintenance technicians. This phenomenon was also explained in Guo et al. (2013), which states that maintenance work-order prioritizations are often made based on the experience and knowledge of maintenance technicians. This clearly indicates the problem of not adhering to fact-based decision making in companies for making maintenance decisions. Therefore, the computerized maintenance management systems (CMMS), which should support maintenance decisions, are unused. Ni and Jin (2012) say that existing CMMS are outdated and do not adhere to the dynamic needs of maintenance operations.

Maintenance activities can be broadly categorized as either preventive maintenance (PM) or reactive maintenance (RM), both of which require planning and support. Machine criticality assessment is a tool that supports maintenance decision making (Bengtsson, 2011; Stadnicka et al., 2014), which includes support for both PM and RM activities. The roots of criticality assessment can be found in the reliability centered maintenance (RCM) approach, where failure mode and effects analysis (FMEA) is used to assess failure modes in machine components (Moubray, 1997). This type of tool has been expanded to operate
at machine level as FMECA (where $C = \text{criticality}$) (Bertolini and Bevilacqua, 2006). Manufacturing companies generally employ some form of machine criticality analysis, whether that be FMECA, ABC classification (Marquez et al., 2008; Bengtsson, 2011), risk analysis (Moss and Woodhouse, 1999), fuzzy-based analysis (Ratnayake and Antosz, 2017; Pelaez and Bowles, 1994), etc.

Despite the various methods available for assessing machine criticality, it was previously found that it is hardly used in practice for maintenance prioritization (Gopalakrishnan and Skoogh, 2018). This begs the questions: how can maintenance be prioritized effectively? And if manufacturing companies have criticality assessment tools at their disposal, why do they not use them? Therefore, there is a considerable need to find out how manufacturing companies work with their machine criticality assessment and identify the necessary steps to enable maintenance organization to focus on increasing productivity. Especially, the main objectives for using criticality assessment, the factors considered for criticality assessment and the type of data used for assessment will provide profound knowledge on the assessment tool. This knowledge will help in developing decision support tools for achieving smart maintenance planning.

The purpose of this study is to increase productivity through smart maintenance planning, with the aim of including productivity as an objective for the maintenance organization. As a result, the study aimed at mapping the objectives, uses, methods and data requirements for existing machine criticality assessment and identifying the components of machine criticality assessment to support maintenance decisions that increase productivity. This paper particularly focuses on the discrete manufacturing industry. The results will provide a greater understanding of the existing gaps in criticality assessment and can identify potential productivity improvement opportunities.

Machine criticality assessment studies are rare, especially empirical research. As greater practical focus is needed in maintenance research, an empirical study was chosen (Fraser et al., 2015). The rest of the paper contains the literature review, methodology, results, discussion and conclusion. Additionally, the topics that were chosen for analysis in the study emerged from the literature on machine criticality, as explained in Section 2.

2. Related literature

In this section, the literature related to machine criticality assessment and its relationship with maintenance planning are presented. Based on the goals of the paper, the literature is presented under the headings Objectives of machine criticality assessment, Factors and methods, Data requirements and Maintenance planning. The design of the interviews and focus groups in each of the cases in the multiple case studies was determined by the outcome of the literature analysis. Finally, the codes for analysis were determined based on the synthesis of literature under each heading.

2.1 Objectives of machine criticality assessment

The overall objective of any machine criticality assessment tool is to support maintenance operations decisions. However, the specific objectives of an individual tool are dependent on the intended usage. Marquez et al. (2015) describe the maintenance management process in two parts: strategic and operational. The strategic part deals with determining objectives and priorities when choosing maintenance strategies, whereas the operational part deals with the implementation of the strategy, for example, maintenance planning, control, supervision and continuous improvement. Additionally, Marquez et al. (2015) and Moss and Woodhouse (1999) describe two types of criticality assessments: those performed during the operational phase and those performed during the asset design phase. For assessments carried out during the operational phase, the objective is to identify critical areas in the production system in order to meet machine availability targets (Marquez et al., 2015).
Generally, maintenance prioritization is the primary objective when assessing machine criticality (Bengtsson, 2011; Márquez et al., 2009). However, priorities can also be assigned with regard to reliability (Roy and Ghosh, 2010; Bevilacqua et al., 2009), PM (de León Higes and Cartagena, 2006), RM (Li and Ni, 2009; Wedel et al., 2016) and costs (Moore and Starr, 2006). Additionally, the productivity as an objective (Moss and Woodhouse, 1999; Stadnicka et al., 2014; Ni and Jin, 2012) and production scheduling quality (Petrovic et al., 2008) are also presented in the literature. Even though productivity is considered as an objective, it is only considered implicitly. Productivity is sought after on individual machines by maximizing its availability, for example Moss and Woodhouse (1999). Another major industrial application area in which criticality assessment tools are used is spare part inventory planning (Stoll et al., 2015; Sun, 2013). The objective of the criticality assessment tool determines its usage and focus in maintenance improvement. Based on the aim of the study and the criticality objectives mentioned above, the topics of the purpose of assessing criticality, productivity focus, PM and RM use and spare part planning are chosen for analysis.

2.2 Factors and methods

Generally, much of the literature on machine criticality suggests multiple factors for assessment (Bengtsson, 2011; Ratnayake et al., 2014; Stadnicka et al., 2014). Two common factors for maintenance organizations to focus are safety and environment (Pintelon and Parodi-Herz, 2008). Certainly, other factors have been used for assessing machine criticality for maintenance purposes. Therefore, it is important to know which factors have been included in assessing criticality. When FMEA is used to assess failure modes, particularly attention is paid to the probability and consequence of failure (Moss and Woodhouse, 1999), whereas when an ABC-type criticality classification is used, factors such as redundancy, utilization, quality, age and cost are assessed (Bengtsson, 2011; Ratnayake et al., 2014). FMECA methods consider additional factors such as environmental aspects when assessing criticality (Costantino et al., 2013). Moving on to methodology, FMEA uses the multiplication of factors to calculate a risk priority number (RPN) for maintenance planning (Moss and Woodhouse, 1999; Pelaez and Bowles, 1994). ABC-type criticality assessments use some form of a scoring system, where the total criticality score for each machine is calculated on a scale of A, B or C in order to determine the levels of criticality (Ratnayake et al., 2014; Stadnicka et al., 2014).

In additionally to the machine criticality assessment literature, there are several other methods for maintenance decision making. Maintenance decision making is often viewed as an optimization problem for planning and scheduling work orders. A large amount of literature has been published in this area for finding optimal maintenance solutions (Ding and Kamaruddin, 2014). Some of the main maintenance optimization models include multi-criteria decision making (MCDM), analytic hierarchy process, fuzzy logic and simulation (Garg and Deshmukh, 2006). Similar to criticality assessment, maintenance optimization process also includes objectives, factors and methods, analytical approach for analysis and function description (maintenance planning and scheduling activity) (Ding and Kamaruddin, 2014). One of the main criticism toward optimization models is that they are unable to fully cover the gap between research and industrial practice, as industrial environment is highly complex, and the fluctuations with factors and variables are not fully documented and analyzed (Ding and Kamaruddin, 2014). Because of the lack of extensive usage in the industry for decision making, optimization models are not considered further in this paper. Also, the central aim of the paper is about machine criticality assessment and not the optimization of the maintenance policies. Therefore, the factors and methods used to determine the ease of analysis and utility of machine criticality are considered for analysis. Hence, the topics factors for assessing criticality and methods for assessing criticality are chosen as for analysis within factors and methods of assessing criticality.
2.3 Data requirement

The next step after analyzing objectives, factors and methods for assessing criticality is to understand the data required to perform the assessment. Moss and Woodhouse (1999) state that human psychology is important as statistical considerations when implementing machine criticality assessments, meaning that all relevant members of the workforce should be included in setting priorities. The model provided by Pelaez and Bowles (1994) combines qualitative and quantitative factors to determine “riskiness.” Failure data are a specific requirement in many criticality assessment methods (Stadnicka et al., 2014; Bengtsson, 2011), as these are main data that directly correspond to maintenance. In other situations, purely qualitative data such as group discussion (cross-functional) with the relevant participants are used for assessment (Bengtsson, 2011; Márquez et al., 2015). Cost-based criticality (CBC) uses different cost calculations for assessing criticality, for example, CBC (Moore and Starr, 2006) and cost deployment (CD) (Yamashina and Kubo, 2002) to assign costs for machine downtime and loss of production from which criticality is then assessed. A model developed by Antosz and Ratnayake (2016) uses real production data such as machine failures, product quality deterioration and machine availability/downtime for criticality assessment. Additionally, Gopalakrishnan and Skoogh (2018) demonstrate “operator influence” as a factor in deciding criticality levels. Machine data from manufacturing execution system are not commonly used for criticality analysis. It is therefore important to consider the usability of the criticality assessment tool and the frequency of updates. Hence, the topics of data usage and usability and updates are chosen for analysis.

2.4 Maintenance planning

Machine criticality assessment is not the only tool that supports maintenance planning. Garg and Deshmukh (2006) provide a detailed account of the various maintenance management models that are used for maintenance planning and scheduling activities. However, if machine criticality is insufficient, then achieving optimum maintenance planning is unlikely as it shows where to prioritize maintenance efforts (Stadnicka et al., 2014). To support the need for criticality assessment, Ni and Jin (2012) claim that maintenance prioritization is an effective decision support tool for maintenance engineers. There are several examples demonstrating the importance of setting priorities for maintenance staff in the execution of maintenance planning and scheduling activities (Garg et al., 2010; Wedel et al., 2016; Li et al., 2009). The above-mentioned literature seeks productivity improvement on a system level. To have productivity as objective calls for cross-functional collaboration within the company. Bengtsson (2011) and Zanazzi et al. (2014) also emphasize the importance of synergy between production and cross-functionality across the organizations. The cross-functional approach can be achieved by having a system perspective for solving maintenance problems, which will lead to improve the system productivity (Ylipää et al., 2017). Therefore, ownership synergy and production synergy are the topics chosen on the maintenance planning level for the analysis in this study. In addition to this, problems in machine criticality were also chosen as an additional topic for analysis in order to identify the perceived problems with criticality assessment.

3. Methodology

The aim of the paper requires that the study to be conducted in the natural setting (empirical) through observing actual practice and capturing the complexity of criticality assessment, which is why case research methodology was chosen (Voss et al., 2002). This approach provides a deepened knowledge of machine criticality practices in manufacturing companies. An embedded multiple case study approach was adopted for a more detailed level of inquiry (Yin, 2013). A multiple case study was chosen to increase the
generalizability of the theory-building process (Flynn et al., 1990). Six cases were studied from three multi-national automobile manufacturers. The design of the study was tested in a pilot case with an industrial partner, where the data collection and analysis procedure were tested. The research design is illustrated schematically in Figure 1.

3.1 Case selection
The case selection is an important process that needs to be in order with the purpose of the study. A total of six case studies were chosen from six different production sites across three multi-national manufacturing companies located in Sweden. All the selected cases were from discrete manufacturing companies but the cases were ensured that they were varied from each other. Six empirical data sets (ED1–ED6) were collected in each of the six manufacturing sites separately, and this forms the basis for building theory within machine criticality and maintenance prioritization. The criteria for choosing the cases include: the case company should use or have machine criticality assessment tool, willingness to improve maintenance practices, different products being produced and type of production set-ups and geographically separated from each other and employed different work procedures, i.e. no two cases were from the same manufacturing site. The cases were distributed among the three companies: four data sets (referred as ED1–ED4) were collected from four chosen manufacturing sites in case company A, while one manufacturing site was selected for each of case companies B and C (referred as ED5 and ED6, respectively).

3.2 Empirical data collection
Data collection was carried out through interviews, focus groups and archival records. However, data were predominantly collected in each of the cases through interviews and focus groups. A total of eight interviews and five focus groups were conducted across all cases. See Table I for the distribution of data collection in each case. The interviews and focus groups were developed from the theory of machine criticality assessment. The interview and focus group questionnaires were revised with the help of both industrial partners and senior researchers from the university. Archival records include documents on the criticality assessment tools at the various sites, which were gathered from the CMMS system of the company.
All the interviews and focus groups were performed face to face, except in ED1 (case company A). Data were collected from a single telephone interview because the production site is located outside of Sweden. However, in the other case sites (ED2–ED6) at least two interviews or focus groups were conducted. The empirical data collected focused on machine criticality assessment and maintenance prioritization practices. The face-to-face interviews lasted between 45 and 60 min, whereas the focus group interviews lasted about 120 min on average. All the interviews and focus groups were audio recorded with the consent of the participants and further transcribed for data analysis.

3.3 Data analysis
The six sets of empirical data were triangulated leading toward a strong theory-building process (Creswell, 2013). As the first step, a within-case analysis was conducted. The within-case analysis was conducted with guidance from theory, which allowed analysis to focus on the significant parts of the study (Yin, 2013). First, theory on machine criticality assessment objective (Section 2.1) was used to code the empirical data for the purpose, PM and RM use, productivity focus and spare part planning. Second, the theory on factors and methods of the criticality assessment (Section 2.2) was used to code the empirical data to identify the factors and methods involved. Third, the theory on data requirement for assessment (Section 2.3) was used to code the data on understanding the quantitative and/or qualitative nature and usability of the criticality assessment. Finally, additional coding was performed using theory on maintenance planning (Section 2.4) for connecting the assessment tool with maintenance decision-making practices. These form the predefined topics for within-case analysis.

The predefined topics from theory were used to code the six data sets. The coding process was performed with the help of NVIVO qualitative data analysis software. The transcripts of the interviews and focus groups, which form the six data sets, were coded in the software. The software enables maintaining of the links between the predefined topics and the first-order codes from the data. A total of 284 first-order codes were coded from the six empirical data sets. These codes were used to present as results in each ED.

In addition to the within-case analysis, a cross-case analysis was also performed. With the cross-case analysis, the aim was to identify the similarities and differences between the cases (Yin, 2013). The cross-case analysis further increases the generalizability of the results achieved.

3.4 Generalizability
One of the common misunderstandings about case study research is that generalization cannot be achieved (Flyvbjerg, 2006). Even though generalizability is possible from a single case study, the use of multiple case study design in this paper increases generalizability to a large extent in comparison to a single case study (Yin, 2013). The empirical data sets were first analyzed individually within each case, thereby allowing the emergence of a unique pattern in each. A cross-case analysis was then

<table>
<thead>
<tr>
<th>Data</th>
<th>Interviews</th>
<th>Focus groups</th>
<th>Archival records</th>
<th>Type of production layout</th>
</tr>
</thead>
<tbody>
<tr>
<td>ED1</td>
<td>1</td>
<td></td>
<td>Yes</td>
<td>Assembly</td>
</tr>
<tr>
<td>ED2</td>
<td>3</td>
<td></td>
<td>Yes</td>
<td>Machining</td>
</tr>
<tr>
<td>ED3</td>
<td>3</td>
<td></td>
<td>Yes</td>
<td>Assembly, foundry and machining</td>
</tr>
<tr>
<td>ED4</td>
<td>2</td>
<td></td>
<td>Yes</td>
<td>Assembly and machining</td>
</tr>
<tr>
<td>ED5</td>
<td>2</td>
<td></td>
<td></td>
<td>Machining</td>
</tr>
<tr>
<td>ED6</td>
<td>2</td>
<td></td>
<td></td>
<td>Machining</td>
</tr>
</tbody>
</table>

Table I. Cases and data sources
conducted to assist in seeking generalization (Voss et al., 2002). Additionally, in each of the cases, the data were gathered from more than one data source, with each data source including different types of production set-ups. Triangulation through the use of different methods and data sources also increases the generalizability and validity of the research (Voss et al., 2002; McCutcheon and Meredith, 1993).

4. Results
The multiple case study was conducted in the form of interviews and focus groups at each of the case sites, along with archival records from some sites where available. The first six sections consist of the within-case results of the EDs, and the last section contains the cross-case analysis results.

4.1 Within-case analysis – ED1
The results of the first case (ED1) are presented in Table II. ED1 data are gathered from a single interview with the maintenance manager of an assembly line. It can be observed that the machine criticality classification is being used in this assembly line for maintenance planning purposes. A clear productivity focus is also observed in the classification by working closely with production organizations. However, a central problem in ED1 was that more machines were classified as high critical machines.

4.2 Within-case analysis – ED2
The second case (ED2) consisted of three interviews, and the chosen production line had a machining layout. The results of the analysis are presented in Table III. It can be observed that there was no clear answer regarding the productivity objectives of machine criticality. Analysis of ED2 also showed that the use of the classification tool was limited and the usage of data for the analysis was limited. Additionally, several machines ended up being classified as highly critical. The reasoning was highlighted by the lack of knowledge regarding the type of criticality each machine was classified under.

| Objectives | Critical from customers’ point of view (i.e. production) |
| Productivity focus | Clear connection with production. Working with production organization |
| PM and RM use | Used to prioritize PM and deferred work orders, plus RM |
| Spare parts planning | Separate classification for spare parts planning |

| Factors and methods | Safety and environment, quality, back-up solution, production, MTBF, MTTR and repair costs were the factors |
| Levels of criticality are AA, A, B, C. A decision tree is used to make decisions for above factors |

| Data requirement | MTBF and MTTR were used |
| Usability and updates | Very useful and updated annually |

| Maintenance planning | Maintenance owns the classification and there is good consensus with production |
| Problems in criticality assessment | Over half the machines are classified AA; data quality becomes an issue |

Table II. Results – ED1
4.3 Within-case analysis – ED3

The results for ED3 analysis, where data were collected from a production site that comprised of assembly, foundry and machining lines, are presented in Table IV. Three focus group interviews formed the data set. The results show that in addition to a lack of focus on productivity as an objective for machine criticality assessment, there was also a failure to use data from production. The criticality classification used in ED3 was used to identify critical machines across the entire factory. Furthermore, the criticality assessment was helpful in providing a good understanding with the production organization.

4.4 Within-case analysis – ED4

The fourth case (ED4) comprised of assembly and machining lines, and the results of the analysis are presented in Table V. Similar to ED3 results, productivity as an objective for machine criticality assessment was considered for criticality assessment. In addition, spare parts planning was also excluded from machine criticality classification in ED4. Bottleneck machines not being captured in their existing classification tool came across as a specific problem. There was also a problem with multiple machines being classified as highly critical.

4.5 Within-case analysis – ED5

The results from the analysis of ED5 are presented in Table VI. ED5 comprised of two interviews conducted at the production site, where a production line chosen for the study had machining layout. The results showed that at this site, machine criticality is used mostly for securing spare parts and not much in maintenance planning. The main problems in the classification tool are the lack of trust and poor standardization of the analysis process. As with the other case results, many machines end up with a classification of highly critical.
4.6 Within-case analysis – ED6

Finally, the results of the ED6 analysis are presented in Table VII. These were obtained from two interviews and the chosen production line had a machining layout. The results showed that there was a clear focus on productivity as an objective for

<table>
<thead>
<tr>
<th>Objective</th>
<th>Purpose of assessing criticality</th>
<th>Productivity focus</th>
<th>PM and RM use</th>
<th>Spare parts planning</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Purpose is to increase quality and availability. Also, to start autonomous maintenance and preventive maintenance projects</td>
<td>Productivity not linked to criticality assessment</td>
<td>Not used for PM; PM plan was the same for all machines. Prioritized RM work orders but priorities not based on criticality classification; usually it comes from production</td>
<td>Spare parts plan was same for all machines and not determined by classification</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factors and methods</th>
<th>Factors for assessing criticality</th>
<th>Methods for assessing criticality</th>
<th>Data requirement</th>
<th>Maintenance planning</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Environment, safety and complexity of machine, difficulty for operator; single flow or parallel flow; MTTR; safety and environment; bottleneck were the factors</td>
<td>Used cost deployment to allocate AA, A, B and C classes. Discuss with manager to identify critical machine. Choosing between single and parallel machines. Analysis includes root cause, monthly follow-up MTTR, MTBF, MWT and maintenance cost</td>
<td>Mostly use maintenance technician’s experience for decisions. MTBF and MTTR from CMMS</td>
<td>Maintenance owns the classification. Good understanding of production as the two departments work as a team</td>
</tr>
</tbody>
</table>

| Problem in criticality assessment | Assembly tends to be more advanced; classification process such that same machine is classified as critical every time |

Table IV. Results – ED3

<table>
<thead>
<tr>
<th>Objective</th>
<th>Purpose of assessing criticality</th>
<th>Productivity focus</th>
<th>PM and RM use</th>
<th>Spare parts planning</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Improve the quality of PM and allocate more maintenance to critical machines, bottlenecks and minimize maintenance costs</td>
<td>Productivity not linked to criticality assessment</td>
<td>No PM related use. RM priorities line-based rather than on criticality classifications. This is usually set by production</td>
<td>Spare parts not planned using criticality assessment</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factors and methods</th>
<th>Factors for assessing criticality</th>
<th>Methods for assessing criticality</th>
<th>Data requirement</th>
<th>Maintenance planning</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single or parallel machine, spare parts in-house and technician resource availability</td>
<td>Cost deployment for classifying machines. Inventory showing type of manufacture, type of software/hardware, status of machine, quality, spare parts availability and knowledge availability</td>
<td>OEE and CD were used</td>
<td>Maintenance own classification. Usually obtain consensus but production has final say in case of mismatch</td>
</tr>
</tbody>
</table>

| Problem in criticality assessment | Need to limit number of machines classified as highly critical. Procedure in CD problematic as method fails to adequately capture bottlenecks. Cost calculations in CD provide wrong results |

Table V. Results – ED4
Machine criticality assessment, even if availability remains the main purpose for assessing criticality. Bottlenecks are also used for providing a productivity focus, but data were not used in the assessment. The main problem in ED6 is that the participants felt that the criticality assessment tool does not correctly identify the correct critical machines.

4.7 Cross-case analysis
The cross-case analysis results are presented below:

(1) Similarities:
- Generally, many machines end up being classified as highly critical, i.e. the machines are not differentiated.
Some sorts of classifications (ABC type) are used.
The objective of classification tends to focus on increasing machine availability.
Productivity is not considered an objective in the criticality assessments.
Data usage ranges from “nothing” to the use of “mean time between failure (MTBF)” and “mean time to repair (MTTR).”
Subjective group-discussion-type analysis for setting criticality (qualitative approach) even when data are used.
Maintenance organization responsible for classification.
Hardly used for maintenance planning activities. PM activities are not based on criticality, whereas RM activities are conducted by random prioritization or on a first-come-first-served basis.
Technicians (and their experience) seem to make routine maintenance decisions on the shop-floor.
Criticality classifications rarely updated (quarterly to annually).
Maintenance organizations use classification tool to achieve consensus with the production organization on critical machines.
Current classification tools do not identify the correct machines as critical.

(2) Differences:
Classification tends to work well for assembly and foundry production set-ups, but poorly for machining lines. CD works particularly well on assembly and foundry lines.
Despite using ABC-type classification, the approach for assessing criticality differs, ranging from scale questions, to flowcharts and CD matrices.
Same machine classification tools used for spare parts planning. However, some sites use a separate classification tool solely to identify critical spare parts.
Despite achieving consensus with the production organization on critical machines using the classification tool, decisions or priorities from the production organization override the classification tool, and the maintenance organization must adhere to these.

The results show that the cases have more similarities than differences between them. In particular, current assessment methods that classify large numbers of machines as highly critical creates an issue of trust that militates against their use in maintenance decision making. As multiple unweighted factors are taken into consideration, machines tend to be assessed as critical under one or other of the chosen factors. The lack of focus on productivity can also be attributed to the generic objective of increased availability to which maintenance organizations strive. Subjective assessment methods and decision making based on operator experience are prevalent across the cases as they do not use data from production systems in assessing criticality. However, with regard to the differences between cases, the criticality classification tool works better on certain production flows than others. Production lines with assembly and foundry layout where the production flows are tightly coupled, the criticality assessment tool appears to be used for maintenance decision making and had fewer problems identifying critical machines. Since there are more similarities than differences, it is likely that the problems
with machine criticality assessment prevail across the cases companies. This situation implies that the problems involved in the machine criticality assessment are highly complex.

5. Discussion
This paper presents the problems in machine criticality assessment practice in manufacturing companies and identifies criticality assessment components based on a multiple case study. Six empirical cases were studied, and the results were analyzed within-case and cross-case analyses results. This section synthesizes the results in terms of criticism of existing practices, arguments for achieving smart maintenance planning, and scientific and industrial contributions. Subsequently, discussion on the methodology is presented.

5.1 Existing practices and criticism
On examination of the machine criticality assessment in manufacturing companies, deeper understanding of the existing practices and the problems in its usage were identified. One of the main findings from this multiple case study is the identification of reasons for the manufacturing companies not using their machine criticality assessment tool for planning maintenance. The results strongly indicate improvement opportunities for increasing not only machine efficiency but also the productivity of the system. It was identified that manufacturing companies do not use their classification tools for planning any type of maintenance. A similar phenomenon was observed previously by Gopalakrishnan and Skoogh (2018). The criticality assessment tools were rather simply used only for obtaining consensus with the production organization. Guo et al. (2013) state that maintenance work-order prioritizations are often made using the experience and knowledge of maintenance technicians. Reasons such as lack of trust in the existing classification tool and the assumption that maintenance technicians have a better understanding of the current situation within the production system than the criticality assessment tool can provide were identified for not using the tool for maintenance planning. Especially, the untrustworthy attitude comes from the fact that the method for assessment has not been mastered, and multiple machines end up being highly critical. From the findings, it was further narrowed down to the criticisms in existing classification tools: static, conjectural, complex, biased toward the opinions of those assessing criticality and basing the assessment on multiple factors. As demonstrated in many of the cases, this results in a failure on the part of the criticality assessment tool to identify the correct critical machines. Even in the literature qualitative, multiple factor and static approaches are used for assessing criticality (Márquez et al., 2015; Moss and Woodhouse, 1999; Bengtsson, 2011).

Using multiple factors for assessing criticality is common practice. The case companies use multiple factors in an ABC-type assessment to classify machines. More options are provided in the literature: RPN (Márquez et al., 2015), fuzzy logic (Moss and Woodhouse, 1999), a decision-making scale (Antosz and Ratnayake, 2016), logical algorithm (Moore and Starr, 2006), among others. In addition, there are MCDM models for achieving maintenance optimization. However, when it comes to assessing criticality, using multiple factors hides the critical machine’s primary criticality criterion. Even though this problem was only observed in ED2, the authors argue that the problem may persist in all cases. The very nature of classification means grouping machines in one class or another. However, when multiple factors are used to arrive at that conclusion, the primary criterion or the combination of factors by which a machine was classified as highly critical can be lost. This situation is the main reason, multiple machines within a system end up being classified as highly critical. The results also show that the main objective of the classification is to increase the availability of critical machines. Therefore, maintenance is planned for
improving machine availability. Since multiple factors are used for assessment, the critical machines will not be solely availability critical. For example, a safety-critical machine will need safety-related maintenance activities to improve availability. Additionally, the availability objective of the criticality assessment implicitly indicates the productivity of individual machines. On the other hand, system productivity cannot be ensured by increasing the availability of individual machines because of the rippling effects. Prioritized maintenance efforts for the critical machines will ensure that the availability is maximized for the critical machines. Therefore, the current maintenance decisions may generate non-value adding maintenance activities, resulting in financial losses and also reducing machine availability with concomitant productivity losses. Resolving this situation is not simply a matter of knowing which machines are critical to a production system, it is also necessary to know their type of criticality.

Furthermore, the results show that when different people conduct criticality assessments, different machines might emerge as critical. In most of the cases, achieving increased machine availability was the main purpose. It can be argued that if increasing machine availability was indeed the main purpose, then the factors chosen should be based on increasing availability. Since this was not the case, it can be argued that the current classification tool lacks a clear purpose. The results repeatedly showed from many cases that data of any kind other than MTBF and MTTR were used for assessment. This indicated that the criticality classification tools are not created based on the actual state of the machines production system, i.e. the tool is not fact-based. A criticality assessment which lacks a clear purpose and is not fact-based cannot identify the critical machines. Hence, data-driven tools for maintenance decision support are needed for assessing machine criticality (Ni and Jin, 2012). Another result showed that existing criticality classifications tend to work better in cases where the production site in question had an assembly or a foundry production layout. These cases, in particular, used CD for assessing criticality. Classification then tends to work better because assembly and foundry lines are tightly coupled, meaning that the effects of the failure of a single-machine/station on the rest of the system are easily captured. The participants felt that the tool identified the critical machines at all time. However in the same cases (ED3 and ED4), when machining lines were analyzed criticality classification proved to be less useful, as it was unable to correctly identify the critical machines. Even though the tool is perceived to work well in tightly coupled systems, it is less useful as it is intuitive that a single-machine failure will stop the entire system. In such scenarios, criticality needs to be assessed using machine-level factors to reduce failure on the least reliable machines.

Maintenance planning activity is performed to mitigate the variabilities in production systems so that productivity can be maximized, i.e. a swift and even flow of production is desirable to maintain flexibility and increase productivity (Schmenner and Swink, 1998). This swift and even flow can be achieved by taking a systems perspective to maintenance planning (factory focus). Based on the current practices and criticisms mentioned above, it can be concluded that a standardized procedure with a clear purpose, data-driven decisions and systems perspective is required to assess machine criticality. From the results obtained in this paper, the current state of machine criticality assessment is modeled and presented in Figure 2. The model shows the generalized state-of-the-art practices in machine criticality assessment, and the problems obtained from the six cases. The bullet point list in-between each of the arrows of the figure describes the attributes of the industrial criticality assessment at each stage. The attributes comprise of the current state as well as the criticism against the criticality assessment.

To sum up the results achieved, maintenance organizations in manufacturing companies lack decision-making support that is needed for the planning of maintenance activities to increase productivity. As shown throughout all cases, the productivity of the system as an
objective is overlooked. However, maintenance planning should not only aim to improve individual machine performance (maximizing availability) but also the productivity of the entire system. Therefore, maintenance organizations require new technologies in the form of data-driven, dynamic decision support, e.g., digitalized tools for smart maintenance planning such as IoT. Moreover, organizational changes are also called for to facilitate approaching maintenance issues from a systems perspective (Ylipää et al., 2017).

5.2 Machine criticality assessment for smart maintenance planning

Digitalized manufacturing has increased expectations on the role of maintenance management in delivering high-performing production systems. There is, however, a wide gap between the expectations on digitalized manufacturing and the future role of maintenance. Bokrantz et al. (2017) point out that seven dominant themes will influence the internal environment of maintenance organization in the future. Two among them are fact-based maintenance planning and planning with a systems perspective. This study has particularly addressed these challenges by studying maintenance decision support for smart maintenance planning. This paper has mapped state-of-the-art practices for assessing machine criticality and mapped the gaps in current assessment techniques that hinder the development of high-performance production systems. The results obtained suggest that the focus of maintenance tends to be on solving single-machine problems. The objectives of criticality assessment are therefore related to machine availability and reliability. A large amount of research has focused on single-machine problems, and there is a need to refocus on planning maintenance for multiple machines (Helu and Weiss, 2016; Roy et al., 2016). Because machine downtime can cause rippling effects which lead to idling losses and the machines downstream and upstream. These rippling effects reduce the productivity of the whole system (Skoogh et al., 2011).

On the technical aspect of maintenance organizations, i.e., decision support tools, CMMS have been argued to be obsolete and can no longer support maintenance decision making given the dynamic needs of production systems (Ni and Jin, 2012). The results of this study have exemplified this argument by showing that existing machine criticality assessment techniques are inadequate in terms of identifying critical machines for planning maintenance activities and support effective maintenance decisions.
Production systems are dynamic in nature; naturally, the criticality of the machine in the system as well will tend to change from time to time. Digitalized manufacturing provides opportunities in terms of machine data availability and quality, connectivity through IoT and digital tools. Real-time data analysis of data sets from machines can enable a more accurate and dynamical approach to identify critical machines. Additionally, such an approach can also provide insights into not only which machines are critical but also why they are critical. This kind of decision support can assist maintenance planners/engineers to plan maintenance with greater accuracy based on the needs of the machines. Therefore, a data-driven approach is necessary for assessing machine criticality in order to make fact-based decisions.

Regarding the organizational aspect, industrial practices on and approaches to maintenance issues lack a systems perspective, something that is reflected in this study by the types of goals (e.g. machine availability) and KPIs (e.g. MTTR and MTBF) that are used within maintenance organizations. These are focused on individual machine performance. Even though these measures and goals are important, they alone cannot improve system performance. Therefore, future machine criticality assessment should focus on prioritizing PM and RM maintenance activities on the critical machine for the sake of the whole system (e.g. bottlenecks) at any given point in time. Maintenance organizations tend not to work with bottleneck machines, preferring to consider all machines as on the same level with regard to the throughput of the system. To think in terms of and apply bottleneck-critical based maintenance prioritization is the desired organizational change. Even though the results have shown that classification tools provide synergy between the maintenance and production organizations, incorporating productivity as an objective in the overall maintenance goals will truly enable reaching production synergy. This organizational change (systems perspective) together with the technical advancements (data-driven and dynamic approach) can bring us closer to the smart maintenance planning that is necessary for digitalized manufacturing.

5.3 Scientific contribution

The scientific contribution of the paper is the identification of components for data-driven machine criticality assessment. Traditionally, machine criticality assessment has not been widely studied in research communities. Even though RCM-based approaches such as FMEA are prevalent, these only assess component-level criticality using failure modes (Moubray, 1997). System-level criticality assessments are rare and tend to adopt a static, qualitative, multiple-factor approach (see examples in Márquez et al., 2015; Bengtsson, 2011; Moss and Woodhouse, 1999). However, the results of this study have shed light on the problems faced in companies due to poor criticality assessments. Arguably, the biggest problem is that, despite the efforts expended in creating criticality classifications, these are not used for maintenance planning purposes because they are deemed to be untrustworthy and unable to identify the correct critical machines. Therefore, future criticality assessment needs to be developed in such a way as to resolve these issues. In particular, more empirical research is needed within maintenance (Fraser et al., 2015). With this in mind, the following are identified as the major components of machine criticality assessment that should support maintenance decision making:

- to have productivity as the main objective (systems perspective);
- continuous monitoring of machine states (producing, downtime, idling losses, etc.) to identify criticality;
- data analytics on machine-state data to facilitate real-time decisions;
- define the type of criticality in addition to assessing criticality;
selecting factors and assessment windows based on needs (e.g. PM needs a larger time window with several factors, whereas RM needs a shorter time window with throughput criticality as the sole factor); and

- machine failure pattern and root cause analysis (predictive and prescriptive maintenance) to decide on type and frequency of maintenance allocation.

Automated decision support that continuously predicts and prescribes critical machines for maintenance decision making is desirable. This decision support will make maintenance efforts selective, fact based and enable faster decisions. Most importantly, it clearly brings the productivity objective into the maintenance organization. It should be noted that achieving automated decision support is not the first step. Problems such as data analytics, data availability, data quality, data security and IT competencies within maintenance organizations need to be addressed before a robust machine criticality assessment tool can be obtained. However, the opportunities provided through digitalized manufacturing, such as IoT tools, fast internet connectivity, etc., will enable this to be rapidly achieved. In particular, the authors intend to develop a framework for machine criticality assessment in the future.

5.4 Industrial contribution

The results of the study, i.e. a deeper understanding of machine criticality assessment practices and struggles in maintenance planning, are of great importance to the maintenance organizations in manufacturing companies. Additionally, as an empirical study, the results achieved are highly relevant to the companies concerned. The results also provide opportunities and methods to improve maintenance planning and seek productivity increase. The main contribution of the research work is the inclusion of productivity as an objective in overall maintenance goals. The components of machine criticality assessment identified in the previous headings suggest that smart maintenance planning offers productivity improvement opportunities without major financial investment to the machines. However, the greatest challenge will be the technical and organizational changes discussed, as these will require the combined efforts of those on both the managerial side and the shop-floor level. Competition and the need for aggressive growth are pushing manufacturing companies toward rapid change, making the results that can be achieved by improving maintenance organizations highly relevant to the current and future marketplace.

5.5 Methodology discussion

The goals of the paper dictated for in-depth understanding of the industrial practices on machine criticality assessment and maintenance decisions supported by the tool. The multiple case study methodology helped in achieving the goals of the paper by enabling in-depth studies at six different production sites from three different companies. Additionally, the six cases had variety in terms of work culture and procedure, different production set-ups and different products being produced. This case study approach provided the advantage of deep learning from six different production sites than compared to that of a large scale questionnaire survey which will not enable in-depth study. Even though case study approach was employed, careful considerations have been made to increase generalizability and validity. Triangulation of different data sources (ED1–ED6) and different data collection methods (interviews and focus groups) ensured that the results obtained were generalizable for discrete manufacturing (Voss et al., 2002; McCutcheon and Meredith, 1993). Furthermore, cross-case analysis was also performed seeking generalization. As a result, a generic model of existing machine criticality assessment and components of machine criticality assessment for increasing productivity were obtained.
6. Conclusion
The advancements in digitalized manufacturing require traditional maintenance practices to transform into smart maintenance which supports the dynamic maintenance needs and increase productivity. This study focuses on the maintenance decision making by studying the machine criticality assessment tool to achieve smart maintenance. Previously, it was found that manufacturing companies work with assessing machine criticality, but it was rendered ineffective for making maintenance decisions. Therefore, the goals of the paper are to map the objectives, uses, methods and data requirements for machine criticality assessment and to identify its components to increase productivity, with the aim of including productivity as an objective for the maintenance organization.

The results were achieved through a multiple case study was conducted with six cases in three multi-national companies. An in-depth understanding of the industrial practices on setting machine criticality, the purpose and problems with it for planning maintenance was identified. Specifically, the study identified that the companies perceive the existing criticality assessment tools to be untrustworthy. The tools did not identify the right critical machines which are crucial for decision making. It was identified that qualitative approach, lack of data usage from machines, static procedure, multiple assessment factors and lack of clear objectives were the main reasons behind this. Furthermore, the results obtained also provide additional reasoning behind operator-influenced and experience-driven decision making instead of fact-based decision making. On analysis of the results, technological (dynamic and data-driven decision making) and organizational (systems perspective) changes that are needed within the maintenance organization were prescribed. Data-driven machine criticality can enable maintenance decisions to be based on facts, whereas approaching maintenance with a systems perspective enables maintenance to focus on maximizing system productivity instead of maximizing availability. By the results achieved, this study describes the components of future machine criticality assessment: to have productivity as the main objective, continuous monitoring of machine states, data analytics, defining the type of criticality for the machine and selection of factors for assessment based on machine needs and including failure pattern and root cause. In conclusion, this study points toward a data-driven machine criticality assessment for making factual maintenance decisions. Such a decision support will be essential for achieving smart maintenance planning, thereby enabling also to fulfill the demands of digitalized manufacturing.

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Modeling the efficiency of Tunisian and Moroccan banks using the SFA approach

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Abstract
Purpose – The purpose of this paper is to evaluate and compare bank efficiency between the two Maghreb countries, Tunisia and Morocco, over the period 2005–2014.
Design/methodology/approach – The authors follow the stochastic frontier analysis, where the preferred cost model is determined via various hypothesis tests based on the maximum likelihood estimation. Then, the first and the second derivatives of the cost function are employed to determine scale elasticities, scale inefficiencies and technological progress.
Findings – Specification tests indicate that the Fourier Flexible form provides better fit to the data set. Further, the estimated model shows that Tunisian and Moroccan banks’ efficiency is positively affected by banking service quality, but negatively influenced by both bank capitalization and GDP growth. Overall, Moroccan banks are found to be the most efficient despite the decrease of efficiency levels in both countries. Additionally, foreign banks have a higher scale inefficiency and, therefore, a lower cost efficiency. Equally, the technical progress raises banking costs in both countries, providing a decrease in efficiency scores.
Practical implications – The findings of this study provide novel insights to Tunisian and Moroccan policy makers on the relevance of the smaller banks’ consolidation to improve bank efficiency by achieving unrealized economies of scale. Also, more reforms should be implemented in Tunisia to reduce non-performing loans.
Originality/value – To the best of the authors’ knowledge, this study is the first which offers a comparison between Tunisian and Moroccan banks to clarify the sources of inefficiency and to make strategic decisions.
Keywords Banks efficiency, Environmental variables, Fourier Flexible form, Scale economies

1. Introduction
Following the universally maintained financial liberalization strategy, banks have begun to look for new sources of income and new businesses or services. As a result, banking products have multiplied, making performance analysis as undertaken via traditional tools insufficient and unreliable. Such a procedure entails taking into consideration both of the economic as well accounting aspects of performance, through the implementation of new performance indicators. In this respect, efficiency and cost optimization turn out to be essential factors for assessing banks’ performance.

In the Maghreb countries, the banking systems have witnessed a period of increased competition as a result of deregulation and financial liberalization. In particular, Tunisia and Morocco have experienced similar phases in their way toward a liberal economy. Their banks are currently operating in a very competitive environment marked with the development of foreign capital. This situation has culminated in increased banks’

JEL Classification — C1, G21, G3
activities as well as their size. Hence, the bank’s cost structure has been marked with significant changes, leading to a change in their efficiency. Thus, a study of these banks’ efficiency determinants turns out to be very important. Such a procedure would enable us to identify the country-specific as well as the bank-specific variables likely to influence the level and variability of cost efficiency.

The contribution of our study is threefold. In the first place, it aims to provide recent data relevant to the efficiency of Tunisian and Moroccan banks through the application of the Fourier Flexible form, which takes into account the banking costs’ characteristics in modeling the cost frontier. In this context, the cost efficiency concept is applied using a number of different cost frontier forms (the Translog form vs the Fourier Flexible form, the inclusion of control variable, the distribution of the inefficiencies’ term) to a single data set. On choosing the “preferred” cost model to estimate efficiency levels, various hypothesis tests are administered to reach the preferred model specification. It is also noteworthy that robust evidence drawn from the implementation of the Fourier approach, as appropriate banking cost function, appears to cast doubt on the previously conducted studies’ documented results, based on the application of the Translog form. Hence, on applying the present research provided guidelines, bank policy makers are enticed to reconsider their strategic decisions. In the second place, this study aims to make a distinction between scale inefficiencies, scale economies and technological progress in a bid to determine their relationships with bank efficiency. Finally, we intend to fill the gap persistent in banking literature through comparing the banking efficiency as prevailing in two Maghreb countries. Indeed, most of the previously conducted studies have been focused on either establishing a comparison between several MENA region sited countries, or conducting analysis studies relevant to a single country. Consequently, the interpretation of our results could well have certain repercussions on bank regulation, not only concerning Tunisia and Morocco, but also potentially regarding the Arab Maghreb region, where the banking and regulatory systems and structures appear to be significantly comparable.

The remainder of this paper proceeds as follows. Section 2 depicts a literature review dealing with efficiency studies, paying special attention to the various methods used to describe bank efficiency analysis. Section 3 is focused on highlighting the applied data and adopted methodology framework. Section 4 displays the reached empirical results, while Section 5 bears the relevant conclusion along with a discussion of the major policy implications.

2. Literature review
In the economic literature, various studies appear to use different methods whereby banks’ efficiency could be estimated with regard to several countries, following the parametric approach. The most recent of these research works used a Cobb–Douglas specification to model the cost function using the stochastic frontier approach, as introduced by Aigner et al. (1977) and Meeusen and van den Broeck (1977). As for Hasenkamp (1976), he documented that if the structure of (single output) production technology is more complex than its Cobb–Douglas representation, the unmodeled complexity will be revealed in the error term, and might well result in biased estimates of the inefficiency cost. In fact, ever since the mid-1980s, most studies have made use of the Translog functional form to estimate the cost efficiency as relating to the banking sector. For example, Dietsch (1993) undertook to examine cost efficiency in the French banking sector, while Lang and Welzel (1996) estimated cost economies as associated with German cooperative banks.

A study by Altunbaş, Gardener, Molyneux and Moore (2001) provided a contribution to the established literature by modeling efficiency via stochastic cost frontier with the Fourier Flexible functional form, to account for the cost characteristics of the European banking sector. According to them, the Fourier Flexible form proves to be more global than the Translog form, as it allows for better data approximation of the true form.
of the unknown cost function. This is mainly due to the mathematical behavior of the sine and cosine functions, which can fit exactly well with any well-behaved multivariate function (Tolstov, 1962). Following Altunbaş, Gardener, Molyneux and Moore (2001), this form was initially proposed by Gallant (1981, 1982) and was also applied to depict bank efficiency analysis by Spong et al. (1995) as well as Mitchell and Onvural (1996). Among other studies based on this methodology, one could also cite those conducted by Kraft et al. (2006) and Al-Jarrah and Molyneux (2006). The latter outlined that the “preferred” cost model is the Fourier Flexible form as applied to estimate the banking systems’ efficiency levels relevant to Croatia over the period 1994–2001 and to various Arab banking sectors (Jordan, Egypt, Saudi Arabia and Bahrain) concerning the period 1992–2000, respectively.

In addition to the various related methods targeted to explain the efficiency analysis, there exist two major trends that categorize and distinguish efficiency-related studies as figuring in the relevant literature. The first trend is represented by cross-country based studies, and undertakes to compare banks efficiency as depicted across countries. In this regard, Fries and Taci (2005) investigated the efficiency of banks in 15 Eastern European countries observed over the period 1994–2001 via the SFA methodology. Similarly, Yildirim and Philippatos (2007) studied cost and profit efficiency of banks in 12 countries over the period 1993–2000 using both of the SFA and the DFA approaches, considered as parametric methods. In turn, Bonin et al. (2005) used the SFA to estimate scores’ efficiency relevant to 11 transition countries, studied over the period 1996–2000. More recently, Lee and Huang (2017) established a comparison of banks’ efficiency levels operating in Western European countries concerning the period 1996–2010 using a new stochastic meta-frontier Fourier Flexible cost function. Additionally, Haque and Brown (2017) examined the impact of bank regulation and ownership on bank efficiency in the MENA sited countries using the DEA with a one-step maximum likelihood.

As for the second major line of thought, it involves the single country in based studies. In the Tunisian context, Chaffai (1998) stood among the pioneers who are interested in examining the efficiency of Tunisian commercial banks using the distance function. In Morocco, Abdelkhalek and Solhi (2008) adopted a non-parametric approach to measure banks’ efficiency. Concerning Karas et al. (2010), they adopted the SFA approach to study the effect of banks’ ownership structure on bank efficiency in Russia. In a recently conducted study, Montgomery et al. (2014) opted for the Fourier Flexible form to model the cost frontier in order to examine the effect of banking sector consolidation and merger events on banks’ profit and cost efficiency, using data derived from the Japanese context.

Following the examination of the massive amount of the banking efficiency-related literature, two major lessons could be drawn. They relate mainly to the heterogeneity of results and the absence of a comprehensive review aimed at a rather thorough explanation and understanding of the reasons being behind such variability. This fact has made appeal to some meta-analysis studies to be conducted in a bid to fill such a noticeable gap. With citing in this respect is the meta-regression analysis elaborated by Irsova and Havranek (2010) including 32 studies dealing with the subject of frontier efficiency measurement as related to the banking sector. It is focused on investigating the reported estimates’ sensitivity to the methodological design. Their findings prove to suggest that the undertaken study design stands as a crucial factor for the resulting scores. Indeed, the higher the number of observations is, the higher the average estimated efficiency will turn out to be. Recently, Aiello and Bonanno (2016) conducted a meta-regression analysis through examining 1,661 efficiency scores collected from 120 papers published over the period 2000–2014. They ended up highlighting that the parametric methods appear to yield lower levels of banking efficiency than the
non-parametric studies do. In addition, efficiency scores are also discovered to be more
equitably determined through the quality of studies as well as the number of observations
and variables applied in the primary papers.

Most of the previously conducted studies, as appearing in the relevant literature,
appear to suggest that bank efficiency is nothing but the result of a combination of several
factors. It is actually highly related to the banking characteristics and economic
environment. In this respect, and in a bid to explain the bank efficiency determinants,
Chaffai (1998) concluded that the efficiency of Tunisian banks has increased following the
adoption of the liberal process, starting from 1986. As for Abdelkhalek and Solhi (2008),
they highlighted that the increase noticed in the Moroccan banks’ efficiency is
predominantly related to technological progress rather than to internal performance.
In turn, Bonin et al. (2005) stressed that foreign banks turn out to be more cost-efficient
than the other banks operating in transition countries, as observed over the period
1996–2000. Besides, bank size has also been discovered to be negatively correlated with
efficiency. It is also noteworthy that the result confirming foreign banks’ superior
efficiency proves to corroborate most of the related literature dealing with the transition
countries’ associated banking systems, worth citing among which are the works
conducted by Weill (2003), Fries and Taci (2005) and Karas et al. (2010). The latter outline
that foreign banks prove to be more efficient than domestic private banks but they are not
more efficient than national public banks operating in Russia as observed over the period
2002–2006. Similarly, Kraft et al. (2006) documented that banks’ privatization in Croatia
appears to require robust macroeconomic framework and regulations to attenuate the
relating shocks. As for Bennour and Labidi (2013), they outlined that small banks in
Tunisia display, on average, better efficiency scores than the large size banks. In turn,
Regaieg and Abidi (2015) highlighted that Islamic banks generally exhibit greater
efficiency than conventional banks during both the crisis and non-crisis periods.
Concerning Lee and Huang (2017), they argued that banks operating under an integrated
market condition usually tend to undertake analogous technology, stressing that
managerial ineffectiveness constitutes the primary source of inefficiencies.

3. Data, variables’ measurement and methodology

3.1 Data

Our study sample involves a balanced panel data set of 170 observations examined over the
period 2005–2014. We use banks’ balance sheet and income statement data relevant to 11
Tunisian banks and 6 Moroccan banks, collected from the Stock Exchange of Tunis BVMT
and the Casablanca Stock Exchange. In effect, the application of panel data offers several
advantages. First, it helps account for the unobservable heterogeneity and reduce the multi-
collinearity related risk (Hsiao, 2007). Second, panel data display fewer restrictive conditions
than transversal data. Indeed, they help relax certain assumptions about the applied
distributions. In a cross-sectional study, the estimated coefficients usually turn out to be
relatively rather too sensitive to the cost values of each bank (the dependent variable), mainly
due to the reduced degree of freedom (Fries and Taci, 2005). According to Kumbhakar (1993),
cost frontier appears to be more conveniently modeled with panel regressions.

The choice of the study period is not arbitrary. According to DeYoung (1997), it should
be neither short, as inefficiencies may be over or under estimated, nor should it be too long,
as efficiency scores would turn out to be less representative due to the possible changes in
management and other events (such as external shocks). Following Fries and Taci (2005), a
five-year observation period is the minimum requirement for an accurate distinction
between error and inefficiency terms of estimated cost functions to take place.

Only universal banks have been retained to maintain the availability of a homogenous
sample and technology similarity among banks when estimating the cost frontier. Similarly, only
listed banks have been included to ensure the availability and continuity of banks’ information and to neutralize the market capitalization associated effect on bank efficiency.

Finally, a reference is also made to another data source, namely, the World Bank’s World Development Indicator database, in order to measure country-level variables and capture macroeconomics differences noticeable between countries. It should also be noted that the selected banks’ accounting data are converted into USD with respect to the annual exchange rate.

3.2 Variables’ measurement
In this paper, we undertake to rely on the cost function option, even though profit function might appear to stand as an ideal instrument for estimating bank efficiency. Unfortunately, a profit function requires the recognition of output prices, which are not easily accessible with respect to the banks subject of our study sample. Besides, option for a production function is not feasible in our cases, as the banking industry is characterized with a multi-product nature. Actually, cost efficiency serves to measure the differences noticeable in costs between a bank and a “best practices” bank when producing the same outputs under similar conditions. Hence, our dependent variable turns out to be the bank’s total cost.

Hence, on modeling the cost function of multi-product firms, such as banks, we are faced with the problem of having to determine the appropriate specification. Despite the great deal of literature treating the issue of banks’ efficiency, no general consensus has been reached as to the process of how the inputs and outputs of multi-product financial firms could be defined. The two associate issues relate mainly to the role of deposits, and whether inputs and outputs should be measured in physical or monetary units. The following five approaches constitute the most applied methods in the relevant literature. The intermediation approach, as developed by Sealey and Lindley (1977), considers that banks are considered as financial intermediaries and use inputs (labor, physical capital and deposits) to generate outputs (loans and securities).

The production approach, as advanced by Benston (1965), was initially adopted in the study of bank efficiency by Berger and Humphrey (1992). Under this approach, the financial institution uses both the labor and capital factors to produce credits and deposits. Thus, the banking product turns out to consist of the accounts opened by the bank to manage deposits, and the loans’ interests paid on deposits are not included in bank total costs (Ferrier and Lovell, 1990). Consequently, inputs and outputs are measured in physical quantity.

The value added approach, initially developed by Hancock (1991), helps identify any balance sheet item as an output once it appears to absorb a relevant share of capital and labor. Otherwise it would stand as an input or even as a non-relevant output. Accordingly, deposits are accounted for an output in so far as they denote the creation of added value.

Finally, there comes the user cost approach, which rests on the bank revenues’ net contribution to determine inputs and outputs. Accordingly, deposits are considered as outputs.

For the purpose of categorizing the banking industry related output and input prices, an appeal is made to the intermediation approach. This choice depends essentially on the specific features which characterize the banking sector. Indeed, both Tunisian and Moroccan banks collect funds from savers and allocate them in the credit policy. Besides, this approach takes the interest expenses into account, which represent more than half of the bank total costs. From this perspective, we undertake to define the cost function variables by considering two outputs and three input prices.

3.2.1 Dependent variable. The dependent variable is represented by the total cost TC, including financial costs and operational costs (Weill, 2003). Financial costs correspond to the financial capital charges, mainly composed of interest expenses. As for operating costs, they include personnel expenses (payroll), operating expenses and depreciation charges. It should be noted that dividend payments are excluded from total cost in a bid to exclude the bank’s return on equity on measuring efficiency (Fries and Taci, 2005).
3.2.2 Independent variables. With reference to the previously elaborated literature, the independent variables include banks’ outputs and input prices.

Outputs: to determine the appropriate bank products to be included as outputs, we consider modeling the bank as an intermediary institution that collects deposits to make loans. Hence, two bank outputs are deployed, as already determined by Lensink et al. (2008). The first output composes the loans reserved to customers ($Y_1$), which include the entirety of loans destined to non-bank entities and loans oriented to other banks. As for the second output ($Y_2$), it includes all other earning assets, such as securities and bonds with fixed or variable incomes.

Input prices: each input’s price is measured through the ratio between the relative cost and quantity. In this respect, three input prices have been exhaustively defined in several previously conducted studies, mainly, conducted by Lin et al. (2016). They are the price of funds, capital and labor. More specifically, the price of funds ($P_1$) is measured through the ratio of interest expenses to total deposits. The price of capital ($P_2$) is defined by the ratio of non-interest expenses (expenditure on premises, depreciation charges and other operating expenses) to total fixed assets. We also consider calculating the ratio of personal expenses to total number of employees, as a better proxy of labor price ($P_3$), as proposed by Lensink et al. (2008).

3.2.3 Control variables. In this paper, the focus of interest is placed on the establishing an international comparison of banking efficiency between two countries, Tunisia and Morocco. However, it is noteworthy that cross-country efficiency comparisons require the setting up of an appropriate definition of a common frontier that accounts for the differences emanating from the prevalent environmental and regulatory conditions, on the one hand, and from the bank-specific aspects, on the other hand. More particularly, cross-country differences could well induce important differences in bank efficiency. In fact, the inclusion of country-specific variables allows for the efficiency levels to vary consistently across countries, as shown by Dietsch and Lozano-Vivas (2000). In addition, there exists another set of variables that could affect the banking characteristics and service quality, namely, the bank-specific variables. Consequently, they will be included in this study to treat the problem of heterogeneity likely to persist between banks. The aim of this research is to emphasize the influence of environmental conditions and bank characteristics on the cost efficiency of the Tunisian and Moroccan banking industry. In this respect, we suggest to categorize some of the control variables into two sets. The first set called “country-specific variables” helps define the main conditions under which the banks operate. The second set, which involves the “bank-specific variables”, serves to describe the differences between banks in risk behavior and output quality.

Country-specific variables: this set of variables includes the banking structural measures and macroeconomic variables likely to explain each country’s banking industry specific features. In this regard, Mohanty et al. (2016) highlighted that the country-specific variables have a significant impact on the cost efficiencies of the GCC countries’ operating banks. Concerning the present study, we measure the development level and the growth of market demand for banking services (Berger and Mester, 1997), through the GDP growth ($gdp$), as suggested by Sokic (2015). According to Dietsch and Lozano-Vivas (2000), a more developed economy often displays higher operating and financial costs that banks incur when supplying a particular service. Accordingly, we estimate a positive relationship to persist between GDP growth and the banking production costs. Following Lensink et al. (2008), we propose to control for the banking market concentration ($concentration$) by the ratio of the assets’ sum of the three largest banks to the entirety of banks’ total assets per country. Market concentration can lead either to higher costs, or to lower costs (Fries and Taci, 2005). Hence, if market concentration reflects the market power of some banks,
concentration and costs are, then, positively related. In this context, Al-Gasaymeh (2016) suggested that higher concentration within banking sector operating in the GCC countries appears to result in lower efficiency. However, if higher concentration reflects the selection of the most efficient banks, it will be associated with reduced costs (Grigorian and Manole, 2006). Thus, this particular variable’s expected sign appears to be ambiguous.

Bank-specific variables: the second category englobes such variables, such as bank risk and output quality, that are useful for controlling the heterogeneity between banks in risk behavior and output quality. For Berger and Mester (1997), the equity level must be included in the estimated cost frontier, as it helps control for differences in risk preferences. According to Weill (2003), we consider measuring the equity variable \( \text{legit} \) through the natural logarithm of bank equity rather than the capital to total assets ratio, as the latter might well engender a scale bias. Moreover, we propose to implement a transformation of this variable by means of the logarithmic expression, since some of the sample banks’ prove to display a negative equity level. This variable reflects the capital constraints related regulation, whose impact depends on the banks’ risk aversion. A priori, a positive relationship is expected to persist between this variable and bank costs, as both Tunisia and Morocco are noticeably involved in risky loans. In addition, we propose to control for the variation in banking services qualities \( \text{bsq} \) by including the ratio of other operating income to total assets, following Lensink et al. (2008). This variable is generally higher with respect to those banks that derive most of their income from commissions. Indeed, Lin et al. (2016) indicated that banks with greater non-interest income tend to be less efficient in matters of cost management. Accordingly, a positive relationship is estimated to prevail between this variable and bank costs.

Time trend: According to Altunbaş, Gardener, Molyneux and Moore (2001), including the time trend \( T \) variable in the cost function allows to examine the influence of technological change on banking costs. If this variable turns out to be significant, one could then conclude that technological change proves to have a certain effect on bank efficiency.

One may well note that time trend accedes into the stochastic frontier model in the same way as the independent variables, and it is fully interactive with the model’s other parameters, given the direct impact it has on input prices and output costs through technological progress. Yet, the control variables (country-specific and bank-specific variables) are not interactive with the model’s other parameters for the freedom degree to be considerably reduced, mainly due to the expansion of the terms and the limited number of observations (Weill, 2003).

### 3.3 Methodology
Regarding the bank efficiency measure, most of the previously conducted studies used to apply either the stochastic frontier analysis (SFA), as a parametric approach, or, the non-parametric Data Envelopment Analysis (Niţoi and Spulbar, 2015). Concerning the present paper, we opt for applying the SFA, as it helps greatly to control for measurement error and other random effects (Sun and Chang, 2011). As for the non-parametric approach (DEA), it does not appear to allow for the presence of a random error term to quantify luck factors. It attributes any deviation from the best practice bank to technical inefficiency (Matousek and Taci, 2004). Besides, the observations’ number is discovered to be lower than that of inputs and outputs, which constitutes major disadvantage of the DEA, as it can lead to a large number of 100 percent efficient banks once it proves to be incapable of implementing a comparable linear combination of banks. For these reasons, and following the previously conducted trends figuring in the banking industry, the present research tends to investigate the Tunisian and Moroccan banks’ efficiency by means of the SFA.
The SFA is based on conventional econometric regression approaches to estimate a production, cost or profit function. It entails a particular specification for the functional form to be completed by Bauer et al. (1998), which can be either Cobb–Douglass, Translog or Fourier. The first cannot receive multiple outputs without violating the requisite curvature properties in output space (Hasenkamp, 1976). So, it is inappropriate to be applied in the banking industry context. Actually, most studies tend to apply the Translog form to estimate the cost frontier several; however, mainly Mitchell and Onvural (1996) showed that the Fourier Flexible form (FF) is but a global approximation that can dominate the conventional Translog form. The major difference between these two specifications is that the FF includes trigonometric terms containing “sines” and “cosines” of the log output, scaled to lie in the interval \([0, 2\pi]\). Thus, it allows for inflection points to persist in the cost frontier, which makes Altunbaş, Gardener, Molyneux and Moore (2001) maintain that the FF helps provide a better approximation once the true form of the cost function proves to be unknown. It is most often used to cope with the problem arising when the relationship between input prices, output quantities, and production costs accurately cannot be determined. This is mainly due to the mathematical behavior of the Fourier series (sine and cosine function), which are mutually orthogonal and space-spanning. Considered as a semi-nonparametric approach, the FF was originally proposed by Gallant (1981, 1982) and initially applied in the analysis of bank cost efficiency by Spong et al. (1995) as well as Mitchell and Onvural (1996). Such an approach helps maintain the main advantage provided by the FF form, namely, the conjunction of mathematical approximation and statistical properties (Gallant, 1982). Regarding the present paper, the aim lies in testing whether the FF form stands as better fit than the Translog form for modeling Tunisian and Moroccan banks’ efficiency, just as it has stand a preferred form for modeling the Arab (Jordanian, Egyptian, Saudi Arabian and Bahraini) banks’ efficiency, as documented in Al-Jarrah and Molyneux (2006).

The estimation of the cost function will proceed with the application of the panel model, as proposed by Battese and Coelli (1995) (the BC model). The latter should serve to simultaneously estimate the efficiency scores and the determinants of a bank’s cost efficiency. It helps avoid the pitfalls of the alternative two-step method, in which the frontier-based inefficiencies’ estimates are regressed on efficiency selected influences within a second-stage equation. For this regard, Wang and Schmidt (2002) outlined that the two-step method inherently renders biased coefficient, once the exogenous variables “z” (firm characteristics) and inputs prove to be correlated. They argued that the first step estimation ignores the effect of “z” on inefficiency, while the second step is a regression of some measure of inefficiency on “z”. In fact, the efficiency terms are highly dependent on the explanatory variables and are assumed to be normally distributed. Nevertheless, the BC model allows for inefficiency scores to have a truncated normal distribution that is independently and identically distributed (iid) over different banks.

In this work, appeal is made to the BC methodology likely to help estimate the stochastic frontier while accounting for the possibility for inefficiency to vary over time. Thus, flexibility could be maintained, whereby the different assumptions concerning the efficiency terms’ distribution could be examined while comparing the time-variant vs time-invariant as well as truncated vs half-normal correlates, including efficiency.

In addition, a comparison is established between both of the Tunisian and Moroccan banking industries’ cost efficiencies while incorporating environmental variables within the cost frontier estimation. Our goal consists, then, in comparing the banks operating in each country in respect of the same standard through the implementation of a common frontier. In this respect, Al-Gasaymeh (2016) indicated that a cross-country efficiency study requires a clear determination of a proper definition of a common frontier. Hence, both of the country and bank levels’ associated environmental conditions turn out to play an important role in the setting up of a common frontier definition.
Thus, based on the BC model and following the steps taken by Al-Jarrah and Molyneux (2006), we undertake to estimate the efficiency levels by specifying an appropriately fit FF cost function. For convenience purposes, we exclusively consider to demonstrate the following equation only:

\[
\ln(\text{TC}/P_3) = \alpha + \sum_{i=1}^{N} \beta_i \ln(P_i/P_3) + \sum_{k=1}^{I} \gamma_k \ln y_k + \Psi_t T
\]
\[
+ \frac{1}{2} \sum_{i=1}^{N} \sum_{j=1}^{N} B_{ij} \ln(P_i/P_3) \ln(P_j/P_3) + \frac{1}{2} \sum_{k=1}^{I} \sum_{m=1}^{I} \tau_{km} \ln y_k \ln y_m
\]
\[
+ \frac{1}{2} \left[ \Psi_t T^2 \right] + \sum_{i=1}^{N} \eta_i \ln(P_i/P_3) \ln(y_i)
\]
\[
+ \sum_{i=1}^{N} \rho_i \ln(P_i/P_3) T + \sum_{k=1}^{I} \tau_{kt} \ln y_k T + \sum_{r=1}^{R} Z_r
\]
\[
+ \sum_{n=1}^{N} \left[ \phi_n \cos(x_n) + \omega_{nq} \sin(x_n) \right]
\]
\[
+ \sum_{n=1}^{N+I-1} \sum_{q=n}^{N+I-1} \left[ \phi_{nq} \cos(x_n + x_q) + \omega_{nq} \sin(x_n + x_q) \right]
\]
\[
+ \sum_{n=1}^{N+I-1} \left[ \phi_{nn} \cos(x_n + x_n + x_n) + \omega_{nn} \sin(x_n + x_n + x_n) \right] + u_{it} + v_{it},
\]

(1)

where TC is the total cost; \( Y_k \) the vector of the output of banks; \( P_i \) the vector of the input prices of banks; \( I \) the number of outputs; \( N \) the number of inputs; \( \alpha, \beta, \gamma, \Psi, \rho, \eta, \tau, \omega, \phi \) the parameters to be estimated; \( T \) the time trend, as fully interactive with the entirely of the model’s parameters; \( Z_r \) the control variables’ related vector, as non-interactive with the model’s other variables; \( R \) the number of the control variables; \( v_{it} \) the two-sided error term, assumed to be iid of the normal distribution \( N(0, \sigma_v^2) \); \( u_{it} \) the inefficiency term, assumed to be an exponential function of time, and is defined by:

\[
u_{it} = \left\{ \exp(\eta(T - T)) \right\} u_i,
\]

where \( u_{ij} \) is assumed to be iid with the truncated normal random variable \( N(\mu, \sigma_u^2) \) and \( \eta \) an unknown scalar parameter to be estimated.

3.3.1 Model restrictions

- The duality theorem entails that the cost function should be linearly homogenous in regard to input prices, such as:

\[
\sum_{i=1}^{N} \beta_i = 1; \sum_{i=1}^{N} \beta_{ij} = 0; \sum_{i=1}^{N} \eta_{ij} = 0; \sum_{i=1}^{N} \rho_{ij} = 0.
\]

(2)

For the linear homogeneity of the cost function relevant input prices to be maintained, we consider to scale TC and \( P_i \) by \( P_3 \) (labor price). This scaling procedure implies that the sum of these coefficients is equal to one.
The second-order parameters are symmetric:
\[
\gamma_{km} = \gamma_{mk}, \beta_{ij} = \beta_{ji} \text{ and } \eta_{ik} = \eta_{ki},
\]
(3)
\[
x_q \text{ span } [0.1 \times 2\pi, 0.9 \times 2\pi].
\]
(4)

In this paper, our focus of interest also lies in estimating the scale elasticity (SE) of banks under study. SE refers to the proportional variation in cost as resulting from the change in output. According to Al-Jarrah and Molyneux (2006), the SE measure is given by differentiating the cost function with respect to output, as follows:
\[
SE = \sum_{i=1}^{I} \frac{\partial}{\partial \ln Y_i} \frac{\partial \ln TC}{\partial \ln Y_i} = \sum_{k=1}^{I} \gamma_k + \sum_{l=1}^{L} \sum_{m=1}^{M} \gamma_{km} \ln y_m + \sum_{n=1}^{N} \sum_{k=1}^{I} \eta_{ik} \ln (P_i/P_3)
\]
\[+ \sum_{k=1}^{I} \sum_{r=1}^{R} \tau_{kr} \ln z_r + \sum_{n=1}^{N+I+R} \left[ -\phi_n \sin (x_n) + \omega_n \cos (x_n) \right]
\]
\[+ \sum_{n=1}^{N+I+R} \sum_{q=1}^{N+I+R} \left[ -\phi_{nq} \sin (x_n + x_q) + \omega_{nq} \cos (x_n + x_q) \right]
\]
\[+ \sum_{n=1}^{N+I+R} \left[ -\phi_{nn} \sin (x_n + x_n + x_n) + \omega_{nn} \cos (x_n + x_n + x_n) \right].
\]
(5)

Following Altunbaş, Evans and Molyneux (2001), if SE > 1, decreasing returns-to-scale should be persistent, implying scale diseconomies. Inversely, however, if the value of SE < 1, this implies scale economies prove to be associated with increasing returns-to-scale. Finally, constant returns-to-scale should prevail once SE = 1.

Still, the comparison, as established between economies of scale and inefficiency scores, remains biased given the fact that the former is an elasticity measure, while the latter stands as a relative efficiency measure. Indeed, scale elasticity is related to incremental changes noticeable in output while scale inefficiency is associated with change in output necessary to produce at the minimum efficient scale. It is generally associated with significantly larger output changes, since it helps measure the difference in total average cost as perceived at different production levels. According to Evanoff and Israilevich (1995), “Scale inefficiency, \(I\), can be measured as the aggregate cost of \(F\) inefficient firms \((\varepsilon \neq 1)\) relative to the cost of a single efficient firm \((\varepsilon_E = 1)\) where \(F\) = the size of the efficient firm relative to the efficient one. That is, \(I = [F/C_E]/C_E - 1.0\), where \(C_j\) and \(C_E\) are the cost of production at the inefficient and efficient firms, respectively.”

A simple representation of the cost function looks like:
\[
\ln TC = b(\ln y) + \frac{1}{2}c(\ln y)^2.
\]
(6)
The scale elasticity, as associated with inefficient banks, \(\varepsilon_I\), and the scale elasticity for the efficient bank, \(\varepsilon_E\) are as follows:
\[
\varepsilon_I = \frac{\partial}{\partial \ln Y_I} \frac{\partial \ln TC_I}{\partial \ln Y_I} = b,
\]
\[
\varepsilon_E = 1.0.
\]
(7)
As a result, Evanoff and Israilevich (1995) suggested calculating scale inefficiencies \( I \), as figuring below, for such a comparison, in the following form:

\[
I = e^{(\theta)\gamma(1-\alpha)^2} - 1.
\]  

Thus, scale inefficiency encloses both the first and second derivatives of the cost function with respect to output given that second derivation aims to reach \( c \).

Additionally, a time trend variable included in the cost function serves to study the technical change impact on banking cost. For Altunbaş, Evans and Molyneux (2001), time trend allows to capture the effect of the technological factors relating effects. In fact, learning-by-doing, along with organizational changes that allow for more efficient use of existing inputs, as well as technological progress enable the firm to produce, over time, a given output with lower costs, under the same input prices and environmental regulations. The authors argue that technical progress can be deduced from the changes marking the banks’ cost function over time. Accordingly, technological progress can be estimated by the partial derivates of the cost function with respect to the time trend variable, as shown below:

\[
PT = \frac{\partial \ln TC}{\partial T} = \Psi_t + \Psi_{tt} T + \sum_{i=1}^{N} \rho_{di} \ln(P_i/P_3) + \sum_{k} \tau_{dk} \ln y_k.
\]  

4. Empirical results

4.1 Choice of the functional form and estimation results

This subsection includes the steps undertaken to reach the preferred cost model through the implementation of various hypothesis tests, based on the maximum likelihood estimation. Thereafter, the cost frontier related estimation results are depicted using the preferred model. In effect, seven steps are necessary for the best specified model to be attained. The estimation is realized through Stata 13.0 software. The relevant steps are depicted below.

**Step 1: estimating the cost frontier model without restrictions.** Our starting point is to estimate the unrestricted Fourier Flexible model, assuming inefficiency to be truncated and to include the all the control variables. This unrestricted model is represented by Equation (1). The likelihood ratio test is administered to help in verifying the model’s global significance. The estimation results are shown in Table I.

The attained results indicate that the likelihood ratio is greater than the theoretical value of \( \chi^2 \) at 5 percent. Hence, it can be concluded that the unrestricted model adjustment is considered to be explanatory at the level of 5 percent.

**Step 2: comparing the Fourier specification with the translog specification.** In this step, the Fourier specification, as estimated in the first step, is compared to identical Translog specification. The null hypothesis \( H_0 \) states that the Translog form stands as more appropriate than the Fourier form for estimating efficiency associated with our data set. Under this hypothesis, all the coefficients of the trigonometric terms are jointly equal to zero (Table II).

<table>
<thead>
<tr>
<th>Cost model</th>
<th>Log-likelihood</th>
<th>Wald ( \chi^2 )</th>
<th>Prob &gt; ( \chi^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fourier Flexible form without restrictions Equation (1)</td>
<td>190.4707</td>
<td>6,170.54</td>
<td>0.0000</td>
</tr>
</tbody>
</table>
Based on the log-likelihood ratio, the null hypothesis $H_0$ is rejected at the 1 percent significance level. This denotes that the Fourier Flexible form provides better fit to our data set than the Translog form.

**Step 3: examining the time trend impact on the Fourier cost model.** The Fourier truncated model including the efficiency correlates is estimated but without the time parameters. We thus verify whether there has been a technical change in the Tunisian and Moroccan banking sectors over the 2005–2014 period. At this level, the null hypothesis $H_0$ states that the specification of the truncated Fourier model, without time parameters, stands as more appropriate than the unrestricted model (1). This implies that all the time trend associated coefficients turn out to be equal to zero.

As Table III indicates, and based on the log-likelihood ratio, the null hypothesis $H_0$ is rejected at the 1 percent level. Accordingly, the unrestricted model (1) provides a better specification than the Fourier truncated model without time parameters.

**Step 4: examining the impact of efficiency correlates (country-level and bank-level) on the Fourier cost model.** In this step, the unrestricted model (1) is compared to the efficiency correlates’ excluding model. The null hypothesis $H_0$ states that the Fourier truncated model, without including control variables, proves to stand as better specified than that which including them. In other words, with the entirety of these variables, associated coefficients are equal to zero.

As indicated in Table IV, the null hypothesis $H_0$ is rejected in favor of the alternative hypothesis stating that both of the country-specific and bank-specific related variables must be included in the cost model. This finding is in line with that attained by Dietsch and Lozano-Vivas (2000), confirming that these variables play an important role in the common frontier definition for cross-country comparison purposes.

### Table II.
Comparing Fourier specification with translog specification

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Restrictions</th>
<th>Log-likelihood</th>
<th>df</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H_0$</td>
<td>$\omega, \phi = 0$</td>
<td>153.3663</td>
<td>28</td>
</tr>
<tr>
<td>$H_1$</td>
<td>–</td>
<td>190.4707</td>
<td>64</td>
</tr>
</tbody>
</table>

$LR \chi^2(36b) = 74.22; \text{prob } > \chi^2 = 0.0000$

**Notes:**
- The degree of freedom equals to the number of parameters being estimated under each hypothesis;
- the difference between the numbers of parameters estimated under the alternate and the null hypothesis

### Table III.
Examining the impact of time trend on the Fourier cost model

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Restrictions</th>
<th>Log-likelihood</th>
<th>df</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H_0$</td>
<td>$\rho = \tau = 0$</td>
<td>170.06001</td>
<td>60</td>
</tr>
<tr>
<td>$H_1$</td>
<td>$k = i = 1, 2$</td>
<td>190.4707</td>
<td>64</td>
</tr>
</tbody>
</table>

$LR \chi^2(4) = 40.82; \text{prob } > \chi^2 = 0.0000$

### Table IV.
Examining the impact of environmental variables on the Fourier cost model

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Restrictions</th>
<th>Log-likelihood</th>
<th>df</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H_0$</td>
<td>$\Psi_i, r = 0$</td>
<td>172.8808</td>
<td>60</td>
</tr>
<tr>
<td>$H_1$</td>
<td>$r = 1, \ldots, 4$</td>
<td>190.4707</td>
<td>64</td>
</tr>
</tbody>
</table>

$LR \chi^2(4) = 35.18; \text{prob } > \chi^2 = 0.0000$
Step 5: examining the efficiency terms’ impact on the Fourier cost model. This stage helps estimate the Fourier specification that excludes the inefficiency term from the model. Thus, the null hypothesis $H_0$ denotes that the banks subject of our sample are fully technical efficient. In other words, the technical inefficiency error term $u_{it}$ is inexistent in the cost function, and the resulting model would be appropriately estimated by means of OLS regression estimation.

Based on the result presented in Table V, the model that accounts for inefficiency is the best specified. Therefore, inefficiency terms must be included in confirming with the unrestricted model (1) provided specification.

Step 6: comparing the Fourier truncated with the Fourier half-normal models. In the unrestricted model (1), and following mainly the study conducted by Lensink et al. (2008), we consider opting for the truncated normal distribution of the inefficiency term, with no restrictions being imposed. In this step, a comparison is established between the truncated model (1) and the half-normal model to distinguish the most appropriately fit model specification. Then, we restrict $\mu$ to be equal to 0 for the half-normal model, as applied by Jondrow et al. (1982) as well as Kaparakis et al. (1994), to be reached. At this level, the null hypothesis $H_0$ denotes well that half-normal model is better fit than the truncated model (Table VI).

On applying the log-likelihood ratio, the null hypothesis turns out to be rejected, and the truncated model is chosen as providing a better fit specification.

Step 7: comparing the Fourier time-variant with the Fourier time-invariant models. To compare the estimated truncated time-variant model with the truncated time-invariant one, we maintain that, at this stage, the second model provides better specification than the first one. Indeed, a reference is made to the Battese and Coelli’s (1992) time-varying approach, in a bid to examine the time-varying model in respect of the time-invariant model. Hence, the null hypothesis $H_0$ appears to highlight that $\eta$ is equal to 0, testifying that the time-invariant model is convenient for implementation.

As indicated in Table VII, the null hypothesis is rejected at the 1 percent level, given the appropriate degree of freedom. Thus, one may confirm that the time-variant model provides

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Restrictions</th>
<th>Log-likelihood</th>
<th>df</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H_0$</td>
<td>$\eta = \mu = 0$</td>
<td>136.82095</td>
<td>61</td>
</tr>
<tr>
<td>$H_1$</td>
<td></td>
<td>190.4707</td>
<td>64</td>
</tr>
<tr>
<td>LR $\chi^2(3) = 107.3$; prob $&gt; \chi^2 = 0.0000$</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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<thead>
<tr>
<th>Hypothesis</th>
<th>Restrictions</th>
<th>Log-likelihood</th>
<th>df</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H_0$</td>
<td>$\mu = 0$</td>
<td>173.45315</td>
<td>63</td>
</tr>
<tr>
<td>$H_1$</td>
<td></td>
<td>190.4707</td>
<td>64</td>
</tr>
<tr>
<td>LR $\chi^2(1) = 34.04$; prob $&gt; \chi^2 = 0.0000$</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Restrictions</th>
<th>Log-likelihood</th>
<th>df</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H_0$</td>
<td>$\eta = 0$</td>
<td>168.3780</td>
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<tr>
<td>$H_1$</td>
<td></td>
<td>190.4707</td>
<td>64</td>
</tr>
<tr>
<td>LR $\chi^2(1) = 44.2$; prob $&gt; \chi^2 = 0.0000$</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
a better fit to our data set than the time-invariant model. Moreover, the technical inefficiency change over time can be easily distinguished from the technological change, especially that the time trend proves to be significantly specified in the cost function (Step 3). Nevertheless, the time-varying model, as set by Battese and Coelli (1992), proves to suffer from a major disadvantage. Indeed, it does not consider the situations in which some firms may be relatively inefficient initially to become relatively more efficient later[2]. Besides, it does not make it possible to include environmental variables directly into the cost model. This justifies our opting for the time-varying approach, as advanced by Battese and Coelli (1995), as a means to resolve such problems.

The different undertaken steps’ reached results appear to indicate that the stochastic frontier model, with a Fourier truncated time-variant including time trend, country-specific and bank-specific variables (the unrestricted model), is discovered to be the “preferred” cost model. Indeed, it provides a better statistical fit useful for measuring Tunisian and Moroccan banks’ efficiency throughout the period 2005–2014.

Table VIII provides a summary statistics of the variables used to estimate bank efficiency. It displays the average and standard deviation values of total costs, outputs and input prices relevant to the whole sample and by country[3]. It indicates that the Moroccan banks exhibit, on an average, a higher level of total costs and total loans than the Tunisian banks. Equally, the average labor and capital prices are more expensive with respect to the Moroccan than the Tunisian banks. This fact can have its explanation by the differences persistent in the labor regulations and real estate markets. Yet, the fund prices are almost the same across both countries. Additionally, it is clear that the Moroccan bank market proves to be more concentrated than the Tunisian, as the latter encloses a remarkable number of small-size banks. Finally, it is worth noting that the standard deviation of output variables is significantly high. This finding reflects well the differences marking the banks subject of our study sample.

The estimation results relevant to the cost preferred model are depicted in Table IX. As can be noted, our applied cost model is discovered to be significant at the 1 percent level. Likewise, the trend intercept turns out to be significant, bearing a positive sign. Most of the output and input prices’ associated coefficients are significant, except for the capital price relating coefficient. The latter does not seem to have any influence on total cost, nor does it affect banking efficiency in Tunisia and Morocco. Inversely, however, the price of financial capital $P_1$ proves to be positive and statistically significant. This implies that a higher price of this input generates higher total costs, which is intuitive as a situation, since deposits constitute the major source of funding for both of the Tunisian and Moroccan banks. Somewhat counterintuitive is the negative sign associated with the total loans’

<table>
<thead>
<tr>
<th>Total sample</th>
<th>Tunisia</th>
<th>Morocco</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC (in million US$)</td>
<td>350,757.4</td>
<td>485,469.7</td>
</tr>
<tr>
<td>$Y_1$ (in million US$)</td>
<td>144,019.5</td>
<td>73,811.13</td>
</tr>
<tr>
<td>$Y_2$ (in million US$)</td>
<td>1,131,701</td>
<td>10,892,673.17</td>
</tr>
<tr>
<td>$P_1$</td>
<td>0.043</td>
<td>0.049</td>
</tr>
<tr>
<td>$P_2$</td>
<td>0.043</td>
<td>0.044</td>
</tr>
<tr>
<td>$P_3$ (in million US$)</td>
<td>12.782</td>
<td>5.244</td>
</tr>
<tr>
<td>leqt</td>
<td>0.019</td>
<td>0.021</td>
</tr>
<tr>
<td>bsq</td>
<td>0.019</td>
<td>0.021</td>
</tr>
<tr>
<td>concentration</td>
<td>0.574</td>
<td>0.019</td>
</tr>
<tr>
<td>gdp</td>
<td>3.891</td>
<td>1.79</td>
</tr>
</tbody>
</table>

Table VIII. Descriptive statistics of variables used in bank efficiency estimations.

892
coefficient $Y_1$. That is, an increase in granted loans helps reduce total banking cost. In our mind, this result can have its explanation in the fact that by increasing this particular output level, banks are enabled to cover their expenditures. Consequently, it is possible to expect that scale economies are prevalent across the Tunisian and Moroccan banking systems. More in line with this intuition is the positive sign relating to the variable applied to proxy portfolio activity $Y_2$. Accordingly, a higher level of such an output generates, in general, increased cost. This fact can be justified by the lack of skills necessary for managing securities portfolio, a very complex task to implement nowadays. It requires the presence of highly qualified personnel, often very expensive for small banks.

As already started, including the control variables in the definition of the common frontier has a significant influence on banking costs and efficiency scores. Most of these variables related coefficients appear to be significant at the 10 percent level, except for the concentration rate (Table X). In a first place, let us consider the role of the “bank-specific” variables. In line with the expectation, the position equity relevant coefficient turns out to have a positive sign. Hence, a higher capitalized bank proves to have an elevated costs’ level. A major reason for that lies in the capital level necessary to cover the risks undertaken. Thus, the higher

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Coefficient</th>
<th>Parameter</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant $\alpha$</td>
<td>15.0185***</td>
<td>tlp13</td>
<td>0.0038</td>
</tr>
<tr>
<td>$ly_1$</td>
<td>$-2.5917$***</td>
<td>tlp23</td>
<td>$-0.0076$</td>
</tr>
<tr>
<td>$ly_2$</td>
<td>1.0281***</td>
<td>cosy1</td>
<td>$-0.0081$</td>
</tr>
<tr>
<td>$lp_{13}$</td>
<td>1.6876***</td>
<td>siny1</td>
<td>$-0.0041$</td>
</tr>
<tr>
<td>$lp_{23}$</td>
<td>$-0.3647$</td>
<td>cosy2</td>
<td>$-0.0211$***</td>
</tr>
<tr>
<td>$tt$</td>
<td>0.0244</td>
<td>siny2</td>
<td>0.0149</td>
</tr>
<tr>
<td>$ly_{12}$</td>
<td>0.3048***</td>
<td>cosy13</td>
<td>$-0.0049$</td>
</tr>
<tr>
<td>$ly_22$</td>
<td>0.0298</td>
<td>siny13</td>
<td>0.0033</td>
</tr>
<tr>
<td>$lp_{1323}$</td>
<td>$-0.1059$***</td>
<td>cosy23</td>
<td>0.0021</td>
</tr>
<tr>
<td>$lp_{2323}$</td>
<td>$-0.0327$***</td>
<td>siny23</td>
<td>$-0.0054$</td>
</tr>
<tr>
<td>$t_t$</td>
<td>$-0.0045$*</td>
<td>cosy11</td>
<td>$-0.0141$</td>
</tr>
<tr>
<td>$ly_{1y_2}$</td>
<td>$-0.0946$***</td>
<td>siny11</td>
<td>$-0.0054$</td>
</tr>
<tr>
<td>$ly_{1p_{13}}$</td>
<td>$-0.0185$</td>
<td>cosy12</td>
<td>$-0.0051$</td>
</tr>
<tr>
<td>$ly_{1p_{23}}$</td>
<td>0.0374</td>
<td>siny12</td>
<td>0.0078</td>
</tr>
<tr>
<td>$ly_{2p_{13}}$</td>
<td>$-0.0050$</td>
<td>cosy22</td>
<td>0.0012</td>
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<tr>
<td>$ly_{2p_{23}}$</td>
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<td>siny22</td>
<td>$-0.0031$</td>
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<tr>
<td>$tty_1$</td>
<td>$-0.0119$*</td>
<td>cosy1p13</td>
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<tr>
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<td>cosy1313</td>
<td>$-0.0045$</td>
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<tr>
<td>siny1p23</td>
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<td>0.0074</td>
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<tr>
<td>cosy2p13</td>
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<td>cosy2323</td>
<td>$-0.0213$***</td>
</tr>
<tr>
<td>siny2p13</td>
<td>$-0.0195$*</td>
<td>siny2323</td>
<td>0.0052</td>
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<tr>
<td>cosy2p23</td>
<td>$-0.0001$</td>
<td>$legt$</td>
<td>$0.0740$***</td>
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<tr>
<td>siny2p23</td>
<td>$-0.0022$</td>
<td>$bsq$</td>
<td>$-3.309$***</td>
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<tr>
<td>cosy1313</td>
<td>0.0151</td>
<td>concentration</td>
<td>0.0306</td>
</tr>
<tr>
<td>siny1313</td>
<td>0.0038</td>
<td>gdp</td>
<td>0.0009$^{***}$</td>
</tr>
<tr>
<td>cosy2323</td>
<td>$-0.0053$</td>
<td>$/\mu$</td>
<td>$-33.6761$***</td>
</tr>
<tr>
<td>siny2323</td>
<td>0.0035</td>
<td>$/\eta$</td>
<td>0.0451$^{***}$</td>
</tr>
<tr>
<td>cosy1323</td>
<td>$0.0179$*</td>
<td>$/\lnsigma2$</td>
<td>2.4388$^{***}$</td>
</tr>
<tr>
<td>siny1323</td>
<td>$-0.0239$***</td>
<td>$/\lnlgtgamma$</td>
<td>7.8924$^{***}$</td>
</tr>
<tr>
<td>cosy111</td>
<td>0.0124</td>
<td>$\Sigma_2$</td>
<td>11.4602</td>
</tr>
<tr>
<td>siny111</td>
<td>0.0267***</td>
<td>Gamma</td>
<td>0.9996</td>
</tr>
<tr>
<td>cosy222</td>
<td>0.0033</td>
<td>$\Sigma_{u2}$</td>
<td>11.4558</td>
</tr>
<tr>
<td>siny222</td>
<td>0.0097</td>
<td>$\Sigma_{v2}$</td>
<td>0.0044</td>
</tr>
<tr>
<td>LR $= 190.4707^{***}$</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table IX. Estimation results for the cost preferred model

Notes: *, **, ***Significant at 1, 5 and 10 percent levels, respectively
capitalization characterizing the sample banks, especially the Tunisian ones, seems to indicate that they are too engaged in risky activities. Moreover, increasing the bank’s level equity turns out to be a more costly procedure than increasing the level of deposits. Contrary to expectation, the banking service quality (bsq) proves to have a negative effect on total cost. This finding suggests well that the banks with a greater commission income tend to be more efficient in matters of cost management. In fact, efficient banks have most of their income derived from commissions to improve their performance, owing mainly to the high level of non-performing loans characterizing both of the Tunisian and Moroccan banking systems. This result is in contrast with that reached by Lensink et al. (2008). Probably, differences in the applied samples may explain the dissimilarities perceived in outcomes.

Regarding the role of the country-specific variables, it has been discovered that the GDP growth (gdp) associated coefficient is significantly positive. This result is in line with that attained by Dietsch and Lozano-Vivas (2000) who confirmed that a rather developed economy leads to increased total banking costs when supplying a given level of services. As already stated, market concentration does not prove to affect the cost of the Tunisian and Moroccan banks.

4.2 Analysis of efficiency results
In this subsection, an analysis of the Tunisian and Moroccan bank’s cost efficiency, scale efficiency and technical change is provided regarding the period ranging between 2005 and 2014. A comparison of these measures is established between banking groups with respect to their origin and ownership.

4.2.1 Cost efficiency comparison. An estimation of the cost function in confirming with Battese and Coelli (1995) should enable to calculate each observation’s distance from the efficient frontier. This distance is decomposed into an error term $v_i$ and an inefficiency term $u_i$. Efficiency is measured through the inverse of the inefficiency term, which varies between zero (total inefficiency) and unity (perfect efficiency).

Table XI displays the average bank-efficiency scores by country and by year, along with the overall sample relating scores. On average, inefficiency is of the rate of 71 percent. This suggests that banks could reduce their costs by an approximate rate of 29 percent to
produce the same output level if they appear to operate on the most efficient frontier. It is also noteworthy that these scores have proved to decrease from 72 percent in 2005 to 69 percent in 2014. In effect, both countries’ banks are marked with such deterioration in cost efficiency. Two possible reasons may lie at the origin of this negative trend. The first is structural and consists in the increasing total costs registered in both countries. The second reason relates to the economic situation, which might well have its explanation in the noticeable increase in non-performing loans (NPLs).

It has also been discovered that, on an average, Moroccan banks tend to be more efficient than the Tunisian counterparts (79 percent vs 66 percent). This finding may well be explained by the fact that the high number of small-size banks contribute in impeding the scale economies with respect to the Tunisian banking sector. Besides, the latter is characterized with a high level of the NPLs, especially following the Spring Arab dubbed revolution.

Table XII reports the bank’s average efficiency scores and asset size, as classified by country and by ownership. There is a summarizing of the major reached findings. As can be noted, the efficiency levels of the private and public banks’ relevant to both countries are relatively dissimilar. In Tunisia, private banks appear to be more efficient than the public ones, expect the single public bank which has a foreign state as principal shareholder. This finding has its justification in the NPLs-related problems, which prove to be noticeably high for most of the state national banks. However, state banks operating in Morocco seem to be relatively more efficient, highlighting that the Moroccan state banks have greater scale economy advantages over their private counterparts. They represent, on an average, the sample largest banks in terms of assets. This fact might well reveal these banks’ ability to provide greater outputs for which they can charge costs. It is noteworthy, however, that the state-owned banks operating in developing countries are generally subject to social pressures. This may partially explain the motives behind the decrease in state ownership noticeable over the last year. Indeed, the banking systems in the Maghreb region were liberalized through the privatization of several state banks and allowing entry for foreign banks. Based on such results, and by referring to Taktak and Triki (2012), it seems that the deterioration noticeable in the Tunisian banks’ efficiency levels is predominantly due to the state banks’ attached failure. Indeed, these banks have kept making attempts to absorb the deficits affecting other sectors such as tourism. Consequently, more reforms must be implemented to improve the Tunisian banking system’s efficiency, especially in regard to the public banks. In fact, the latter appear to suffer from high NPL levels and are in urgent need of deep restructuring. According to the International Monetary Fund (2008), the NPLs’ level reached about 18.3 percent with respect to the Tunisian banks and about 10.1 percent relevant to Moroccan ones concerning the period ranging between 2005 and 2008.

It is worth mentioning, also, that domestic banks are noticeably rather efficient in both countries. They probably enjoy several advantages compared to foreign banks according to “the home field advantages” hypothesis advanced by Berger et al. (2000). Similarly, Taktak and Triki (2012) documented that the presence of foreigners in the ownership structure has a negative effect on the Tunisian banks’ efficiency. Lensink et al. (2008) indicated that such a

<table>
<thead>
<tr>
<th>Country</th>
<th>Domestic private Asset size</th>
<th>Efficiency score</th>
<th>Domestic public Asset size</th>
<th>Efficiency score</th>
<th>Foreign private Asset size</th>
<th>Efficiency score</th>
<th>Foreign public Asset size</th>
<th>Efficiency score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tunisia</td>
<td>3,445,585</td>
<td>0.6487</td>
<td>4,171,929</td>
<td>0.6216</td>
<td>2,109,811</td>
<td>0.5336</td>
<td>394,485</td>
<td>0.8734</td>
</tr>
<tr>
<td>Morocco</td>
<td>27,388,222</td>
<td>0.8123</td>
<td>12,419,850</td>
<td>0.8548</td>
<td>6,054,833</td>
<td>0.7248</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

*Note:* Total assets are in million US$ for both countries

Table XII. Average bank efficiency scores by country and by ownership
negative impact depends on the regulations prevailing in the transition characterized countries. Moreover, our reached results suggest that foreign banks constitute, on an average, the smallest banks in the sample. Apparently, they operate with significant unreleased economies of scale. As already stated, the exception of the Tunisian-based foreign state bank with the high efficiency level, despite its small size, may well be related to a more effective control of its spending. This bank is highly enticed by profit maximization motives in a bid to meet the foreign shareholder’s requirements.

4.2.2 Estimated scale elasticity level. Table XIII depicts the average scale elasticities for banks, as grouped according to origin and ownership. The results reveal well that scale economies are persistent across the Maghreb banking system. More particularly, the Tunisian banks appear to operate with a low-level scale elasticity. Thus, a 100 percent increase in the outputs’ level would generally lead to about 61 percent increase in total costs for the Tunisian banks. Based on ownership structure, foreign-owned banks seem to display the largest proportion of unrealized scale economies in both countries owing to their small size. Moreover, these banks exhibit the least cost efficiency rate (except for the unique foreign state bank in the sample). Yet, the Moroccan domestic banks prove to exhibit almost constant returns-to-scale and turn out to be the most efficient. This finding suggests that the consolidation of small-size banks in the region, such as the foreign ones, would contribute in maintaining greater efficiency. Indeed, a scale efficient firm produces outputs with a constant return-to-scale.

4.2.3 Estimated scale inefficiency level. As indicated in the methodology devoted subsection, establishing a comparison between economies of scale and inefficiency scores turns out to be a biased procedure. Thus, we consider comparing scale inefficiency ($I$) and cost efficiency ($ineff$) in terms of bank origin and ownership’s structure. Based on Figure 1, foreign banks represent the most-scale inefficient institutions. In general, these banks tend to exhibit similar cost and scale inefficiency levels. Accordingly, it is worth highlighting that the foreign banks related inefficiency is strongly linked to their production on an inefficient scale with

| Table XIII. Average bank scale elasticity by country and by ownership |
|-----------------------|------------------|------------------|----------------|
|                      | Domestic banks   | Foreign banks    | Overall sample |
| Tunisia               | 0.66771          | 0.54889          | 0.6137         |
| Morocco               | 0.98461          | 0.55613          | 0.8417         |

Figure 1. Comparison between scale inefficiency and cost inefficiency by country and by ownership
respect to both Maghreb countries. Sum it up, most banks in our sample are scale inefficient, especially the Tunisian ones. This result confirms that the small size characterizing the Tunisian banks tends to hinder the scale economy associated advantages, thus negatively affecting their cost efficiencies. These results appear to corroborate those attained by Al-Jarrah and Molyneux (2006) relevant to Arab banks, indicating that the most efficient banks are those characterized with the largest asset size.

4.2.4 Estimated level of technological progress. The estimates of technological progress are reported in Table XIV. They generally reveal that technical change has the same effect on all banks of both countries, thus providing a negative contribution. It appears to result in about 3.7 percent increase in total costs. Hence, one might well note that, overall, Tunisian and Moroccan banks cannot benefit from technological progress to improve their cost efficiency. Inversely, they prove to suffer from a significant increase in their total costs, which justifies the deterioration in efficiency noticeable over the study period (Table XI). These results are remarkably different from those published by Altunbaş, Gardener, Molyneux and Moore (2001), who noted that the European banks prove to benefit from technical progress through the noticeable reduction in total banking costs.

5. Conclusion
The main goal of this paper consists on estimating the efficiency levels relevant to two Maghreb countries’ banking systems, by applying various statistical analyses to a data set related to both Tunisia and Morocco. To this end, various model specifications have been tested for the preferred cost mode to be reached. It has been proved, then, that the Fourier Flexible form turns out to fit better to our data set than the Translog form for a cross-country efficiency comparison to be established using a common frontier. Additionally, both environmental and bank-specific variables have been accounted for on determining an appropriate definition of a common frontier. Based on stochastic frontier analysis, this methodology proves to reveal the importance of both of the country-level and bank-level related factors, in explaining the differences perceived in cost efficiency between the Tunisian and Moroccan banks, as observed over the period 2005–2014. More specifically, the GDP growth and the high capitalization levels’ banks turn out to contribute in increasing total costs. Inversely, however, the banking service quality proves to have a negative effect on total cost. In other words, banks with a greater commission income tend to display greater efficiency in cost management.

The empirical results reached through the present study can be summed up as follows. First, the Moroccan banks are discovered to be more efficient throughout the entire study period. This finding could be explained by the high NPLs levels, characterizing the majority of Tunisian banks, particularly the public ones. Second, the efficiency levels appear to have been deteriorated over the study period, with respect to the entirety of sample banks, whatever their origin and ownership structure might be. In effect, the rise noticeable in total costs, relevant to both countries, may stand as the major reason lying behind the negative trend marking the banking efficiency.

As for the scale elasticities related results, it has been discovered that scale economies are prevalent across both the Tunisian and Moroccan banking systems. Still, the small size

<table>
<thead>
<tr>
<th>Domestic banks</th>
<th>Foreign banks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tunisia</td>
<td>0.0337</td>
</tr>
<tr>
<td>Morocco</td>
<td>0.0403</td>
</tr>
<tr>
<td>Overall sample</td>
<td>0.037</td>
</tr>
</tbody>
</table>

Table XIV. Technological progress by country and by ownership
characterizing Tunisian banks proves to hamper the scale economy associated advantages, thus reducing their cost efficiency. In addition, our findings indicate that, owing to their small size, the foreign banks sited in both countries appear to operate with a significant scale inefficiency. The study also reveals that technical progress proves to have a negative effect on banking costs.

As a result, the main policy recommendation likely to be drawn following conduction of the present study consists in the fact that consolidation and mergers of smaller banks across the region would contribute to a further enhanced cost efficiency in the banking sector through the achievement of the unfulfilled scale economies. Indeed, banks could well profit from mergers through providing the opportunity to transfer new management technologies, along with the best practice policies during consolidation. They may also benefit from the availability of a larger market share, greater market power, as well as the post-merger scale economies. Moreover, the present research contributes in shedding light on the loan-quality associated role in further enhancing banking efficiency. This finding can be of great importance, given the fact that NPLs prove to affect economic growth remarkably with serious implications on society. Consequently, more effective reforms need be implemented on the Tunisian banking system to resolve the NPLs problems, especially concerning public banks. As a matter of fact, the latter should never be used by the authorities to direct the resources’ allocation. It is also imperative that policy makers should participate in improving the regulatory and supervisory framework for the banking efficiency to be effectively promoted. More particularly, they should be enticed to continue with implementing the banking sector relevant reforms by fostering privatization and the flow of foreign banks, although a deeper analysis of these questions could make subject of a potential research work. Actually, it is of great importance to recognize the extent to which the strategic foreign investors’ relating privatization helps in improving banking efficiency. Another interesting direction lies in thoroughly investigating the reported estimates’ sensitivity to the methodological design in frontier efficiency measurement, and how the latter could well differ from the parametric approach to the non-parametric approach one.

Notes
1. They were supporting the Fourier truncated.
2. The technical inefficiency of the different banks at any given time period, t, is equal to the same exponential function \( \exp \left[ -\eta (t - T) \right] = \exp \left[ \eta (T - t) \right] \) of the inefficiency at the last period of the panel.
3. It should be noted that all variables measured in domestic currencies were converted to US dollars following the purchasing power parity hypothesis.

References


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Leadership attributes and their impact on work-related attitudes

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Universiti Sains Malaysia, Minden, Malaysia

Abstract
Purpose – The purpose of this paper is to understand the emergence of employee leadership attributes and, further, examine its impact on employee work-related attitudes in terms of the competitive context of higher education institutions.

Design/methodology/approach – A data from a survey of 245 academic employees in Malaysian public universities were tested and analyzed on the 12 proposed hypotheses.

Findings – The results reveal that the emergence of employee leadership attributes, independently, has a significantly positive effect on work-related attitudes. Specifically, executive leadership has a significantly positive effect on organizational commitment, career satisfaction and job satisfaction, while innovative leadership has a significantly positive effect on organizational commitment and career satisfaction. In contrast, adaptive and effective leadership is associated when explaining organizational commitment, career satisfaction and job satisfaction, while innovative leadership is associated when explaining job satisfaction.

Practical implications – Academic scholars/leaders in higher education should realize that the emergence of employee leadership attributes has a positive effect on work-related attitudes, such as organizational commitment, career satisfaction and job satisfaction.

Originality/value – The paper extends the knowledge regarding complexity leadership theory which explains the emergence of employee leadership attributes naturally and, further, provides empirical evidence.

Keywords Performance management, Employee productivity, Higher education institution, Career satisfaction, Organizational commitment, Job satisfaction, Employee attitudes, Leadership theory, Work-related attitudes

Paper type Research paper

1. Introduction
The intrinsic value of leadership leads to human civilization that differentiates the success and the failure of organizations or nation. It should be regarded as the most important aspect in the twenty-first century. Values-based leadership is acknowledged to be the most prominent indicators to increase job performance and accomplish strong organizational performance (Yates, 2014; Abbas et al., 2016; Al-Malki and Juan, 2018). Such attributes embedded in employee leaderships are significant for organizations’ competitive advantage and productivity, especially in higher education institutions’ (HEIs) that nurture human capital.

Creative research and educational excellence are crucial for HEI performance and competitive advantages (Cheung and Chan, 2010; Asaari, Dwiedi, Lawton and Karia, 2013; Haan, 2015). Universities have to compete for research grants and academic employees should not only produce excellent research and publications but also include high impact evidence. In the era of industry 4.0 and dynamic environments, the future competitive advantage of the HEI counts on the leadership attributes embedded in its academic employees (Mendes et al., 2016). Given such degree of workload and stress that the human capital has faced; it is significant for the HEIs to preserve its human value and intelligence for sustainable competitive force in such environments.

The university excellence ranking system is causing academic employees’ increased work-related stress. Several scholars have, indeed, concluded that, currently, this is the case (Villeneuve-Smith et al., 2008). This has produced a substantial impact on academic employees’ work-related attitudes. HEIs, hence, need to capitalize upon their high-performing employees effectively and protect them from increasing levels of stress in order to preserve
staff well-being, organizational performance and competitiveness, and the intellectual health of a nation. Additionally, academic employees should be nurtured, knowledgeable and competent enough to deal with pressure when faced with challenges and environmental change. Respectively, HEIs should understand how to balance their employees’ work-related attitudes and stress in order to realize a high-performing academic employee.

Prior research suggests that practices, commitments and spiritual beliefs have a positive impact on psychological and physical health/well-being, positive interpersonal performance and better/improved quality of life and work (Seybold and Hill, 2001; Karia and Asaari, 2006; Yates, 2014). Although employee leadership plays a critical role in the current HEI environment, the evolution of leadership attributes toward work-related attitudes has yet to be explored and well-defined. Consequently, research concerning leadership attributes and employee work-related attitudes contains limited observations and is immature. Accordingly, this paper explores and attempts to comprehend the evolution of leadership attributes and such a role in fostering work-related attitudes.

Three main gaps have been identified in the research field of leadership and work-related attitudes. First, traditional research focuses on leadership as factors for influencing others or the social influence of superiors toward subordinates (Kochan et al., 1975; Jenkins and Jensen, 2010) that lead to improved organizational performance (Jogulu and Wood, 2008) but ignores employees’ work life. This contemporary study acknowledges the urgency of knowledge for a new leadership model in the era of rapidly expanding technology and dynamic environments that will boost employees’ work-related attitudes. Second, since most leadership research concentrates on the organizational context (Andert et al., 2011), little is known and there is almost non-existent research about knowledge of leadership complexity and attributes embedded in employees that are inimitable and non-substitutable for predicting employee work-related attitudes, and academic employees in HEIs in particular. Accordingly, there is a need for the study to advance the understanding of leadership attributes that anticipate employees’ work-related attitudes, such as job satisfaction, organizational commitment and career satisfaction. The third gap is the absence of theory-driven empirical evidence to explain what leadership attributes are and how employees’ work-related attitudes are transformed through these attributes (Lee and Feng, 2008).

 Apparently, the absence of knowledge on leadership complexity and attributes embedded in employees and its effects on work-related attitudes permits an opportunity for the study to acknowledge the novel findings of a new leadership model. By conquering the employees’ view, this study pursues to research the emergence of leadership attributes and, further, examines the extent to which these attributes induce work-related attitudes among academic employees in HEIs. This novel contribution, apparently, clarifies how HEIs and leaders (organizations and managers) can progress work-related attitudes and achieve high-performing employees through leadership attributes in the era of industry 4.0, rapid technological advancement and a dynamic environment; and why organizations need to be aware of their employees’ attitudes toward their work life.

This paper is structured as follows. Section 2 presents the theoretical framework and hypotheses. Section 3 outlines the methodology applied in this study. Section 4 presents the results of the study. The research findings and implications are discussed in Section 5. Finally, the paper concludes by discussing contributions, limitations and suggestions for future research in this field.

2. Theoretical framework and hypotheses
A future organization counts on human intrinsic values, the intelligence and innovation of knowledge resources, where rivalry and internationalization awaken uncertainty and vulnerability (Audenaert et al., 2016). According to dynamic knowledge theory, the evolution of a human intelligence built-in organization becomes the most crucial booster of
competitive advantage (Barney and Clark, 2007). The resource-based theory endorses that knowledge resources can become apparent in leadership from the learning and innovation process, people recruitment and development or better employee retention (Karia and Wong, 2013) and practices (Karia and Asaari, 2006) that are not easy to be imitated, hence enabling a sustained competitive advantage over the long term (Barney, 1991).

Accordingly, in the era of industry 4.0 and technological advancement, leadership attributes are becoming increasingly more dynamic, complex and multidimensional; they have the great potential to generate economic value and competitive force for HEIs. Leadership attributes are lasting and non-transferable, hence, they favor organizations’ long-term success and sustainable competitive advantage. However, the leadership literature suffers concerning understanding the emergence of leadership attributes and its roles and values on work-related attitudes. The data highlight that traditional research favors analysis of leadership as factors for influencing others (Kochan et al., 1975; Jenkins and Jensen, 2010; Yates, 2014; Abbas et al., 2016) and its impact on organizational performance (Jogulu and Wood, 2008; Andert et al., 2011). The review of literature highlights leadership influence on work-related attitudes remains unexplained.

Appropriately, it is mandatory for the study to conceptualize leadership under such environments in order to be pro-active and dynamic. In this contemporary study, leadership is operationalized as a multidimensional construct encompassing innovative, effective, adaptive and executive leadership (Asaari, 2012) that anticipates the determination of three key work-related attitudes (Karia, 1999) in terms of organizational commitment, job satisfaction and career satisfaction. This approach helps to clarify the distinct effects of leadership attributes on work-related attitudes. Hence, multidimensional constructs for both leadership and work-related attitudes are urgently required.

2.1 Complexity leadership theory
Complexity leadership theory regards leadership attributes as the appearance of leadership behaviors which lead to higher efficiency (Fitzgerald et al., 2013) and better performance (Carte et al., 2006). The theory postulates that leadership behavior is emerging from the learning and innovation process which enables effective and future adaption that is informal, evolved, complex and dynamic (Mendes et al., 2016). According to Uhl-Bien et al. (2007), leadership attribute is achieved from adaptive, creative and learning actions that commence from interaction within a complex adaptive system that build-in human intelligence and evolve human capital in HEIs.

Meanwhile, leadership theory regards leadership in an organization that has a positive effect on employee performance (Holt and Seki, 2012; Sharkey et al., 2012). Conversely, some scholars have discovered that leadership has no direct effect on employee performance (Hermawati and Mas, 2017; Hayward, 2005). Literally, most leadership theory describes a process of one specific person or group having an influence on others (Avolio et al., 2004; Abbas et al., 2016). The literature review shows that the immature relationship between leadership and work-related attitudes are far from conclusive findings or steady in the theory. Therefore, it is imperative for the study to advance knowledge on the emergence of leadership attributes that contributes to employee work-related attitudes.

2.2 Leadership attributes
In general, leadership attributes of academic employees/leaders have been identified and mentioned in the literature, e.g., credibility, inspirational personality, knowledge, skills, abilities and experience to lead others, eagerness to learn new things and adapt to changes, awareness of environment, selflessness, flexibility, openness in sharing information and accepting the input of people while making decisions when required, being supportive, fair in giving credit concerning their achievements, accepting, valuing and recognizing the
efforts of subordinates, providing developmental opportunities to subordinates, and giving them professional autonomy, responsibility, being serious, honest, trustworthy and concerned for other people (Bass, 1985; Avolio et al., 1999; Avolio and Gardner, 2005; Reave, 2005; Yang and Wei, 2017).

Exceptionally, some scholars highlight academic leadership attributes, such as vision, adaptability to change, competencies, effective leadership, transactional leadership, transformational style and charisma (Koen and Bitzer, 2010; Asaari, Dwiedi, Lawton and Karia, 2013). Prior research also considers adaptive leadership (Randall and Coakley, 2007), charisma (Javidan and Waldman, 2003) and leadership style (Yiing and Ahmad, 2009; Anitha, 2014; Pawirosumarto et al., 2017) as leadership attributes.

As stated by Asaari (2012), academic employees possess four dimensions of academic leadership: executive, innovative, adaptive and effective. Such academic leadership credibility and competences are claimed enable creative research and educational excellence as well as employee performance. In a similar vein, complexity leadership theory describes that leadership attributes emerge from various characteristics such as being innovative, adaptive, creative, emergent, complex and dynamic when the system contains uncertainty and is changeable (Mendes et al., 2016). These leadership attributes contribute to work-related attitudes (Kidwell and Valentine, 2008; Bhal et al., 2009; Butler, 2009; Eddleston, 2009; Asaari, Dwiedi and Lawton, 2013) and, subsequently, enhance the competitive advantage and performance of HEIs.

In this contemporary study, the emergence of leadership is operationalized as a multidimensional construct encompassing innovative, effective, adaptive and executive leadership (Asaari, 2012; Asaari, Dwiedi, Lawton and Karia, 2013).

2.2.1 Innovative. Innovation is the most important leadership attribute of academic employees as it shows the leader is thinking about the future, is optimistic and seeks for betterment (Asaari, 2012). It can include the action or process of innovation that covers new ideas or creativity and behaviors directed toward implementing these new ideas within the work setting (Rank et al., 2004). Innovative leadership is regarded as being present in leaders who carry out innovative activities with the intention of benefiting from them when responding to uncertainty and demand within the context (West, 2002). Academic employees with innovative affect are ahead of other members in thinking and acting creatively in research, publications, teaching and other related activity that tends to include positive work-related attitudes. Yanez (2004) found that innovation has an influence on the performance of a group at a Mexican university. Audenaert et al. (2016) indicate that individual innovation is related to employee performance management in public organizations.

2.2.2 Adaptive. The adaptive leadership is regarded as being present in leaders who are able to adapt to changes and challenges, tolerate postponement and uncertainty, see positive outcomes and accept defeat and delay (Asaari, 2012). Adaptive leadership is required to manage any changes and challenges in HEI (Randall and Coakley, 2007).

2.2.3 Effective. The effective leadership is regarded to include leaders who can encourage members’ ideas and judgment to work with complete freedom, minimal supervision, and have the power to put plans, actions, or laws into effect (Asaari, 2012). Effective leadership reflects a good leader who empowers the desired and expected results as determined by HEI objectives and encourages a positive culture (Nicholson et al., 2007).

2.2.4 Executive. The executive leadership is regarded to include leaders who work independently based upon their expertise in teaching, supervision, research consultancy and service; they delegate and share information to members, and notify what is expected from them. Executive leadership emphasizes the interaction between leader and followers which requires full participation in the HEI such as visionary, thinking, decision-making and administration (Nicholson et al., 2007; Asaari, 2012).
2.3 Work-related attitudes

In general, work-related attitudes are a determinant of employee job performance which reflects the constructive or affective reaction of individuals to jobs; or, the employee attitude which reflects job satisfaction and the individual’s commitment to the organization (Landy et al., 1993; Al-Malki and Juan, 2018). These are regarded as positive effects such as happiness or encouragement, and are triggered by the employee’s current or most recent job, in other words, the positive attitude of the employee with his workplace or the positive emotional connection of an employee toward work (Anitha, 2014). Most studies use affective components such as organizational commitment, job satisfaction and intention. According to Guimaraes (1996), work-related attitudes reflect task characteristics such as job involvement, job satisfaction, career satisfaction and organizational commitment. Notably, the study of work-related attitudes has been associated with high levels of job satisfaction, job involvement, career satisfaction and organizational commitment (Karia, 1999; Karia and Asaari, 2006).

These work-related attitudes can be achieved by leadership attributes (Kidwell and Valentine, 2008; Bhal et al., 2009; Butler, 2009; Eddleston, 2009). For example, past scholars indicate the leadership effects on work outcomes or employee performances such as employee commitment (Tjosvold, 2008; Eddy et al., 2008; Lee and Ahmad, 2009), job satisfaction (Lee and Ahmad, 2009; Duffield et al., 2009), turnover intention (Walsh and Taylor, 2007; Ansari et al., 2007), performance (Por and Fields, 2006; Kivipold and Vadi, 2010) and attitudes (Rahman and Norling, 1991; Martin and Bush, 2003).

2.4 Impact of leadership attributes

Scholars acknowledge that leadership style has a significantly positive effect on employee performance (Anitha, 2014; Pawirosumarto et al., 2017). Anitha (2014) has found that leadership is the factor that impacts employee engagement and, hence, enhances employee performance significantly. In particular, leadership styles have a positive, significant relationship with organizational commitment (Ying and Ahmad, 2009). Leadership can have a direct and indirect impact on job satisfaction (Neubert et al., 2009). Other scholars indicate that leadership can determine job satisfaction (Eddy et al., 2008; Erkutlu, 2008; Neubert et al., 2009), career satisfaction (Burke et al., 2008; Eddleston, 2009) and organizational commitment (Eddy et al., 2008; Erkutlu, 2008; Neubert et al., 2009).

2.4.1 Organizational commitment. The term organizational commitment is conceptualized based on Karia (1999), measuring the degree of attachment and loyalty by employees to the organization. According to Karia and Asaari (2006) employees who are highly committed to their organizations contribute more effectively to company growth and success. Hence, the emergent leadership attributes fixed in academic employees increase their commitment to enhance excellence in research, publication, teaching and service. Such leadership attributes are possible to be positively associated with organizational commitment. Committed employees tend to be motivated to perform well, contribute more effectively to their performance and success and remain in the organization. Leadership styles commonly have a positively significant impact on organizational commitment (Ying and Ahmad, 2009). The arguments suggest leadership attributes should positively affect organizational commitment. Therefore, the following hypotheses are suggested:

H1. There is a positive relationship between leadership attribute and organizational commitment.

H1a. There is a positive relationship between adaptive leadership and organizational commitment.

H1b. There is a positive relationship between executive leadership and organizational commitment.
There is a positive relationship between effective leadership and organizational commitment.

There is a positive relationship between innovative leadership and organizational commitment.

2.4.2 Job satisfaction. Job satisfaction commonly reflects a positive, affective reaction of employees to their job (Rahiman and Kodikal, 2017). According to Alas and Edwards (2006), job satisfaction is regarded as affective; a pleasurable emotional state resulting from the appraisal of one’s work. Job satisfaction has been associated with employee behavior, motivation and increased employee productivity and is measured to the extent in which employees feel positive or negative toward their job (Bhuian and Islam, 1996). Hence, leadership attributes embedded in academic employees are expected to empower high levels of job satisfaction by enhancing the quantity and quality of research, publications, teaching and service. The academic employees’ job satisfaction relies on the important factors that are conducive, such as mentally challenging work, equitable rewards, supportive working conditions and helpful colleagues. Other studies indicate that ethical leadership has a direct and indirect influence on job satisfaction (Neubert et al., 2009; Yates, 2014). The arguments suggest leadership attributes should positively affect job satisfaction. Therefore, the following hypotheses are suggested:

H2. There is a positive relationship between leadership attribute and job satisfaction.
H2a. There is a positive relationship between adaptive leadership and job satisfaction.
H2b. There is a positive relationship between executive leadership and job satisfaction.
H2c. There is a positive relationship between effective leadership and job satisfaction.
H2d. There is a positive relationship between innovative leadership and job satisfaction.

2.4.3 Career satisfaction. Career satisfaction reflects a positive affective reaction of employees to their career. It measures an employee’s achievements in their career by capitalizing upon their skills and abilities to improve the quality of work and enhance their promotions (Karia, 1999). There are no studies concerned with leadership attributes and impact on career satisfaction. In different studies, Tu et al. (2006) indicate that, among Chinese managers, leadership in a middle management position is associated with greater career satisfaction. These satisfied leaders have no intention of leaving because they are satisfied with their careers (Eddleston, 2009). Satisfied employees are able to provide high levels of service to organizations and enhance the organization’s key performance index. Hence, leadership attributes embedded in academic employees empower high levels of career satisfaction by contributing quality levels of research, publications, teaching and service to HEIs which, in turn, enable them to achieve their career goals and remain with the organization. The arguments suggest leadership attributes should positively affect career satisfaction. Therefore, the following hypotheses are suggested:

H3. There is a positive relationship between leadership attribute and career satisfaction.
H3a. There is a positive relationship between adaptive leadership and career satisfaction.
H3b. There is a positive relationship between executive leadership and career satisfaction.
H3c. There is a positive relationship between effective leadership and career satisfaction.
H3d. There is a positive relationship between innovative leadership and career satisfaction.
In brief, the research model developed provides the theoretical framework for examining the relationship between leadership attributes and work-related attitudes (Figure 1). Based on the theoretical framework, 3 main hypotheses and 12 minor hypotheses are proposed.

3. Methodology

3.1 Sample and data collection
A random sample of 1,000 academic employees in Malaysian public universities was drawn from the universities’ web sites. An online survey (www.surveymonkey.com) was used for distributing questionnaires to academic employees via e-mail, of which 245 responded, hence giving a response rate of 24.5 percent. Follow-up calls were carried out to foster completion and return of the questionnaires. Regression analysis using SPSS version 22.0 was used to analyze the data of the study.

3.2 Respondent profile
A profile of the participants represents academic employees in Malaysian public universities. The descriptive statistics show an almost equal number of male (45.3 percent) and female (54.7 percent) participants in the sample. The majority of academic employees are Malay (87 percent) followed by Chinese (4.5 percent) and Indian (4 percent). Most are lecturers (37.5 percent) followed by senior lecturers (34.7 percent), assistant professors (3.3 percent), associate professors (12.2 percent) and professors (9.8 percent). About half are PhDs (53 percent) and Masters’ (44.9 percent) holders representing an academic discipline in the field of pure science (8.4 percent), applied science (45.8 percent), pure arts (3.8 percent) and applied arts (38.3 percent). Some of the academic employees are program chairs (29.5 percent), deans (8.2 percent), deputy deans (5.7 percent), directors (4.9 percent) and deputy directors (4.1 percent). About more than half of academic employees have served less than nine years (65 percent), between 9 and 16 years (23 percent) and above 16 years (12 percent) whereby they have indicated high organizational commitment (mean = 3.77, SD = 0.64) followed by job satisfaction (3.69, SD = 0.65) and career satisfaction (mean = 3.64, SD = 0.84).

3.3 Measures
Table I presents the measures used in the study. The leadership attributes are measured using Asaari (2012) including innovative, effective, executive and adaptive leadership. A five-point

<table>
<thead>
<tr>
<th>Leadership attributes</th>
<th>Work-related attitudes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Innovative</td>
<td>Organizational commitment</td>
</tr>
<tr>
<td>Executive</td>
<td>Job satisfaction</td>
</tr>
<tr>
<td>Effective</td>
<td>Career satisfaction</td>
</tr>
<tr>
<td>Adaptive</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1. Research model of new leadership attributes
<table>
<thead>
<tr>
<th>Construct</th>
<th>Item</th>
<th>Cronbach’s α</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Leadership attribute</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Innovative</td>
<td>I am able to...</td>
<td>0.910</td>
</tr>
<tr>
<td>18 items</td>
<td>assign certain tasks to member</td>
<td></td>
</tr>
<tr>
<td></td>
<td>inspire member through conversing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>handle complex problems</td>
<td></td>
</tr>
<tr>
<td></td>
<td>encourage member</td>
<td></td>
</tr>
<tr>
<td></td>
<td>speak with a strong inner confidence</td>
<td></td>
</tr>
<tr>
<td></td>
<td>inspire members on projects</td>
<td></td>
</tr>
<tr>
<td></td>
<td>convince my arguments</td>
<td></td>
</tr>
<tr>
<td></td>
<td>speak as a representative of members</td>
<td></td>
</tr>
<tr>
<td></td>
<td>manage many demands</td>
<td></td>
</tr>
<tr>
<td></td>
<td>represent members at outside meetings</td>
<td></td>
</tr>
<tr>
<td></td>
<td>influence my views</td>
<td></td>
</tr>
<tr>
<td></td>
<td>speak for members when visitors are present</td>
<td></td>
</tr>
<tr>
<td></td>
<td>create and design new things</td>
<td></td>
</tr>
<tr>
<td></td>
<td>act as the spokesman of members</td>
<td></td>
</tr>
<tr>
<td></td>
<td>be a convincing speaker</td>
<td></td>
</tr>
<tr>
<td></td>
<td>be a very persuasive speaker</td>
<td></td>
</tr>
<tr>
<td></td>
<td>schedule work to be done</td>
<td></td>
</tr>
<tr>
<td></td>
<td>be skillful in an argument</td>
<td></td>
</tr>
<tr>
<td>2. Effective</td>
<td>I allow member to...</td>
<td>0.800</td>
</tr>
<tr>
<td>10 items</td>
<td>contribute ideas</td>
<td></td>
</tr>
<tr>
<td></td>
<td>exercise good judgement</td>
<td></td>
</tr>
<tr>
<td></td>
<td>have a high degree of initiative</td>
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</tr>
<tr>
<td></td>
<td>use their own judgement in solving problems</td>
<td></td>
</tr>
<tr>
<td></td>
<td>work what they think best</td>
<td></td>
</tr>
<tr>
<td></td>
<td>handle assigned tasks</td>
<td></td>
</tr>
<tr>
<td></td>
<td>do the job with minimal supervision</td>
<td></td>
</tr>
<tr>
<td></td>
<td>have a complete freedom in their work</td>
<td></td>
</tr>
<tr>
<td></td>
<td>have any freedom of action</td>
<td></td>
</tr>
<tr>
<td></td>
<td>set their own pace</td>
<td></td>
</tr>
<tr>
<td>3. Executive</td>
<td>I am able to...</td>
<td>0.810</td>
</tr>
<tr>
<td>10 items</td>
<td>share my ideas</td>
<td></td>
</tr>
<tr>
<td></td>
<td>let members know what are expected from them</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ask members to follow rules and regulations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>encourage members to use of work procedures</td>
<td></td>
</tr>
<tr>
<td></td>
<td>make my attitudes clear to members</td>
<td></td>
</tr>
<tr>
<td></td>
<td>make sure my part among members is understood</td>
<td></td>
</tr>
<tr>
<td></td>
<td>schedule my work</td>
<td></td>
</tr>
<tr>
<td></td>
<td>organize my works</td>
<td></td>
</tr>
<tr>
<td></td>
<td>maintain standards of performance on members</td>
<td></td>
</tr>
<tr>
<td></td>
<td>allow others know about members’ activities</td>
<td></td>
</tr>
<tr>
<td>4. Adaptive</td>
<td>I am able to...</td>
<td>0.760</td>
</tr>
<tr>
<td>8 items</td>
<td>be positive about the outcome of any new procedure</td>
<td></td>
</tr>
<tr>
<td></td>
<td>accept defeat in a calm way</td>
<td></td>
</tr>
<tr>
<td></td>
<td>remain calm in facing uncertain situations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>wait patiently for the results of a decision</td>
<td></td>
</tr>
<tr>
<td></td>
<td>be patient to wait for an outcome</td>
<td></td>
</tr>
<tr>
<td></td>
<td>delay action till the proper time</td>
<td></td>
</tr>
<tr>
<td></td>
<td>tolerate postponement and uncertainty</td>
<td></td>
</tr>
<tr>
<td></td>
<td>accept delays without being upset</td>
<td></td>
</tr>
</tbody>
</table>

Table I. Construct reliability analysis (continued)
Likert scale ranging from 1-strongly disagree to 5-strongly agree was used for leadership attributes. The work-related attitudes, measured using Karia (1999), comprise organizational commitment, job satisfaction and career satisfaction by using a five-point Likert scale ranging from 1-strongly disagree to 5-strongly agree. The reliability analysis is summarized in Table I, the Cronbach’s $\alpha$’s for all variables (independent and dependent) are above 0.7 indicating measures for leadership attributes and work-related attitudes are reliable (Hair et al., 2010).

Pallant (2007) points the Cronbach’s $\alpha$ that has a value 0.77 is considered acceptable, a value of 0.80 is preferable and a value of 0.89 is a very good internal consistency.

### 4. Results

#### 4.1 Descriptive statistics and correlation results

The Pearson correlation results between each of the leadership attributes and work-related attitudes show positive, significant correlations, suggesting that adaptive, executive, effective and innovative attributes of leadership are positively associated with their work-related attitudes, namely, organizational commitment, job satisfaction and career satisfaction (Table II). The results, hence, support $H1$–$H3$. Further investigation is required to justify the proposed relationship.

#### 4.2 Regression

Multiple regression analysis was performed to gain further insight into the effects of leadership attributes on work-related attitudes (Table III). The $F$ statistics ($F = 16.44$) is significant at $p = 0.000$. With respect to organizational commitment, the coefficient of
determination, $R^2$, is 22.5 percent, indicating that the emergent leadership attributes of academic employees' have explained most of the variance in organizational commitment. However, only innovative and executive leadership have a positively significant effect on organizational commitment. $H1b$ and $H1d$ are, thus, verified. These imply that the greater the extent of these two attributes, the greater the organizational commitment. The most essential aspect of leadership in explaining variance in organizational commitment is innovative leadership, with the highest beta (0.216), significant at the $p = 0.01$. It is confirmed that increasing innovative leadership will enhance greater academic employees' organizational commitment. Adaptive and effective leadership are not significant but they are associated with explain organizational commitment.

With respect to career satisfaction, the $F$ statistics ($F = 11.99$) is significant at $p = 0.000$. The coefficient of determination, $R^2$, is 17.3 percent, indicating the emergent leadership attributes of academic employees' have explained most of the variance in career satisfaction. However, only innovative and executive leadership have a positive significant effect on career satisfaction. $H3b$ and $H3d$ are, thus, verified. These imply that the greater the extent of these two attributes, the greater the career satisfaction. The most essential attributes in explaining variance in career satisfaction was executive leadership, with the highest beta (0.338), significant at the $p = 0.01$. Thus innovation and executive leadership will enhance academic employees’ career satisfaction. Adaptive and effective leadership are not significant but they are associated when explaining career satisfaction.

With respect to job satisfaction, the $F$ statistics ($F = 6.717$) is significant at $p = 0.000$. The coefficient of determination, $R^2$, is 10.5 percent, indicating the emergent leadership

<table>
<thead>
<tr>
<th>Leadership</th>
<th>Organizational commitment</th>
<th>Career satisfaction</th>
<th>Job satisfaction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Std $\beta$</td>
<td>Sig.</td>
<td>Std $\beta$</td>
</tr>
<tr>
<td>Innovative</td>
<td>0.216**</td>
<td>0.007</td>
<td>0.060</td>
</tr>
<tr>
<td>Effective</td>
<td>0.115</td>
<td>0.125</td>
<td>-0.006</td>
</tr>
<tr>
<td>Executive</td>
<td>0.192*</td>
<td>0.023</td>
<td>0.338***</td>
</tr>
<tr>
<td>Adaptive</td>
<td>0.053</td>
<td>0.439</td>
<td>0.077</td>
</tr>
</tbody>
</table>

| $R^2$ | 0.225 |
| Adjusted $R^2$ | 0.212 |
| SE | 0.591 |
| $F$ Statistics | 16.441 |
| Sig. $F$ | 0.000 |

**Notes:** ***,***significant at 0.05, 0.01 and 0.001, respectively

Table II. Pearson correlation results

<table>
<thead>
<tr>
<th>Leadership</th>
<th>Mean</th>
<th>SD</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Innovative</td>
<td>3.691</td>
<td>0.487</td>
<td>0.473**</td>
<td>0.633**</td>
<td>0.425**</td>
<td>0.446**</td>
<td>0.334**</td>
<td>0.199**</td>
<td></td>
</tr>
<tr>
<td>Effective</td>
<td>4.100</td>
<td>0.351</td>
<td>0.588**</td>
<td>0.501**</td>
<td>0.338**</td>
<td>0.242**</td>
<td>0.211**</td>
<td>0.211**</td>
<td></td>
</tr>
<tr>
<td>Executive</td>
<td>4.111</td>
<td>0.362</td>
<td>0.414**</td>
<td>0.414**</td>
<td>0.420**</td>
<td>0.420**</td>
<td>0.322**</td>
<td>0.322**</td>
<td></td>
</tr>
<tr>
<td>Adaptive</td>
<td>3.618</td>
<td>0.461</td>
<td>0.256**</td>
<td>0.195**</td>
<td>0.220**</td>
<td>0.220**</td>
<td>0.334**</td>
<td>0.334**</td>
<td></td>
</tr>
</tbody>
</table>

Table III. The regression analysis results
attributes of academic employees’ have explained most of the variance in job satisfaction. However, only executive leadership has a positive, significant effect on job satisfaction. H2b is, thus, verified. These imply that the greater the extent of executive leadership, the greater the job satisfaction. The most essential attributes in explaining variance in job satisfaction is executive leadership, with the highest $\beta$ (0.276), significant at $p = 0.01$. The executive leadership is, therefore, significant in enhancing academic employees’ job satisfaction. Innovative, adaptive and effective leadership are not significant but they are associated when explaining job satisfaction.

5. Discussion and implications
In spite of many studies about leadership and its effects, this contemporary study provides novel findings on the new leadership model in an era of rapidly expanding technology and a dynamic environment that can boost employee work-related attitudes. The study reveals the emergence of four leadership attributes embedded in employees that determine three key work-related attitudes among academic employees in HEIs. The evidence shows the distinct effects of leadership attributes on work-related attitudes. The finding advances knowledge concerning the complexity of leadership’s emergent nature (Mendes et al., 2016) that explains leadership as emergent leadership behaviors which lead to higher and better work-related attitudes. So far this study is the first to discover the effects of leadership attributes that justify how leadership attributes empower high levels of employee work-related attitudes; whereby previous scholars have been more concerned with the academic leader-follower linkage and, hence, have neglected the valuable leadership capability of employee academics.

The results justify that leadership attributes are positively correlated to work-related attitudes, indicating work-related attitudes are thus enhanced when the four attributes of leadership increase. Specially, the study confirms that innovative, executive, adaptive and effective leadership induce employees’ work-related attitudes, thus providing theoretical and empirical evidence concerning the complexity of leadership theory (Carte et al., 2006; Fitzgerald et al., 2013; Mendes et al., 2016). The findings indicate that academic employees in Malaysian public universities have great leadership attributes with the high-level of organizational commitment, job satisfaction and career satisfaction that might be necessary for achieving excellent university rankings and enhancing efficiency and effectiveness. Academic employees in Malaysian public universities possess innovative leadership that can allow them to design creative and innovative research, publications, teaching and related activity. Further, academic employees with executive leadership can work independently with their expertise in teaching, supervision, research, publication, consultancy and service. Meanwhile, academic employees with effective leadership can have the power to put plans, actions or laws into effect and academic employees with adaptive leadership can manage any changes and challenges in the competitive environment. Hence, the emergence of leadership attributes and its construct measurements is verified (Asaari, 2012; Asaari, Dwiedi, Lawton and Karia, 2013; Asaari, Dwiedi and Lawton, 2013).

The findings are meaningful for theoretical leadership and organizational advancement as the effects of leadership attributes among Malaysian academic employees in this study might be diverse from past studies and other contexts, e.g., country and industry. The study contributes more theory-driven empirical evidence to test the effects of leadership attributes on work-related attitudes, which are contemporary and timely in the era of industry 4.0 and dynamic environments. Malaysian public universities struggle for creative research and educational excellence in order to become competitive research universities. To respond to such pressures, it is important for Malaysian public universities to preserve the intrinsic values of their academic employees’ leadership. Such values enable them to stimulate and
inspire the job satisfaction, career satisfaction and organizational commitment obtained through leadership attributes.

The study provides some of the first evidence that leadership attributes have a positive effect on employees’ work-related attitudes; however, when the emergence of four leadership attributes are associated together, not all leadership attributes could directly affect work-related attitudes. This expands earlier leadership and organizational research by analyzing the effects of leadership attributes on work-related attitudes. Fundamentally, the findings suggest the greater the extent of employee leadership attributes, the greater the enhancement of work-related attitudes, indicating innovative, executive, adaptive and effective leadership have a positive impact on the organizational commitment, job and career satisfaction of academic employees. Uniquely, this study discovers that executive and innovative leadership are the most crucial attributes for enhancing work-related attitudes. The results reveal that the high-level of executive leadership has a positive and greater effect on organizational commitment, career satisfaction and job satisfaction and the high-level of innovative leadership has a positive and greater effect on organizational commitment and career satisfaction. In Malaysian public universities, most academic employees with executive leadership are more committed to their organizations and satisfied with their job and career when they can easily work independently within their expertise in teaching, supervision, research consultancy and service (Nicholson et al., 2007). Further, most academic employees with innovative leadership are rather committed with their organizations and satisfied with their career since they can work creatively and innovatively in research, publications, teaching and other related activity (Rank et al., 2004; Yanez, 2004; Audenaert et al., 2016).

The findings confirm that independently, adaptive and effective have a positive impact on organizational commitment, job and career satisfaction but they become insignificant when four leadership attributes are entered simultaneously into the regression. Similarly, innovative independently has a positive impact on job satisfaction but it is insignificant when four leadership attributes are entered simultaneously into the regression. Though adaptive and effective leadership are insignificant with work-related attitudes, and innovative leadership is insignificant with job satisfaction, they are complementary for other two leadership attributes to enhance greater work-related attitudes. Adaptive and effective are associated with executive and innovative to enhance a greater of organizational commitment, career satisfaction and job satisfaction, while innovative leadership is associated with other three leadership attributes in order to enhance a greater job satisfaction. This indicates that without complementing each other, they will be abandoned or wasted, thereby they will decrease the effects on work-related attitudes. This dynamic configuration of leadership shows the complexity of employee leadership emerging naturally and the fixed in human capital which empowers the high-level of employee work-related attitudes.

The results provide valuable knowledge for HEIs and leaders. The study indicates that HEIs should continuously develop and inspire academic employee leadership attributes. To achieve work-related attitudes, it is important for HEIs to gain robust leadership attributes that focus not only upon executive and innovative leadership but also other attributes because they are dynamic and change over time. Significant insight from the research is that leaders should realize that the complementary effects between different leadership attributes will generate different work-related attitudes. These insights give leaders a new approach to understand the academic employees’ leadership attributes and their work-related attitudes.

Another implication is that leaders should not anticipate that leadership attributes can always foster work-related attitudes. The findings show that innovative and executive leadership affect most work-related attitudes, which mean leaders should focus on identifying leadership attributes that could improve work-related attitudes instead of
using leadership as factors having influence over others. The excessive anticipation on leadership factors for influencing others could lead to a failure to focus on designing dynamic and robust leadership attributes and recognizing the valuable leadership capability of academic employees.

Our results would also be worthwhile for HEIs in Malaysia and other countries with identical economies to apply this contemporary leadership model by understanding how leadership complexity and attributes can have an impact on work-related attitudes. HEIs should proactively and innovatively understand the emergent leadership attributes that suit their academic employees’ work-related attitudes which, in turn, will lead to sustainable performance and success.

6. Conclusion
This paper makes an important contribution to the research and literature of leadership and organizational by developing and testing a theoretical model of leadership. The immature conclusions of past studies determine the study to further investigation of the emergent leadership-work-related attitude relationship. Our findings, hence, unveil empirical evidence concerning the effects of leadership attributes on work-related attitudes. We show evidence that the study is significant in the rapid changes in the competitive context of HEIs. The present study not only contributes to the leadership and organizational literature, but also enriches understanding on the complexity of emergent leadership attributes and its effects on employee work-related attitudes. Executive and innovative leadership are acknowledged as the most robust leadership attributes and become the most vital for organizational commitment, career and job satisfaction. Our findings extend the knowledge of employee leadership attributes, emerge research constructs and measurements for leadership attitudes and work-related attitudes, and provide theory-driven empirical evidence to the complexity of leadership theory.

From a practical perspective, our findings provide HEIs and leaders with a deeper understanding about the great leadership attributes evolved in academic employees that transform into work-related attitudes. It is recommended that HEIs should believe and be able to see the unlimited potential of intellectual capital that they have. The leadership attributes stimulate and inspire employees to perform well and give impact in their life and work life as well. Leadership attributes often reflect employees’ self-motivation, courage or belief to challenge, inspire, motivate and move themselves to what they want to be or achieve. Further, HEIs should realize the effects of leadership attributes as factors influencing employees’ work-related attitudes, namely, organizational commitment, job satisfaction and career satisfaction. In the competitive environment, such high-performing employees are a valuable resource-capability and necessary for superior academic employees’ competitiveness in research, publications, teaching, consultation and services and the competitive advantage of HEIs.

Although the study discovers significant results and generalizations, it is limited to a sample of academic employees in Malaysian public universities. It is interesting to know that if the same study would be done in different contexts (e.g. firms, industries, countries) for model justification and enhancing generalization. It would be more favorable for future research to extend the research framework by testing factors influencing leadership attributes and their effects on work-related attitudes or different leadership attributes that might determine work-related attitudes. Future research may further investigate the mediation and/or moderation effects of leadership attributes and how work-related attitudes affect firm performance or competitive advantage. It is highly relevant for future research to examine the impact of leadership attributes on work-related attitudes over the long-term as their effects will be different and varied. Future results could produce different findings from ours.


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Lean culture: a comprehensive systematic literature review

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Abstract

Purpose – The purpose of this paper is to assess the level of pragmatic ambiguity (PA) lean culture has currently in the manufacturing and service literature.

Design/methodology/approach – A comprehensive systematic review of academic (journals, books and theses) and commercial literature was undertaken drawn from a six databases search of two keywords (“lean” and “culture”) and related citations.

Findings – A total sample of 1,066 references (678 academic papers, 121 books, 103 theses and 164 commercial documents) were analyzed. The authors found contributions from 67 countries but oddly, only two came from Japan. In total, 89 percent of citations were directly about lean culture. However, for 86 percent of them, lean culture was only discussed superficially. All four literature segments show an over 85 percent agreement on lean culture being an organizational aim. The authors encountered 103 definitions of organizational culture and found 13 definitions of lean culture. Issues of culture gap, leadership, human resource management, sustainability and innovation are found to amplify lean culture’s already high PA level.

Research limitations/implications – Further research and development are needed to decrease lean culture’s PA level and improve understanding of lean from a cultural perspective.

Practical implications – Current lean culture’s high PA level has positive and negative effects on lean implementation. Taking lean implementation from a cultural perspective may facilitate an organization’s lean transformation journey.

Originality/value – This is the first systematic literature review on lean culture using a broad and inductive approach. An original evidence-based definition of organizational culture is proposed.

Keywords Review, Manufacturing, Culture, Service, Lean

Paper type Literature review

1. Introduction

With the ebbing of the total quality management (TQM) movement and the seminal publication of Womack et al.’s “The Machine that changed the world,” lean has become one of the prominent contemporary performance enhancing business proposition for both manufacturing and service organizations (Gupta et al., 2016; Hines et al., 2004). Portrayed as a salutary solution by its numerous advocates, it is also described as a waning fad by perhaps as many detractors in the academic and practitioner world of all fields (Atkinson and Nicholls, 2013; Newman and Chaharbaghi, 1998; Seddon, 2011; Womack and Jones, 1996/2003). As controversial as TQM once was, lean finds its origins in the same principles and operation management master pioneers teachings of Shewhart, Deming, Juran and others (Bicheno and Holweg, 2009). But it took the ingenuity, the hard work and peculiar contextual circumstances of the Toyota car company to demonstrate the power of lean on operational effectiveness and lead the way (Liker, 2004). Lean instructs organizations to continuously improve all of their operation elements by relentlessly
creating value and removing non-value added or waste activities from the stance of the ultimate end-customer through initiatives of an entire body of trained motivated personnel (Mann, 2015; Rother, 2010; Womack et al., 1990). It is often labeled as a “common sense” approach that is very attractive and appears deceptively simple to master (Holweg, 2007; Radnor et al., 2012).

Lean remains, however, notoriously difficult to implement with a reported adoption failure rate as high as 90 percent (Bhasin, 2012). Even though it has been more than 40 years since Sugimori et al. (1977) published the first English account on Toyota Production System (TPS), Toyota’s foundational actualization and prime inspiration of lean, managers and scholars are still struggling to crack open its code and replicate similar success as Toyota. Amongst all reported possible factors of this enigma, culture has been repeatedly evoked to be as much an explanation, a cause and a key solution (Amhad, 2013; Bortolotti et al., 2015; Wong, 2007). But which culture though?

Culture in management can indeed take several meanings. In their review, “The many faces of culture: making sense of 30 years of research on culture in organizations studies,” Giorgi et al. (2015) present a framework in which, according to them, culture in management has been approached into five interrelated ways: as values, as stories, as frames, as toolkits and as categories. National culture, one of the earliest and longstanding hypotheses to explain lean’s successful development in Japan (Schonberger, 2007) falls into their first form, culture as values. However, national culture is less and less considered to be the issue in lean. Although it took decades to demonstrate, lean has now been convincingly shown not to be exclusively “Japanese” as evidenced by the positive experience of the American Nummi (New United Motor Manufacturing, Inc.) project, the success of many other international lean organizations in all domains and the simple fact that not all organizations in Japan are lean (Krafcik, 1988; Kull et al., 2014; Netland et al., 2012).

In their paper, “Culture change: an integration of three different views,” Meyerson and Martin (1987) further highlight that the analysis of culture in management needs to be interpreted in accordance to three paradigms: an integrative one, which acknowledges the existence of organization-wide culture; a differentiative one, which recognizes that, within any organization, there are sub-cultures that co-exist; and an ambiguous one, which stresses the fact that individuals in organization bring their own cultural contributions which are continuously influenced by other cultures outside the organization and are to be addressed appropriately by management for optimal organizational performance.

Determining what kind of culture (individual, team, organizational and communal) or whose culture (leaders, managers, employees, suppliers and customers) are more important in lean or which features of culture are relevant for lean success or, in fact, finding out what is exactly a lean culture does not come by easily with a rapid search of the manufacturing or service literature. The notion of lean culture appears to be rather used freely by all for all. Lean culture seems indeed to be in a state of convenient pragmatic ambiguity (PA).

PA is a construct developed by Giroux which she defines as: “the condition of admitting more than one course of action” in her analysis of the TQM movement and management fashions (Giroux, 2006). PA allows the co-existence of multiple, even possibly diametrically opposite, interpretations of the same concept leading to many different applications. It creates a situation in which concepts such as lean and its culture find sufficient recognition to exist but may be used in many different ways to support any argument liberally. When there is PA, everyone has sort of an idea of what the actual concepts are and mean. Everyone kind of agrees of what they are not or ultimately agrees to disagree but the concepts survive and may even thrive for a while. However, a condition of PA can only last for so long before flaws and inconsistencies are exposed, confusion sets and interest wanes. As TQM’s faith demonstrates, what may have been in the limelight for a while is at risk of vanishing away unless the concepts are clarified and properly characterized.
For this purpose, systematic literature reviews can be very useful and effective. Templier and Paré (2015) have identified four different types of systematic literature reviews: the narrative, the developmental, the cumulative and the aggregative types. Each one has strengths and challenges which direct selecting the proper type to use. As brief examples, a narrative review aims to strictly summarize knowledge in a topic but does not include novel propositions or theory validation; a developmental review uses a selection of leading documents for the construction of new conceptual framework and theories; a cumulative review compiles evidence methodically to identify patterns and generate new knowledge, whereas aggregative review pools knowledge of similar documents for the performance of evidence-based meta-analyses.

This work intends to assess the level of PA lean culture currently has in the literature and describes its source, its range and its scope through a comprehensive systematic review of Templier and Paré’s cumulative type. A discussion is provided highlighting the positive and negative implications of lean culture’s current PA level and the paper concludes with its limitations and suggestions for further research and development on lean culture.

2. Methods

This systematic literature review emulates, adapts and extends methodology of other recent literature reviews on lean services (Gupta et al., 2016), Lean Healthcare (Costa and Filho, 2016; D’Andreamatteo et al., 2015) and Lean Six Sigma in manufacturing (Albliwi et al., 2015). Findings of the latest one on lean research by Danese et al. (2017) are considered in the discussion. This review respects the three generic stages (planning, conducting and reporting) recommended by Tranfield et al. (2003) for systematic literature reviews and methods of the cumulative type as described by Templier and Paré (2015). Because the purpose of the study was to investigate the extent of lean culture PA which revealed itself during the conduct of the study, we purposely did not pre-determine a data collection plan and proceeded and coded information iteratively. A first literature search was performed October 30 and 31, 2016 on six electronic databases (ABI/inform (Proquest), Business Source Complete (EBSCO), Sage Journals, Science Direct (Elsevier), Web of Science (Reuters) and Google Scholar) in triplicate to confirm stability of listings, using simply two keywords: “lean” and “culture” to maximize findings without brackets and without a time frame limit. Six month later, April 30, 2017, a second literature search was then done with the same two keywords “lean culture” with brackets in all same six electronic databases in triplicate to enhance this work’s comprehensiveness and validity. When permitted, filters were applied to restrict listing regarding management, which allowed avoidance of irrelevant entries relating, for examples, to basic and clinical research on obesity. Then, citation abstracts were screened for relevance to the purpose of investigating the lean culture concept in the literature. To maximize inclusiveness, we did not rate or restrict documents based on their quality but reviews, editorials, commentaries and abstracts were discarded. Figure 1 provides a records selection flowchart. Interestingly, although there was a certain amount of cross-detection between databases (12 percent or n = 127), no record was unanimously cited by all of them. ABI/inform (Proquest) and Business Source Complete (EBSCO) had the most similar search (48 shared citations or about 40 percent) in the first search (31-10-16). There were very few shared records in the second search (30-04-17) (6 percent or n = 37). Search in Business Source Complete (EBSCO) had the most repeat within its own listing citations followed by Google Scholar. Google Scholar had the highest number of erroneous citations. After eliminating these repeats and errors, citations from personal website or of promotional nature were discarded as they carry the heaviest bias load and have little or no review process for diffusion. Citations in foreign languages other the English or French were not considered. Note that only one record in French ended up in the review. As scientific knowledge is traditionally built incrementally, we took advantage
of the contemporary “cited by” feature enabled in Google Scholar to research all found citations for additional references. Many recurrent citations were encountered but 52 new entries were identified by this scheme (for more details, contact corresponding author). Retrieval of documents took 16 weeks (2 periods of 8 weeks) with a success rate of 98 percent (24 missing). Baseline information of each document (authors’ name; country of first author; nature, methods and base industry of the document; publication title, subject and year; and publisher) was collected in an Excel spreadsheet and validated by a research assistant (agreement \( W \geq 95 \) percent). Discordances were settled by discussion and senior author decision. Then lean culture information was extracted from each document and processed in additional Excel spreadsheets. Coding was conducted by making as little inference as possible. Definitions to be considered had to be explicitly stated as well as any feature of lean culture; hence, records were determined superficial if lean culture was basically mentioned without any other precision or along with use of a plain synonym such as culture of continuous improvement (the most common). Substantial records include some form of construct development: either by details on organizational culture or definition or description of lean and/or of lean culture. For the aim to indicate greater support in our results, when appropriate, statistical analyses (\( \chi^2 \) tests) were performed with Excel software v 16.0.9501.2080. Threshold for significance is set at standard \( p < 0.05 \).

### 3. Findings

#### 3.1 Source documents of lean culture pragmatic ambiguity assessment

This systematic literature review covers the content of a total sample of 1,066 documents including 678 academic journal papers, 121 books, 103 theses and 164 commercial
literature articles. No previous systematic review on lean culture was found in our search. Source documents of lean culture PA assessment’s analysis cover information about countries of origin, authorship and timeline, publishers, fields of study, documents’ method, academic contribution and by its extent.

The notion of lean culture is found to have a wide international appeal with contributions from 67 countries. The six most productive countries, as determined by affiliation of the first author, were: the USA ($n = 413, 39\%$), the UK ($n = 129, 12\%$), Sweden ($n = 52, 5\%$), Malaysia ($n = 38, 4\%$), Canada ($n = 33, 3\%$) and India ($n = 30, 3\%$). This finding that sourcing from the USA and UK represents greater than 50 percent of references is consistent among all recent systematic reviews (Danese et al., 2017; Costa and Filho, 2016; Gupta et al., 2016). By continent, 448 lean culture documents were hence from North America, 388 from Europe, 154 from Asia, 33 from Africa, 27 from South America and 16 from Australia. Remarkably, only two Japanese articles addressing lean accounting were found. They essentially though simply referred to the notion of lean culture without any development. Sparsity of Japanese communication on lean has been previously noted by Guimaraes and de Carvalho (2012) who did not find any publications from Japan in their Lean Healthcare literature review. This is also observed in the other three recent aforementioned systematic reviews. Japan’s silence over lean is puzzling. Any explanation at this point would be speculative and requires further investigation, which is more likely to come from Europe as overall, this review findings suggest that European authors contribute to lean culture literature with more scientific contents than North American’s, who write more books and commercial literature ($p < 0.0001$) (for more details, contact corresponding author).

With ten contributions, S. Bhasin is the most prolific author on the topic. However, seven of his papers are essentially re-analysis of the same data collection involving a detailed survey questionnaire of 68 UK manufacturing organizations followed by a comprehensive audit of a subset of 20 of these organizations. We also identified late in the analysis four academic articles published twice, word for word, in two distinct journals under different titles. These are two examples of the risk of conducting systematic reviews on discovering anomalies in the literature. In total, 63 percent entries had more than one author ($670/1,066$), suggesting greater validity through collaborative work. The earliest entry found in our review was published in 1991. In total, 61 percent ($655/1,066$) have been published in the last five years with a peak in 2015 ($n = 147, 14\%$) (Figure 2).

Over the years, lean culture has caught the interest of 418 different publishers: the most important being the Emerald Group Publishing ($106/1,066; 10\%$), closely followed by Taylor and Francis Group ($82/1,066; 8\%$) and then Elsevier ($71/1,066; 7\%$). This finding is very similar to Gupta et al. (2016) review. With 18 entries, International
Journal of Lean Six Sigma is the main journal on the topic, followed by Journal of Manufacturing Technology Management \( (n = 12) \), International Journal of Productivity and Performance \( (n = 12) \), International Journal of Production Research \( (n = 10) \) and International Journal of Operations & Production Management \( (n = 10) \). In total, 16 records were from Proceedings of IIE Annual Conference (IISE) (Institute of Industrial and Systems Engineers). Overall, management publications (67 percent) predominate engineering (33 percent) one.

The majority of entries were clearly from the manufacturing world (598/1,066; 56 percent), 31 percent (330/1,066) came from the service domain and the remaining 138 (13 percent) were general. Authors were inspired from experiences from over 70 different industrial fields. Most of the documents reported on multiple fields. It is remarkable that Healthcare, a service, is the highest single field interest on lean culture (186/304; 61 percent) far ahead the next second one, and construction (86/321; 27 percent), which is surprisingly outnumbering motor vehicle (85/321; 26 percent), both from the manufacturing sector. Despite the large coverage, several important industries such as retail, legal, entertainment or tourism are missing (for more details, contact corresponding author).

Note that out of 103 theses retrieved in this literature search, 22 were at PhD level. Content of the other 81 has been thereafter excluded since the main purpose of baccalaureate and master degree’s thesis is to demonstrate capability and conceptual understanding and not particularly to contribute to the literature. Moreover, thesis’s gradings are not provided. Hence, a total of 985 documents were ultimately considered for further analysis.

In terms of methods, there is almost an even split with a predominance for qualitative analysis: single case (221/985; 22 percent) and multi-case (150/985; 15 percent), whereas quantitative analysis accounted for 21 percent (204/985); conceptual nature/modelization for 15 percent (148/985) and literature review for 7 percent (67/985). Ultimately, the remaining documents were based on expert opinion (195/985; 20 percent) (for more details, contact corresponding author).

In these records, 89 percent (879/985) of documents concerned directly lean culture, whereas the remaining 11 percent covered the topic indirectly either by discussing techniques related to lean such as Six Sigma, Lean Six Sigma, TQM or by making general comments about culture and organizational change not specifically associated to lean. Most of the former addressed the issue of lean culture superficially (753/879; 86 percent) and only 14 percent (126/879) treated the subject with some substance either by providing definitions or any depth in their discussion (for more details, contact corresponding author). A prime example can be found in David Mann’s book, *Creating a Lean Culture*. It does not contain a lean culture definition but suggests a workplace culture definition such as “the way we do things here” and it explains: “As lean management, with its closed-loop focus on process, becomes habitual, little by little – almost unnoticeably at first – a Lean culture begins to grow. The new Lean culture emerges as leaders replace the mindset to work around problems today […].”

### 3.2 Range of lean culture pragmatic ambiguity

Our findings indicate the range of lean culture PA to be demonstrated in terms of nature and bearer of lean culture, publication bias, manufacturing vs service lean culture treatment, quantitative method survey instruments, competing value framework (CVF) vs lean culture and deeper exploration. Table I provide an overview of the range of PA found in the 879 direct lean culture records.

For the large majority (786/879; 89 percent), lean culture was presented as: first, an organizational aim, a status to aspire, as opposed to, second, a pre-requisite or a condition precedent to lean (19/879; 2 percent); third, a mean or a tool used to master lean (57/879; 6 percent); fourth, an outcome (17/879; 2 percent), i.e. a by-product of lean. The role and responsibility of primary lean culture bearer was allocated to the organization leaders
(CEO or upper management team) in 244 articles (28 percent) as opposed to middle managers (46/879; 5 percent) or front-line personnel (32/879; 4 percent). Other includes all and government (10/879; 1 percent). For 547 (62 percent), no one in particular was mentioned to be responsible for upholding lean culture.

The relative similar distribution of all these proportions amongst each literature segment (academic, books, thesis and commercial) suggests that these findings legitimately represent the current lean culture situation. It supports their validity and the quality and relevance of this literature search.

There is, however, suggestion of probable publication bias in the review sample records since most authors but three documents state positive aspects of lean culture for organizations. We found the earliest dissenter in Newman and Chaharbaghi (1998). In their paper "The corporate cultural myth," they stand strongly against any use for the notion of organizational culture. Their virulent argumentation even compares culture to a cancer that may destroy defenseless organizations despite the fact that they paradoxically define culture as "the by-product of a technology that has been developed in exploiting an opportunity." The second negative view on the concept of lean culture comes from Bicheno and Holweg (2009). In their book The Lean ToolBox, they share (Peter) Scholtes’ skepticism about culture and claim that it is a greatly misused word and a too easy fallback excuse for lean’s failure. Finally, the third and last counter argument against lean culture we found resides in Seddon (2011). For him, lean and its culture can only be a fad since it essentially only "solves problems managers think they have" and "is as far as from (Taiichi) Ohno’s philosophy as it is possible to get." He, however, does not provide much more explanation to support his position.

Our analysis reveals several statistically significant differences between contributions from the manufacturing and the service sectors. Manufacturing lean culture literature (61 percent or \( n = 414/678 \)) appears to be of more scientific content than for service’s (28 percent or \( n = 191/678 \)) with a greater relative number of academic papers and lesser proportion of books and commercial articles (20 percent or \( n = 106/530 \)) than service and general domains (38 percent or \( n = 124/325 \); and 42 percent or \( n = 55/130 \), respectively ). General domains authors tend to write more books (32 percent or \( n = 41/130 \)) compared to those in manufacturing (8 percent or \( n = 43/530 \)) and service activities (11 percent or \( n = 37/325 \)) (\( p < 0.0001 \)) (for more details, contact corresponding author).

From Table II, service and general sectors seem to have less direct lean content predominance than manufacturing, which suggests more exploration on other forms of business performance improvement model such as Six Sigma. Authors from the general domain seem to discuss lean culture more substantially. There is no difference...
among manufacturing, service and general documents in regard to their vision of lean culture which is seen by over 89 percent to be an organizational aim as opposed to a pre-requisite, a mean or an outcome ($p = 0.28$ ns). All segments (manufacturing, service and general) put leaders as the main bearer of lean culture in concordance with all growing evidence supporting the crucial impact of leadership on lean mastership ($p = 0.07$ ns) (Al-Najem et al., 2012; Mann, 2009; Schein, 2010).

Additional evidence of the large range of lean culture PA level is demonstrated by methodology analysis of the 185 direct quantitative academic papers retrieved in our literature search. There appears to be little consensus on the proper survey instrument to use as 81 percent (150/185) developed their own original questionnaire. Main stated sources of inspiration for the construction of these surveys were Liker’s Toyota Way, Hofstede’s and the Globe study cultural dimensions, Cameron and Quinn’s CVF and Shah and Ward’s Lean performance indicators. Table III illustrates predicted impact and, whenever actually performed, study findings related to cultural dimensions proposed by Hofstede and the Globe study.

The most glaring discordance is seen in the dimension of future orientation, which relates to long-term planning and working relationships (Wincel and Kull, 2013; Martins et al., 2015). The majority predicted lean to culturally make organizations to have long-term outlook in accordance to the famed Hoshin Kanri tool and to discourage a mentality of short-term gains at any mean and any costs. But Kull et al. (2014) actually found the opposite in their analysis with lean manufacturing organizations showing lower future orientation than non-lean organizations, a result which they could hardly explain. Wincel and Kull (2013) had a similar observation but they offer the following explanation: long future-oriented organizations lack drive to improve their processes based on the western view that their future is predictable and manageable. There is hence no rush and perhaps even harm in changing anything rapidly whereas lean organizations with short future orientation stay restless and more agile, discontent by the status quo and eager to change every day. This duality and peculiar mix of long- and short-term orientation reveal some of the paradoxical features of lean’s nature. Lean seems to contain many nuances that are not well accounted for in prominent management models and frameworks assessment tools such as the cultural dimensions of Hofstede and the Globe study or the CVF of Cameron and Quinn. This may explain the discordant findings reported.

### Table II. Range of lean culture ambiguity (manufacturing vs service sectors)

<table>
<thead>
<tr>
<th></th>
<th>Manufacturing</th>
<th>Service</th>
<th>General</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>By point</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct</td>
<td>510 (94%/58%)</td>
<td>262 (85%/30%)</td>
<td>107 (82%/12%)</td>
<td>879 (89%)</td>
</tr>
<tr>
<td>Indirect</td>
<td>34 (6%/32%)</td>
<td>48 (15%/45%)</td>
<td>24 (18%/23%)</td>
<td>106 (11%)</td>
</tr>
<tr>
<td>Total</td>
<td>544 (55%)</td>
<td>310 (31%)</td>
<td>131 (13%)</td>
<td>985</td>
</tr>
<tr>
<td><strong>By coverage</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Superficial</td>
<td>447 (88%/59%)</td>
<td>231 (88%/31%)</td>
<td>75 (70%/10%)</td>
<td>753 (86%)</td>
</tr>
<tr>
<td>Substantial</td>
<td>63 (12%/50%)</td>
<td>31 (12%/25%)</td>
<td>32 (30%/26%)</td>
<td>126 (14%)</td>
</tr>
<tr>
<td>Total</td>
<td>510 (58%)</td>
<td>262 (30%)</td>
<td>107 (12%)</td>
<td>879</td>
</tr>
<tr>
<td><strong>By culture nature</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aim</td>
<td>449 (88%/57%)</td>
<td>240 (92%/31%)</td>
<td>97 (91%/12%)</td>
<td>786 (89%)</td>
</tr>
<tr>
<td>Other</td>
<td>61 (12%/66%)</td>
<td>22 (8%/24%)</td>
<td>10 (9%/11%)</td>
<td>93 (11%)</td>
</tr>
<tr>
<td>Total</td>
<td>510 (58%)</td>
<td>262 (30%)</td>
<td>107 (12%)</td>
<td>879</td>
</tr>
<tr>
<td><strong>By main bearer</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaders</td>
<td>111 (67%/47%)</td>
<td>92 (77%/39%)</td>
<td>35 (81%/15%)</td>
<td>238 (73%)</td>
</tr>
<tr>
<td>Other</td>
<td>54 (33%/61%)</td>
<td>27 (23%/30%)</td>
<td>8 (19%/9%)</td>
<td>89 (27%)</td>
</tr>
<tr>
<td>Total</td>
<td>165 (50%)</td>
<td>119 (36%)</td>
<td>43 (13%)</td>
<td>327</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-----------------------------------</td>
<td>-------</td>
<td>------------------------------</td>
<td>-------</td>
</tr>
<tr>
<td>Assertiveness</td>
<td>Lower</td>
<td>Lower</td>
<td>Lower</td>
<td>Lower</td>
</tr>
<tr>
<td>Future orientation</td>
<td>Higher</td>
<td>Higher</td>
<td>Higher</td>
<td>Higher</td>
</tr>
<tr>
<td>Humane orientation</td>
<td>Higher</td>
<td>Higher</td>
<td>Higher</td>
<td>No effect</td>
</tr>
<tr>
<td>In-group collectivism</td>
<td>Higher</td>
<td>No effect</td>
<td>Higher</td>
<td>No effect</td>
</tr>
<tr>
<td>Institutional collectivism</td>
<td>Higher</td>
<td>Higher</td>
<td>Higher</td>
<td>No effect</td>
</tr>
<tr>
<td>Performance orientation</td>
<td>Higher</td>
<td>No effect</td>
<td>Higher</td>
<td>No effect</td>
</tr>
<tr>
<td>Power distance</td>
<td>Lower</td>
<td>No effect</td>
<td>Lower</td>
<td>No effect</td>
</tr>
<tr>
<td>Uncertainty avoidance</td>
<td>Higher</td>
<td>No effect</td>
<td>Higher</td>
<td>Higher</td>
</tr>
</tbody>
</table>

**Notes:** As reported by Martins *et al.* (2015), assertiveness refers to “the degree to which organizations or societies are assertive, confrontational, and aggressive in social relationships”; future orientation refers to “the degree to which individuals in organizations or societies engage in future-oriented behaviors such as planning, investing in the future, and delaying gratification”; humane orientation refers to “the degree to which individuals in organizations or societies encourage and reward individuals for being fair, altruistic, friendly, generous, caring, and kind to others”; in-group collectivism refers to “the degree to which individuals express pride, loyalty, and cohesiveness in their organizations or families”; institutional collectivism refers to “the degree to which organizational and societal institutional practices encourage and reward collective distribution of resources and collective action”; performance orientation refers to “the extent to which an organization or society encourages and rewards group members for performance improvement and excellence”; power distance refers to “the degree to which members of an organization or society expect and agree that power should be unequally shared” and uncertainty avoidance refers to “the extent to which members of an organization or society strive to avoid uncertainty by reliance on social norms, rituals, and bureaucratic practices to alleviate the unpredictability of future events.” Bortolotti *et al.* (2015), Kull *et al.* (2014) and Wincel and Kull (2013) compared lean manufacturing organizations to non-lean manufacturing organizations which explain why higher and lower estimation are indicated; whereas for Martins *et al.* (2015), Lacksonen *et al.* (2010) and Abrahamsson and Isaksson (2012) only provide their predictions about what lean culture should be, hence use of high, moderate and low estimate.
Further evidence of wide PA range and common management models’ inadequacy can indeed be found in the works of Hardcopf and Shah (2014), Losonci et al. (2017) and Paro and Gerolamo (2015) using Cameron and Quinn’s CVF (Table IV). Hardcopf and Shah hypothesized that ambidexterity and adhocracy models of organizations would be more favorable to lean but could only find partial support for adhocracy in their study. Results of Losonci et al. suggest lean to be closer to clan and adhocracy organizational types and Paro et al., based on an analysis of the 14 principles of the Toyota way show that lean has predominantly a hierarchy nature.

All these authors are probably right in their own way. Existing instruments, frameworks and models may just be too crude and are ill-fitted to describe and assess lean in all its dimensions and nuances properly.

As already pointed out, the bulk of the current literature on lean culture remains very superficial. In fact, we could only find two papers who attempted to add more depth to their proposed lean culture conceptualization beyond the classic lean features such as continuous improvement or respect for people that are commonly reported. Alpenberg and Scarbrough (2009) sought to describe a TPS cultural archetype from a small meta-analysis. They remarked that TPS basic assumptions/values are not often described and that a large number of TPS behavioral norms, rites and rituals exist but only a few having explicit linkage. No attempt to fill gaps of knowledge was done and no unified TPS archetype is described in the end. In her paper, Parkes (2014) summarized the following characteristics of lean culture:

1. On the level of basic assumptions: particularism, synthesis, collectivism, outer direction, status assigned and synchrony.
2. On the level of values: PDCA process, standardization, visual management, teamwork, paradox, intensity, kaizen and do concept.
3. On the level of artefacts: Japanese terminology, rituals, uniforms, visual control management tools, etc.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhocracy</td>
<td>Positive</td>
<td>Partial</td>
<td>None made</td>
</tr>
<tr>
<td>Ambidexterity</td>
<td>Positive</td>
<td>Neutral</td>
<td>n/a</td>
</tr>
<tr>
<td>Clan</td>
<td>Neutral</td>
<td>Neutral</td>
<td>Non made</td>
</tr>
<tr>
<td>Hierarchy</td>
<td>Negative</td>
<td>Neutral</td>
<td>None made</td>
</tr>
<tr>
<td>Market</td>
<td>Neutral</td>
<td>Negative</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Notes: n/a, not applicable. As reported by Losonci et al. (2017); adhocracy culture type refers to an organization that has external focus and flexibility and “uses ad hoc approaches to solve problems incurred from the surrounding environment with flexibility and discretion. This, combined with the external focus and differentiation, indicates a willingness to take risks, creativity and innovation. Independence and freedom are highly respected” in these organizations; clan culture type refers to organizations that have internal focus and flexibility and is “characterized by internal cohesiveness with shared values, participation and collectivism.” They focus “on internal problems and concerns of individuals and perpetual employment with an informal approach to work characterized by flexibility and discretion”; hierarchy culture type refers to organizations that have internal focus and control with “centralized decision-making and attention to stability and control through formalized structures, standardization and rigidity with policies, instructions and procedures” and where “conformity is encouraged”; market culture type refers to organizations that have external focus and control and have “orientation toward the market and toward maintaining or expanding the current market share. Competition is emphasized within the boundaries of stability and control as with the setting of ambitious, quantifiable goals.” As proposed by Hardcopf and Shah (2014); ambidexterity culture type refers to a combination of high clan and adhocracy culture type levels. Paro and Gerolamo (2015) estimate of theoretical ideal lean culture is based on their scoring of Liker’s (2004) Toyota Way 14 principles with Cameron and Quinn’s competing values framework (CVF)
She does not unfortunately provide much explanation on why and how these characteristics distinguish themselves and are truly and specifically lean’s basic assumptions, values or artefacts. Suggested values of paradox and intensity are particularly intriguing. She does not either illustrate how these levels and characteristics relate to each other as if they were independent and disconnected.

3.3 Scope of lean culture pragmatic ambiguity

In addition to the aforementioned elements of its range, lean culture’s high level of PA is demonstrated also in its scope. Scope or extension of lean culture PA is hereby delineated in the more general concept of organizational culture, a listing of lean culture definitions, the notion of cultural gap and amplification by four primary managerial issues.

Whereas this review finds lean culture to be more often than not treated superficially in the literature, it reveals that in the majority of documents, lean culture relates to culture at an organizational level. However, even the notion of organizational culture appears to show immaturity. We were able to extract 103 different definitions of organizational culture in the 126 documents subset treating lean culture substantially (for more details, contact corresponding author). While this is evidence of PA at least in the discourse, content analysis of these definitions suggests a rather agreeing perception of organizational culture within lean culture scholars based on 14 domains that are translated in this original, evidence-based definition of organizational culture as:

\[
\begin{align*}
\text{learned}_n = 22 & \quad \text{shared}_n = 38 & \quad \text{collective}_n = 70 & \quad \text{knowledge}_n = 70 \\
\text{beliefs}_n = 35 & \quad \text{values}_n = 42 & \quad \text{related artefacts}_n = 20 & \quad \text{guiding}_n = 45 \\
\text{daily}_n = 17 & \quad \text{behaviors}_n = 84 & \quad \text{members}_n = 62 & \quad \text{distinctive}_n = 53 \\
\text{contextual}_n = 14 & \quad \text{powerful}_n = 5 \\
\end{align*}
\]

It is notable that none of the source definitions contained all above elements, which is by itself evidence of added value. Implications of this definition are that organizational culture is both an acquired and transmissible learning. It is deeply ingrained but modifiable as well and hence manageable. It involves a group of people and is characterized by all elements that make that group particular and standing out from other groups. Organizational culture accounts for the way a group of people behave among themselves and in interactions with their environment and with other people every day and for as long as the group choose to stay together. It suggests a constructivist nature in which organizational culture needs to be continuously re-enacted to exist. Organizational culture contains features of peer-pressure amongst its members and distanciation from other people, although how it is actually performed (e.g. whether people are more or less friendly or welcoming) becomes a cultural trait. Organizational culture is observable particularly in its artefacts but because its meanings reside mostly in the minds of members in both conscious and unconscious ways, it is not easily decipherable in its entire richness. However, consideration of even just a few key elements may be informative and productive in understanding and engaging in that culture.

As for a definition of lean culture, 13 were found in the following list. They, however, all appear rather generic and superficial with variable emphasis on a large range of issues from membership (just employees or management as well) to goals (excellence? Reduction or elimination of waste?) or means (reasonably free hand or scientifically based?). They do not provide insights about which beliefs, values or artefacts are specific to lean. These findings certainly contribute to the level of PA lean culture currently has and much work needs to be done to reconcile all these ideas.

Lean culture definitions (academics/book authors/commercial authors/PhD theses):

1. Ahmad (2013): where all employee participating in activities to reduce business waste.
2. Alston (2017): culture that has all of the elements and attributes required to implement and sustain lean process improvement initiatives.
(3) Bicho and Holweg (2009): all people, from CEO to junior, share two related characteristcstics, both related to learning: humility and respect.

(4) Charron et al. (2015): beliefs and behavior characteristics of employees that understand what their company’s goals and objectives are, why they are important, understand the purposes of lean improvements, have had the necessary lean tools and techniques training to effect improvements, and are then given a reasonably free hand to do so on an ongoing basis.

(5) Gaudet and Bergeron (2016): shared language, values and practices of scientifically improving work, every day.

(6) Höök (2008): shared assumptions that the common goal is increased long-term profit, achieved by decreased costs and waste (performance), through a focus on customers and the people that create value.

(7) Integris performance advisors in Salah et al. (2015) organizational environment in which the values and behaviors are aligned with the guiding principles of lean management.

(8) Lotz and Roodt (2014): characterized by a deep respect for people, teamwork and continuous improvement.

(9) Manos and Vincent (2012): sum total of all the lean tools, techniques and knowledge that exist within an organization at the root level and that fuel the overall organizational alignment via collective lean thoughts, words and actions toward the elimination of waste and the creation of value.

(10) Novac and Mihalcea (2014): we think at problem solving with continuous improvement and learning.

(11) Schipper and Swets (2012): an idea that is created in the mind, as an inference, consisting of the collective behaviors, practices and habits of a community of people implementing a lean system.

(12) Stenzel (2007): shared mindset that demands excellence in providing customer value

(13) Zidel (2006) and Dennis (2016): everyone seeks improvement, understands value and strives to attain it, and identifies waste and struggles to eliminate it (Ulhassan, 2014).

Adding another aspect of PA scope, we noted in this literature review that several authors (Ahmed, 2013; Atkinson, 2013; Jenei et al., 2014; Pedersen-Rise and Haddud, 2016, and others) refer to the notion of cultural gap described as the distance between the current organizational culture state to a future desired lean culture one in the widely cited view that lean transformation is an organizational change exercise. In that regard, Testani and Ramakrishnan (2012) describe the most prescriptive and detailed plan to follow in their report relating the successful experience of IBM with the use of various proprietary assessment tools to monitor and to direct progress of their lean journey over a period of two years. Development of lean maturity instruments for the purpose of assessing cultural gap certainly appears to attract much scholarly interests. Our review has encountered over 11, all more or less designed to assess lean organizational culture change and likely many more questionnaires exist and would require a dedicated literature search to discover and meta-analysis to develop learnings.

Finally, this literature review finds four other amplifiers of lean culture PA scope: leadership, human resources (HR) management, sustainability and innovation. Not as much based on any of the authors questioning their relevance in building a lean culture but because these notions, having on their own some level of PA, add other layers of complexity to the concept. For example, if transformational leadership is usually considered to fit more lean
culture compared to transactional leadership, as works of Woehl (2011) suggest, it is not necessarily the case. Hence, further investigations are needed to determine which leadership practices are essential in lean culture and which ones are facultative or even detrimental. In regard to HR management, its optimal position in lean culture appears unclear: whether it should be more at a strategic level as Alagaraja and Egan (2013) suggest or it should serve better an organization’s culture as a supportive function as described by Jorgensen’s (2008) healthy lean framework is yet to be determined. As for sustainability, lean culture authors, more often than not, neglect to specify which kind they refer to in their writing: specifically, sustainability at times appears to relate to maintenance of lean mastership (such as project’s gains over time, standardization and continuous improvement practices) and preservation of lean culture; other times, it is about survival of the organization; and even other times, it is associated with the issues of corporate social responsibility and long-term environmental safety and protection (green lean) (Alves and Alves, 2015).

4. Discussion
This literature review makes several notable contributions. From a methodological aspect, it proposes adaptation and extension of other recent systematic reviews that ensured broad coverage of the topic. Full disclosure of the citation selection process demonstrates the importance and utility of running literature search in several electronic databases, describing strengths and weaknesses of some of them as well. Although complete capture of all writings about lean culture cannot be ascertained, the large sample size and efforts deployed decrease the risk that major contributions or a sufficient number of works have been missed that would affect significantly our findings. Two strategies were employed to decrease threat of validity and increase reliability: descriptive data were independently validated by a research assistant; iterative data collection scheme meant that documents were read over several times, decreasing risk of missed information, bias and misclassification. We submit that use of the PA construct and inductive data collection and analysis plan were particularly suited for this first exploration on lean culture. It allowed constructive generation of knowledge that would not have been as possible under a less flexible methodology.

This comprehensive systematic review of four segments of the literature (academic, books, thesis and gray articles) documents a high level of PA associated to lean culture from three stand points: its international source, its wide range from strong advocates to intense objectors and in terms of its stance, its treatment and main bearer in the manufacturing and service sectors and its scope regarding the notions of organizational culture, cultural gap and its estimation, leadership, HR management, sustainability and innovation.

Unfortunately, this high level of PA is more related to a situation of omission and shallow understanding rather than exposure and constructive debate as the superficiality of documents reviewed and our analysis indicate. Differences noted in the literature between the manufacturing sector and the service sector appear more indicative of the relatively longer lean experience in manufacturing than on fundamental differences in lean nature in manufacturing and service.

The fact that European scholars have contributed more on the topic calls for Americans (North and South) and scholars from every other part of the world to increase their activity and share their knowledge and experiences for a greater and deeper understanding of lean culture. The enigmatic silence of Japan on the matter begs for further inquiry and provision of valid explanations. Furthermore, even if further studies in healthcare, construction and automotive industries are needed, there is an opportunity to seek out lean culture insights in other under-researched areas such as in retail, legal, entertainment or tourism for likely valuable cross-learnings.

This review finds that a majority (80 percent) of lean authors across disciplines and sectors view lean culture as an organizational aim. The concept of culture appears hence less
Lean culture

to be a pre-condition, a tool or a bonus from organizational change efforts and more about
acting as a mirror or barometer of lean transformation journey and mastership. This is
consistent with the notion of cultural gap and the evidence-based definition of
organizational culture we were able to build. Indeed, from a cultural perspective, there is
less “hard” or “soft” sides of lean. Lean culture is progressively built. Every lean action or
decision organization members make or not, and even more telling how these actions and
decisions are made or not, are cultural artefacts. They become part of the organization’s
knowledge base and reflect its values and assumptions.

Lean culture current high PA level may nevertheless have certain positive aspects. As
everyone is entitled to keep its own interpretation of the concept, time and energy are not
spent on debates and counter-argumentations on who’s right and who’s wrong about lean
culture. It maintains room for development and for constructive ideas. It may facilitate some
collaboration between interest groups that may then focus their attention on lean matters
more important to them. However, there are several risks of maintaining lean culture high
PA level which includes: miscommunication, misunderstanding and missed opportunities
that may lead to missteps, mistakes, errors and contribute to lean’s organizational change
failure. Clarifying the nature of lean culture can only mitigate these risks. The process of this
clarification may also help to uncover new lean insights and managerial concepts that may
contribute to the improvements of organizations. By knowing more precisely what lean
culture is and what it is not, academics and practitioners could then spend their resources
and creative drive toward other important aspects of lean and its implementation for the
ultimate goal of gaining lasting improved organizational performance.

5. Limitations
Several limitations of this review must be acknowledged.

The main one concerns its strict focus and restriction on the exploration of two
keywords: lean culture (with and without brackets). Several other cultural labels of lean can
be found in the literature such as Toyota culture, kaizen culture, continuous improvement
culture, kata culture, Japanese management culture and perhaps others. Further work is
needed to determine to what extent all of them are similar and different between each other
and how they make their own contribution to lean knowledge. It is possible that some of
them have been discussed in more depth compared to lean culture in regards to related
beliefs, values and artefacts.

A second limitation is that despite all care taken in the literature search, other databases
exist such as Scopus, Engineering Village and other Journal–Publisher–Association specific
databases and hence, no review could hardly ever be complete. This review appears
nevertheless comprehensive and original in its large inclusion of records including
commercial literature to give a sense of current state of knowledge on lean culture.

A third limitation is the fact that searches were conducted on the same computer at two
different dates. It is possible that hidden “cache” algorithms of databases have introduced
some selection biases. Use of “cited by” feature of Google Scholar in the final step of the
search has, however, made missing of significant documents much less likely. It should be
noted that, in order to overcome security features of Google Scholar, connection to several
different internet access networks had to be done.

6. Further research and development
Based on this review’s findings, we suggest these six areas of research and development:

(1) Further work to decrease lean culture’s level of PA and refine its nature and improve
understanding of its elements (artefacts, values and beliefs) is obviously needed.
Empirical studies in under-researched industries such as retail, legal, entertainment or tourism may support cross-learning on lean culture.

A meta-analysis of quantitative studies and lean culture assessment instruments could be performed, which may eventually lead to the development and validation of a comprehensive lean culture assessment tool or package.

Exploration on lean managerial paradox may deepen our understanding of the construct and help academics and practitioners to appreciate lean and its nuances to develop more appropriate lean mastership implementation and maintenance plans.

There is need to clarify how the concepts of lean and its culture differentiate themselves from each other as from a certain cultural perspective, everything about an organization becomes a manifestation of culture. To remain useful and relevant, lean culture must mean something more than being the mere cultural expression of lean. Considering lean through lenses of other organizational change perspectives or theories such as the adaptation, the configurational, the political, the behavioral or the complexity approaches may be fruitful (Demers, 2007).

Finally, investigating further how lean culture differentiates itself from other lean conceptualization such as lean philosophy, lean thinking and lean principles would enhance our collective lean understanding.

7. Conclusion
This first systematic literature review on lean culture shows that it currently has a high level of PA of a similar extent in four segments (academic, books, theses and commercial) of the management literature, irrespective of sector (manufacturing and service). Interest on lean culture appears to be growing and further work that would increase knowledge on lean and its culture may be inspired by our findings, in particular perhaps by our evidence-based definition of organizational culture.

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An integrated AHP-based scheme for performance measurement in humanitarian supply chains

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Abstract
Purpose – In recent years, several performance indicators have been proposed in humanitarian supply chains (HSCs). Selecting the most relevant key performance indicators (KPIs) is challenging for some humanitarian organizations (HOs) because it involves a considerable amount of complexity and information overload which could lead to judgment biases in the decision-making process. Existing performance measurement studies lack critical analysis for prioritization of performance indicators. Since the process of KPIs selection and categorization is a complex, domain-based and subjective process, a systematic guideline is needed. To address this gap, the purpose of this paper is to propose an integrated performance measurement scheme that can consolidate KPIs into an overall performance score based on the weighting of the performance indicators in HSCs.

Design/methodology/approach – Data collection was based on questionnaire surveys and direct interviews with practitioners from international HOs.

Findings – This paper proposes an integrated scheme based on balanced scorecard and analytic hierarchy process for performance evaluation of HOs.

Research limitations/implications – The respondents were limited to the humanitarian logistics experts from Malaysian-based international HOs.

Practical implications – The scheme enables the benchmarking of HOs’ performance that could be useful for decision makers in HSCs.

Originality/value – This paper provides the ranking and prioritization of KPIs in HSCs. The approach presented in this paper enables an effective and integrated performance measurement in HSCs.

Keywords Performance measurement, Balanced scorecard, Analytical hierarchy process, Humanitarian supply chain

Paper type Research paper

1. Introduction
In recent years, performance measurement in humanitarian supply chain (HSC) has become increasingly important due to a higher demand for transparency, accountability and improvement of disaster-relief operations (D’Haene et al., 2015; Beamon and Balcik, 2008). Productivity and performance management in disaster-relief operations is essential to respond to an ever-increasing pressure from authorities and donors on humanitarian organizations (HOs) for delivering aid in a cost-effective way. This has motivated researchers to develop theoretical and empirical frameworks for HSC performance measurement (Beamon and Balcik, 2008; Haavisto and Goentzel, 2015; Anjomshoae et al., 2017). Some researchers have taken steps to adopt performance measurement systems from the business domain such as the Supply Chain Operations Reference (SCOR) Model and balanced scorecard (BSC) to the HSC domain (Anjomshoae et al., 2017; Schiffling and Piecyk, 2014; De Leeuw, 2010; Lu et al., 2016).

BSC is a widely recognized performance measurement system that emphasizes on incorporating financial and non-financial performance indicators (Kaplan and Norton, 1992). It helps to evaluate organizations’ performance across four distinct perspectives: customer, internal processes, financial, and learning and innovation. Besides its broad applications in the performance measurement of supply chains, BSC has been criticized for its structural shortcomings. While BSC offers a comprehensive view of organizational performance, it involves complexity and information overload in its development phase. Decision makers are
exposed to uncertainty regarding the selection and prioritization of the performance indicators (Nørreklit, 2000; Lord et al., 2005; Bukh and Malmi, 2005). Developing performance measurement schemes without having adequate information about the priorities and categorization of the key performance indicators (KPIs) may lead to ineffective implementation (Cuthbertson and Piotrowicz, 2011). Thus, it is necessary to determine the weights and relative importance of individual KPI. Since the process of KPIs selection among several alternatives is a complex and subjective process, a systematic approach is necessary (Beamon, 1999; Chae, 2009).

Several techniques for KPIs selection and prioritization have been reported in the literature. In particular, analytic hierarchy process (AHP) has been commonly used for prioritizing decision alternatives based on practitioners’ judgments (Lima-Junior and Carpinetti, 2017; Ho and Ma, 2018). AHP breaks down the problem into categories and subcategories and helps to make decisions based on experience, intuition and heuristics. AHP has been largely applied in several performance measurement studies in business supply chains for prioritizing performance indicators (Mathivathanan et al., 2017; Dey and Cheffi, 2012; Govindan et al., 2017; Ho and Ma, 2018).

In HSC, while scholars have proposed several performance indicators, there has been limited attention on prioritizing and synthesizing indicators into an integrated performance measurement scheme. For instance, Davidson (2006) made an early contribution to the performance measurement literature by developing a framework based on four performance indicators including: appeal coverage, donation-to-delivery time, financial efficiency and assessment accuracy. De Leeuw (2010) proposed a BSC strategy map for HOs. These studies did not provide information about performance measurement priorities. Similarly, Beamon and Balci (2008) developed a performance measurement framework that relies on three categories of performance measures including resource, output and flexibility. Likewise, Santarelli et al. (2015) and Nath et al. (2017) who proposed performance indicators for HOs’ performance evaluation did not provide ranking analysis of KPIs.

While the above studies emphasized on both financial and non-financial performance indicators, the procedure on how they were selected is unclear. Existing performance measurement systems focused on the classification of performance indicators and mainly addressed on what to measure in HSC. Most researchers have not adequately addressed questions related to how to select, prioritize and integrate performance indicators into an overall performance score. This limitation introduces judgment biases into the organization’s performance appraisal and decision-making process. Further research is needed to provide a systematic approach that can consolidate KPIs into an overall performance score. To address the above-mentioned issues, in this paper we aim to demonstrate a ranking analysis of KPIs clustered into the BSC’s perspectives. We propose an integrated AHP-based scheme for performance measurement in HSC. The selection of KPIs was derived from practitioners’ feedback.

The rest of this paper is organized as follows: Section 2 presents an overview of performance measurement studies in HSC together with a summary of the existing methods for KPIs selection and prioritization. Section 3 presents the methodology of KPIs ranking. Section 4 discusses the case study data and questionnaire used in this paper. Section 5 presents the results. In Section 6, we present the discussion and Section 7 concludes this paper.

2. Performance measurement in humanitarian supply chains
2.1 Existing performance measurement frameworks and models
Performance measurement frameworks and models in HSC have been mainly reported after the 2004 Indian Ocean tsunami disaster (Abidi et al., 2014). Since then, researchers have been trying to adopt established performance measurement concepts from the business domain to the humanitarian relief sector (Anjomshoae et al., 2017; Lu et al., 2016; De Leeuw, 2010; Schiffling and Piecyk, 2014). However, in general, performance measurement in HSC is
complex and less developed compared to commercial supply chains and there is no commonly acknowledged performance measurement system in humanitarian logistics (Lu et al., 2016; D’Haene et al., 2015; Abidi and Scholten, 2015). Common reasons for this limited practice are the difficulty of the field operations (Kovács and Spens, 2009; Van Wassenhove, 2006), limited technological and infrastructural capacity, complexity of integrating different dimensions of HOs’ performance, and general reluctance to develop and implement performance measurement systems in the humanitarian sector (Abidi et al., 2014; Kovács and Spens, 2009; Van Wassenhove, 2006).

Nonetheless, in recent years, a number of theoretical and empirical performance measurement frameworks have been reported in the literature. These studies cover a wide range of topics including the development of KPIs suitable for relief supply chains (Beamon and Balcik, 2008; Santarelli et al., 2015; Nath et al., 2017), development of performance measurement systems and frameworks (e.g. BSC, SCOR) (Anjomshoae et al., 2017; Lu et al., 2016; Schiffling and Piecyk, 2014) and identification of critical success factors in HSC (Yadav and Barve, 2015; Celik et al., 2014; Oloruntoba, 2010; Pettit and Beresford, 2009). Regarding the recent literature, it is surmised that integrating holistic and balanced approaches into performance measurement can help tackle the complexity of measuring relief supply chain performance (D’Haene et al., 2015; Davidson, 2006). Examples of recent studies are: Van der Laan et al. (2009) discussed necessary requirements for an effective performance measurement system in HSC; Rongier et al. (2013) developed a web-based performance measurement system for the French Red Cross organization that could be used during the response phase of a disaster; Abidi et al. (2014), Gizaw and Gumus (2016) and Banomyong et al. (2017) provided comprehensive reviews of the performance management studies in HSC; Santarelli et al. (2015) developed a holistic performance measurement scheme to evaluate the operational performance of HOs; Lu et al. (2016) proposed a SCOR model for performance measurement in humanitarian logistics; Schön et al. (2018) developed a camp performance indicator system focusing on self-reliance of encamped refugees; Anjomshoae et al. (2017) proposed a reference model for interdependencies of the performance indicators in HOs; and D’Haene et al. (2015) highlighted that BSC was selected more often than other frameworks and they suggested more empirical research on holistic and balanced performance measurement systems are needed.

In addition to the developed performance measurement frameworks, some studies have focused on proposing relevant performance indicators. For example, Acimovic and Goentzel (2016) discussed new humanitarian logistics performance measures based on stochastic optimization models that can be used to evaluate the response capacity of a relief supply chain. Nath et al. (2017) investigated KPIs for evaluating a post-disaster shelter. In this paper, we do not aim to provide an extensive review of the performance indicators since they have been reported in Anjomshoae et al. (2017).

Based on the reviewed literature, HSC performance evaluation involves several qualitative and quantitative KPIs and is a complex multi-criteria decision-making problem. Involvement of multi-faceted performance indicators into an overall performance measurement system increases the complexity of measuring the performance of HSC. The multi-criteria aspect of the problem was recognized in a number of past studies such as Haavisto and Goentzel (2015), Santarelli et al. (2015) and Schulz and Heigh (2009). While existing studies incorporated financial and non-financial performance indicators, little attention has been devoted to the complexity associated with integrating these indicators into an overall performance score (Santarelli et al., 2015; Schulz and Heigh, 2009). Much of the information available in the performance measurement literature relates to the classification of performance indicators and development of frameworks in answering questions that often relate to what to measure in HSC (Abidi et al., 2014; De Leeuw, 2010).
Existing studies have not adequately addressed questions related to how to integrate performance indicators into an overall performance score. This limitation introduces judgment biases into the organization’s performance appraisal and decision-making process. There is a need to aggregate the multi-faceted performance indicators into an overall score for HSC performance evaluation. Formulating an integrated performance measurement scheme in HSC requires a balanced set of performance indicators and a methodology to synthesize financial and non-financial performance indicators. Reviewed literature indicates that BSC was the most commonly used framework in humanitarian relief performance evaluation. Schiffling and Piecyk (2014) highlighted that BSC’s relative ease of use and the ability to balance various performance dimensions may have contributed to its popularity in HSC performance evaluation. Since BSC can be useful for integration of performance indicators, the next sub-section elaborates this further.

2.2 Existing balanced scorecards in humanitarian supply chains

BSC originally developed by Kaplan and Norton (1992) is a widely acknowledged performance measurement framework that evaluates the performance of organizations across four perspectives: financial, customer, internal business processes, and learning and innovation. It is considered a prominent concept in the performance measurement and management context according to a citation analysis (Marr and Schiuma, 2003). Since its initial introduction (Kaplan and Norton, 1992), BSC has gone through several iterations and generational evolution as discussed in Perkins et al. (2014) and Lawrie and Cobb (2004). BSC has gained new features over time (Perkins et al., 2014) and continues to evolve as researchers have been trying to incorporate methodological rigor into it (Hoque, 2014; Franco-Santos et al., 2012). This trend is also evident in HSC.

In HSC, there has been an increasing interest in recent years to develop BSC (Anjomshoae et al., 2017; Widera and Hellingrath, 2016; Schiffling and Piecyk, 2014). Moe et al. (2007) made an early contribution to the performance measurement literature by developing a BSC for the disaster-relief operations. De Leeuw (2010) elaborated on a reference BSC strategy map to guide further development of performance measurement systems. Schiffling and Piecyk (2014) demonstrated a customer-centric approach for BSC using stakeholder theory. Widera and Hellingrath (2016) developed an IT-based BSC to support HOs in the operational performance evaluation process.

Based on the classification proposed in Perkins et al. (2014) for BSC’s generation, existing BSCs in HSC are considered as in transition between generation 1 (early stage) and generation 2 (BSC with strategy map) categories. For instance, Anjomshoae et al. (2017) proposed a conceptual BSC strategy map illustrating the interdependencies of performance indicators in HSC. We believe that BSC will remain relevant and will continue to evolve in HSC. In this research, we aim to further improve the existing BSCs in HSC by focusing on KPIs prioritization and development of an integrated performance score. While existing BSCs in HSC emphasize on a balance between financial and non-financial performance indicators, the procedure on how such performance indicators should be selected is unclear. In general, BSC by itself fails to provide a systematic process for selection and prioritization of relevant performance indicators (Lord et al., 2005; Bulh and Malmi, 2005; Norreklit, 2000). This is particularly challenging in practice since organizations deal with several performance indicators that seldom have equal importance. Determination of the importance of individual KPI is a complex and subjective process for decision makers (Chae, 2009). The next sub-section provides a brief overview of the techniques that were commonly used by researchers for KPIs selection and prioritization.

2.3 Techniques for selection and prioritization of performance indicators

Several performance measurement studies in the business sector have highlighted that an important part of performance measurement systems is the selection of an appropriate set of
performance indicators (Stricker et al., 2017; Maestrini et al., 2016; Keong Choong, 2013; Gunasekaran and Kobu, 2007; Neely et al., 1995). In practice, choosing the right KPIs among several viable alternatives is a complex task and organizations rely on intuition to elicit potential KPIs (Cai et al., 2009). This may cause undesired consequences such as redundancy and selecting incorrect KPIs, wasting the effort and resources of the organizations, and erroneous conclusions for improving performance. Table I provides a summary of seven techniques for KPIs selection and prioritization in performance measurement studies, namely, AHP, analytic network process, interview and survey, interpretive structural modeling, data mining, linear programming and risk assessment.

Although a diverse range of methods and approaches were used in the literature for KPIs selection and prioritization, there are no specific rules about which technique should be used. Adopting a well-known and widely used technique ensures that results are meaningful, that they can be repeated and, therefore, compared, and that the information can be benchmarked against other tools that have used the same methodology. AHP developed by Saaty (1988) is an analytical method for solving complex multiple criteria problems. It formulates a complex problem into a hierarchical structure and employs pairwise comparisons between the decision criteria to find the ranking and importance of the alternatives in a problem. In this research, the AHP method is used to weigh the importance of the performance indicators since it is a commonly used technique and has received a considerable amount of attention among researchers.

In business supply chains, AHP has been used in several performance measurement studies (Gandhi et al., 2016; Maestrini et al., 2016; Ponis et al., 2015) and for BSC formulation.

<table>
<thead>
<tr>
<th>Technique</th>
<th>Description</th>
<th>Performance measurement studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analytic hierarchy process</td>
<td>An analytical approach for structuring a decision problem in order to rank alternative decisions using pairwise comparison</td>
<td>Shahin and Mahbod (2007), Sharma and Bhagwat (2007), Bhagwat and Sharma (2010), Bentes et al. (2012)</td>
</tr>
<tr>
<td>Analytic network process</td>
<td>Analytic network process is a more general form of the AHP which also helps to formulate the dependencies between decision alternatives</td>
<td>Carlucci (2010), Poveda-Bautista et al. (2012), Bhattacharya et al. (2013), Kucuktunc et al. (2016)</td>
</tr>
<tr>
<td>Interview and survey</td>
<td>An approach that includes a number of questions aiming to gather relevant data from respondents and making a proper synthesis to guide decision making</td>
<td>Neely et al. (1995), Lai et al. (2002), Hofmann and Locker (2009), Olugu et al. (2011)</td>
</tr>
<tr>
<td>Interpretive structural modeling</td>
<td>Interpretive structural modeling helps to break down a complex problem into a multilevel structural model that enables quantification of relationships among variables</td>
<td>Sagheer et al. (2009), Sharma and Garg (2010), Azevedo et al. (2013)</td>
</tr>
<tr>
<td>Data mining</td>
<td>Data mining is a technique to extract useful information from large data sets or streams of data</td>
<td>Tardio and Peral (2015), Peral et al. (2017)</td>
</tr>
<tr>
<td>Linear programming</td>
<td>Linear programming is a mathematical approach that aims to achieve the best outcome such as maximum profit or lowest cost in a problem</td>
<td>Stricker et al. (2017)</td>
</tr>
<tr>
<td>Risk assessment</td>
<td>Risk assessment is a technique used to identify, characterize, quantify, evaluate and reduce losses from actions or decisions that may have undesired outcomes</td>
<td>Dialaki et al. (2006)</td>
</tr>
</tbody>
</table>

Table I. Summary of techniques for KPIs selection and prioritization
problems (Sharma and Bhagwat, 2007; Felice et al., 2015). According to Lima-Junior and Carpinetti (2017), it was the most frequently used technique for ranking and selecting supply chain performance measures. For example, Sharma and Bhagwat (2007) developed a generic BSC framework for supply chain performance evaluation using AHP. Bentes et al. (2012) presented an application of AHP for developing a BSC framework for performance measurement in a Brazilian telecom company. Felice et al. (2015) proposed AHP as a mechanism to develop a BSC framework for sustainable outsourcing in a supply chain.

In HSC, a number of researchers used AHP to solve complex problems. Abidi et al. (2015) used it to make decisions related to fourth-party logistics in HSC. Bozorgi-Amiri and Asvadi (2015) solved the problem of ranking and selecting relief logistics centers using AHP. Kabra et al. (2015) demonstrated the applicability of AHP to prioritize the coordination barriers in HSC. Roh et al. (2015) identified the warehouse location factors and the relative importance of these factors for a humanitarian relief organization. Nevertheless, to the best of our knowledge, there is no published AHP study that has prioritized the performance indicators of HSC. This paper is an attempt to fill this gap.

3. Methodology of KPIs ranking using AHP

AHP helps to formulate the relative weight of each alternative with respect to the goal and it involves five main steps:

- **Step 1** defines the problem and designs the decision hierarchy which is clustered into goal criteria and alternatives. The AHP goal is to identify the relative importance of KPIs for performance evaluation of HOs. The four BSC’s perspectives are defined as the criteria, and the alternatives are defined as the selected performance indicators in HSC.

- **Step 2** performs pairwise comparisons among BSC’s perspectives and indicators and constructing the comparison matrices. In this step, a pairwise comparison matrix \( A \) is developed. In the matrix \( A \), each element \( a_{ij} (i, j = 1, 2, \ldots, n) \) represents the relative importance of the two compared elements \((i \) and \( j)\). The matrix \( A \) has the following properties: \( a_{ii} = 1, a_{ij} = 1/a_{ji}, a_{ij} \neq 0 \). The matrix \( A \) is normalized into matrix \( A_1 \) by dividing the elements of each column in matrix \( A \) by the sum of the elements of the same column.

- **Step 3** estimates the relative weights of the decision elements using the *eigenvalue* method (Saaty, 1988).

- **Step 4** checks the consistency property of matrices to ensure that the judgments of decision makers are consistent. The consistency ratio (CR) is calculated to determine the consistency of experts’ judgments. The CR is a ratio between the matrix’s consistency index and random index and in general varies from 0 to 1. A CR of 0.1 or less is considered acceptable (Saaty, 1988). A value of CR above 0.1 requires the revision of judgments in the matrix due to an inconsistent treatment for particular factor ratings. The CR is calculated as shown in the following equation:

\[
    CR = \frac{CI}{RI}
\]

(1)

where CI is the consistency index and RI is the random index. The RI value is drawn based on the size of the matrix (Saaty, 1988). CI can be found by the following equation:

\[
    CI = \frac{\lambda_{max} - n}{n-1}
\]

(2)
where \( n \) is the size of the matrix and \( \lambda_{\text{max}} \) is the largest eigenvalue of the pairwise comparison matrix.

- Step 5 calculates the relative weights of decision criteria to get an overall rating for each alternative. The local weight of each criterion is determined by obtaining the Eigen vector and eigenvalue of the respective pairwise comparison matrix. The overall priority score \( (W) \) of each alternative is obtained by summing the product of the weights of alternatives with respect to the criteria and the local weights of the criteria.

4. Structure of the decision hierarchy

This section provides an overview of the selected case studies, the data collection and questionnaire design, and the structure of the proposed decision hierarchy for AHP analysis.

4.1 Data collection: questionnaire survey and interview

Data collection was based on questionnaire surveys and direct interviews with practitioners. Five international Malaysian-based HOs were selected based on their prominence in the humanitarian operations. However, only three of the HOs agreed to participate in this study. The participated HOs are referred to as HO(1), HO(2) and HO(3) in this paper due to a non-disclosure agreement with them. The other two HOs did not agree to participate due to their operational constraints and organizational policy. HO(1) is a small size HO that operates nationally and internationally, focusing more on the provision of medical items. HO(2) is a medium-size organization that focuses on providing medical relief and sustainable health-related development locally and internationally. HO(3) is a large-sized international HO operating in the emergency and development activities. HO(2) and HO(3) have pre-positioned relief supply warehouses strategically located near an international airport in Malaysia.

The interviews with experts and questionnaire surveys were conducted in August 2017. Out of 15 practitioners approached, 6 had fully participated and had their responses analyzed in this study. Their job titles were procurement officer, national logistics officer, health coordinator, head of program development and operations, national consultant and deputy executive director. Most of the participants had at least three years of experience in the humanitarian logistics operations. The interviews were conducted directly in-person and by responding to an AHP questionnaire.

The questionnaire design was based on the standard AHP questionnaire format originally proposed by Saaty (1988). The questionnaire has two parts: the relative importance of criteria and the relative importance of performance indicators with respect to each criterion. Respondents were asked to fill in the questionnaire by rating the importance of the items via pairwise comparison. The pairwise comparison was based on the relative scale values of 1–9. The value 1 indicates an equal importance of two compared items while 9 indicates a high importance of only one of the items.

4.2 Selected performance indicators and structure of the decision hierarchy

The performance indicators were identified through a systematic review of literature in scientific databases including Science Direct, Springer, Emerald, Wiley Interscience, Scopus, Inderscience and Google Scholar. We reviewed relevant papers and case studies published in international journals from 1996 to 2017. We identified relevant KPIs and clustered them into the four BSC’s perspectives. Performance indicators that are included in the customer perspective are related to the beneficiaries’ and donors’ concerns in the humanitarian relief settings. These stakeholders are considered as the key customer group in HSC (Schiffling and Piecyk, 2014). In general, performance indicators in this perspective are related to speed of delivery, quality of relief items and on-time reporting. Performance indicators in internal business processes are related to response time, sourcing, resource utilization and efficiency in HOs. Performance indicators in the
financial perspective are focused on cost, budgeting and fund management. Those in the learning and innovation perspective are related to human resource management, knowledge management, and information sharing and cooperation. Further details on the relevant KPIs and their interdependencies can be found in our earlier publication (Anjomshoae et al., 2017). Using the KPIs that were identified in Anjomshoae et al. (2017) and through interviews with humanitarian practitioners, we selected 19 KPIs as listed in Figure 1. These final KPIs were structured into a hierarchy for the AHP analysis.

We evaluated the importance of these performance indicators based on the practitioners’ responses. The AHP analysis encompassed two stages: the first stage was concerned with determining the relative weights of the four BSC’s perspectives, and the second stage was related to determining the relative weights of the selected performance indicators for the evaluation of HOs’ performance.

5. An integrated AHP-based performance measurement scheme
This section discusses the ranking analysis of KPIs and elaborates on the development of the performance measurement scheme for HOs. We demonstrate an example of the application of the proposed performance measurement scheme.

5.1 Ranking of KPIs based on BSC perspectives
The Expert Choice® software was used for calculating the weights. The overall CR value of the AHP analysis was calculated as 0.02 which was within the acceptable range for the validity of results. Figure 2 demonstrates the relative weights of the four BSC’s perspectives, while Figures 3 and 4 demonstrate the results for the relative weights of the indicators within each BSC’s perspective. As shown in Figure 2, the beneficiaries’ and donors’ perspective, with a weight of 0.459, was the most important perspective. This was followed by the financial perspective, with a weight of 0.322. The weight of the internal processes perspective was 0.163, and the learning and innovation perspective has the lowest weight of 0.056. The complete results are shown in Table II that summarizes the AHP results into three categories: the relative weights of BSC’s perspectives, the relative weights of the indicators with respect to each BSC’s perspective and the final weights of the indicators with respect to the goal.
The overall ranking of KPIs showed that the quality and availability of relief items, with a weight of 0.180, and speed of delivery, with a value of 0.160, were ranked as the first and second most important KPIs, respectively, among all the BSC’s indicators. The third highest ranked indicator was the amount of timely fund received, with a weight of 0.126 (included in the financial perspective), followed by budgeting for operational activities, with a weight of 0.069 (included in the financial perspective). The fifth-ranked indicator was the response time, with a weight of 0.064 (included in the internal processes perspective).

As shown in Table II and Figure 2, the beneficiaries' and donors' perspective has received the highest ranking among the BSC’s perspectives. The AHP results conform to the findings reported in Schiffling and Piecyk (2014) indicating that the beneficiaries and donors are
perceived as the most important BSC’s perspective. The financial perspective comes next as it provides the necessary input for the internal operations of HOs. The financial and internal processes perspectives are highly interdependent, which is typical for most public and non-profit sectors. Without receiving financial resources, HOs are not able to survive and without effective logistics and supply chain strategies, they are not able to deliver aid in a cost-effective way and convince donors for program funding. It is, therefore, important for HOs to develop effective supply chain and logistics strategies to be able to achieve targets, meet beneficiaries’ requirements and sustain in a competitive environment with a shrinking base of donors (Jahre, 2017; Kovács and Spens, 2007). This can be achieved through innovative approaches as well as adopting and integrating existing concepts in the business world (e.g. lean and agile concept) to the humanitarian logistics settings (Anjomshoae et al., 2017; Tabaklar et al., 2015; Cozzolino et al., 2012; Ramalingam et al., 2009).

In the beneficiaries’ and donors’ perspective, the quality and availability of the relief items and the speed of delivery were ranked highest among the indicators in this perspective. The results are in line with the study of Schiffling and Piecyk (2014) which highlighted that beneficiaries are generally concerned with the tangible outputs of HOs while donors are concerned with the effective and efficient relief operations. These stakeholders are mainly interested in the quality and relevance of the relief supplies that are delivered in a timely and consistent manner in the humanitarian relief operation.

In the financial perspective, the amount of timely fund has received the highest rank (0.419) among the indicators in this perspective. Since donors expect transparency and
appropriate budgeting to monitor the use of their funding, close interactions with donors and reporting of financial performance are essential for satisfying the donors’ scrutiny and HOs’ survival. HOs are indeed highly dependent on corporate, governmental and individual donations. Thereby it is important for HOs to invest resources in fundraising activities and reporting to donors to ensure a sustainable and steady flow of funding. This helps HOs to ensure a sustainable creation of value for the beneficiaries by having enough resources for running their operations.

In the internal processes perspective, the response time (0.277) and percentage of pre-positioned relief items (0.234) scored the highest ranking among the indicators in this perspective. Operational excellence of these measures is linked to the beneficiaries’ and donors’ satisfaction and can be achieved through effective and efficient internal processes in HOs. Performance indicators within the internal processes perspective can be used to evaluate HOs’ operations that have the greatest impact on beneficiaries and donors.

In the learning and innovation perspective, the degree of information sharing and cooperation (0.396) and degree of supply chain ICT utilization (0.255) were ranked highest. These indicators support the HOs’ objectives in the other three BSC’s perspectives and particularly support the internal processes of HOs. The indicators in the learning and innovation perspective help HOs to evaluate their ability to adapt to the chaotic and ever-increasing changes in disaster-relief operations and to coordinate with external parties (Anjomshoae et al., 2017). Relief supply chain coordination is fundamental to improving disaster responses (Akhtar et al., 2012; Balcik et al., 2010). Setting objectives in the learning and innovation perspective enable value creation beyond the scope of goals in the internal processes perspective. Performance indicators within this perspective should be able to assess the HOs’ performance on measures such as employee satisfaction and development of new products or services with the emphasis being placed on innovation as well as the HOs’ ability to coordinate in a disaster-relief supply chain.

5.2 An integrated AHP-based scheme
The AHP results were used in the formulation of an integrated performance measurement scheme. The scheme aims to help HOs to identify areas to invest resources for performance improvement in order to achieve their organizational goals and strategic objectives. Figure 5 demonstrates the scheme together with the weights and ranking of the performance indicators based on the AHP hierarchy.

As highlighted in Van der Laan et al. (2009), issues such as high staff turnover and poor data accuracy and availability are contributing to the limited practice of performance evaluation in the relief supply chain. This necessitates a need for a standardized approach for reporting and benchmarking performance based on few selected KPIs to promote efficient data collection. As a stepping stone, the proposed scheme can be used to measure and compare HOs’ performance. An overall score \( G \) for a HO’s performance could be derived as below:

\[
HO's\ overall\ performance\ score(G) = \text{weighted\ beneficiaries'\ and\ donors'\ perspective}\ + \text{weighted\ internal\ processes\ perspective}\ + \text{weighted\ financial\ perspective}\ + \text{weighted\ learning\ and\ innovation\ perspective}.
\]

The above formulation mathematically can be shown as in the following equation:

\[
G = \alpha \sum_{i=1}^{n=4} B_i W_{B_i} + \lambda \sum_{i=1}^{n=5} I_i W_{I_i} + \gamma \sum_{i=1}^{n=5} F_i W_{F_i} + \beta \sum_{i=1}^{n=5} L_i W_{L_i},
\]

(3)
where $W$ is the global weight of each indicator, and: $i$ the index for indicators ($i = 1$ to $n$); $\alpha$ the relative weight of beneficiaries’ and donors’ perspective; $\lambda$ the relative weight of internal processes perspective; $\gamma$ the relative weight of financial perspective; and $\beta$ the relative weight of learning and innovation perspective.

5.3 An example of the application of the proposed scheme
To demonstrate the application of the above performance measurement scheme, let us assume the scores for each of the 19 KPIs for two HOs are as given in Table III. The scores are based on a five-point Likert scale (0 indicates the lowest performance, and 5 indicates the highest performance). The sum of the weighted perspectives is calculated using Equation (3). The overall score ($G$) for each HO is the summation of the weighted perspectives. As shown in Table III, HO$_{b1}$ received a higher overall score in comparison to HO$_{b2}$. Using this approach, the decision regarding the HOs’ performance can be made more objectively. Such analysis enables benchmarking and comparison of HOs’ performance that could be useful for stakeholders, practitioners and decision makers in humanitarian relief operations.

6. Discussion
Lately, performance measurement of logistics and supply chain operations in disaster relief has become increasingly important due to the significant growth of the scale and complexity
of natural disasters coupled with declining financial support from governments and rising competition for scarce donations (Santarelli et al., 2015; Reyes and Meade, 2006). To tackle the complexity of performance measurement in HSC, researchers have advocated the adoption of holistic and balanced approaches from the business domain (D’Haene et al., 2015; Davidson, 2006). However, majority of the performance measurement systems in HSC are limited to structural frameworks. These performance measurement systems were focused on the classification of performance indicators and mainly answered questions that often relate to what to measure in HSC (Nath et al., 2017; Van der Laan et al., 2009; Beamon and Balcik, 2008). Existing performance measurement frameworks in relief supply chains have not adequately addressed questions related to prioritization of performance indicators and how to measure the performance of HOs’ supply chain. This leads to a problem of lack of integration, standardization and practicality in HSC performance measurement.

HSC performance measurement is a multi-criteria decision-making problem which involves several financial and non-financial performance indicators that are complex to monitor and measure. This challenge necessitates the development of integrated performance measurement schemes based on few relevant indicators for HOs’ performance evaluation. However, selection, prioritizing and synthesizing KPIs is challenging for decision makers in supply chains (Chae, 2009; Cai et al., 2009). KPIs selection and prioritization may overload the cognitive abilities of decision makers and there is a need for a systematic selection process (Stricker et al., 2017). While there have been a number of studies in business supply chains to tackle the problem of KPIs selection and prioritization such as Sharma and Bhagwat (2007), Dey and Cheffi (2012) and Jakhar and Barua (2013), in HSC, little attention has been paid toward critical analyses for prioritizing and synthesizing measures into an integrated performance measurement scheme.

Table III. Example of overall score (G) for hypothetical HOs

<table>
<thead>
<tr>
<th>BSC perspectives and indicator</th>
<th>HO(a)</th>
<th>HO(b)</th>
<th>Relative scores of perspectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beneficiaries and donors perspective (B)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B1</td>
<td>5</td>
<td>2</td>
<td>0.858</td>
</tr>
<tr>
<td>B2</td>
<td>4</td>
<td>3</td>
<td>0.441</td>
</tr>
<tr>
<td>B3</td>
<td>4</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>B4</td>
<td>5</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Internal process perspective (I)</td>
<td></td>
<td></td>
<td>0.153</td>
</tr>
<tr>
<td>I1</td>
<td>4</td>
<td>2</td>
<td>0.060</td>
</tr>
<tr>
<td>I2</td>
<td>5</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>I3</td>
<td>4</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>I4</td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>I5</td>
<td>4</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Learning and innovation perspective (L)</td>
<td>0.012</td>
<td>0.002</td>
<td></td>
</tr>
<tr>
<td>L1</td>
<td>5</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>L2</td>
<td>4</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>L3</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>L4</td>
<td>3</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>L5</td>
<td>3</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Financial perspective (F)</td>
<td></td>
<td></td>
<td>0.430</td>
</tr>
<tr>
<td>F1</td>
<td>5</td>
<td>2</td>
<td>0.175</td>
</tr>
<tr>
<td>F2</td>
<td>5</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>F3</td>
<td>3</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>F4</td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>F5</td>
<td>5</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Overall score (G)</td>
<td></td>
<td></td>
<td>1.453</td>
</tr>
</tbody>
</table>

Scores based on five-point Likert scale

Relative scores of perspectives
Developing performance measurement schemes without having adequate information about the priorities and categorization of KPIs may lead to ineffective implementation (Cuthbertson and Piotrowicz, 2011). Determining the ranking and relative importance of KPIs in HSC facilitates efficient data collection and benchmarking.

This paper, therefore, makes a contribution in addressing this gap in HSC performance measurement. It proposes a scheme for HSC performance assessment using an integrated AHP-BSC approach. To formulate the proposed scheme, 19 selected KPIs were ranked and organized into the BSC framework. The proposed scheme provides important information for KPIs’ weights which are essential in determining the performance of HOs. The integrated scheme can deal with both quantitative and qualitative performance indicators and provide an overall performance score. The scheme facilitates the benchmarking and assessment of humanitarian relief supply chain performance. It also provides useful insights into the integration of BSC and AHP in HSC.

Our ranking results differ from the reported findings of the performance measurement studies in business supply chains. In commercial settings, financial measures typically are highly important as highlighted in Sharma and Bhagwat (2007), whereas in HSC, several studies have confirmed the importance of non-financial and productivity measures (Santarelli et al., 2015; Schiffling and Piecyk, 2014; De Leeuw, 2010). This difference originates from the mission statement of HOs. Non-profit organizations’ and particularly HO’s mission is to fulfill their social obligations (Kaplan, 2001; Micheli and Kennerley, 2007) whereas business supply chains aim for profit (Niraj et al., 2001). Our results conform to the findings reported in the HSC performance measurement literature that emphasizes on the non-financial measures and importance of the beneficiaries as the prominent customer group in humanitarian logistics (Schiffling and Piecyk, 2014). Our results support the contention that HOs should focus on improving productivity measures in order to increase the transparency and accountability of disaster-relief operations.

6.1 Theoretical implications
The proposed performance measurement scheme presents a ranking analysis of KPIs and offers insights into the complex performance measurement priorities in HSC. Existing studies did not focus on the integration of multi-faceted performance dimensions. This deficiency has led us to demonstrate an application of an integrated AHP-BSC approach for the performance assessment of HOs. This paper complements the existing performance measurement concepts in HSC by providing additional insights on KPIs’ priorities and consolidation of these KPIs into an overall performance score. Furthermore, the proposed scheme may contribute to the future theoretical and empirical performance measurement system developments using analytical techniques in humanitarian logistics.

6.2 Practical implications
It is challenging for HOs to identify and adopt the most relevant performance indicators. In large HOs, performance measurement usually involves a considerable number of KPIs and, therefore, selecting the most important and relevant ones becomes imperative. Existing performance measurement systems’ inability to prioritize the performance indicators and to integrate them as an overall score may impose information overload and difficulty in decision making. This could lead to poor judgments and, therefore, render the existing performance measurement frameworks ineffective to a certain extent. The proposed scheme can guide decision makers by providing information about the measurement priorities. It helps to identify which KPIs require more attention for performance improvement strategies. The analysis provided in this research can help practitioners to overcome the challenges of KPIs selection and prioritization and design effective performance measurement systems.
7. Conclusions
This paper has demonstrated a ranking analysis of hierarchically organized KPIs in HSC using AHP analysis. It has briefly discussed the recent literature in HSC performance measurement and highlighted the importance of performance measurement priorities in relief supply chains. This research developed a scheme based on selected KPIs clustered into the four BSC's perspectives. The selection and weights of the KPIs were derived from practitioners. The AHP was used to formulate the integrated performance measurement scheme. The proposed scheme identifies areas for practitioners to invest resources for improvement strategies. The ranking analysis reveals that the beneficiaries' and donors' perspective should be the primary focus of BSC. The quality and availability of relief items together with the speed of delivery are the most important KPIs for this perspective. The financial perspective ranked as the second most important perspective. This enabling perspective confirms earlier findings in the literature that HOs' survival depends on the sufficient and timely fund received. The proposed integrated performance measurement scheme facilitates benchmarking among HOs.

This research has incorporated exact values of information regarding the KPIs' priorities. A valuable future research avenue is to implement fuzzy decision making on the KPIs' priorities and scores given by practitioners. Such research endeavor is a possible solution to scenarios in humanitarian logistics performance evaluation that involve a high degree of uncertain data. Fuzzy decision making has been proven to be a rigorous method to tackle the complexity associated with information uncertainty.

References


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Analysing the 3PL service provider’s evaluation criteria through a sustainable approach

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Abstract

Purpose – The purpose of this paper is to identify and model the evaluation criteria for the selection of third-party logistics service provider (3PLSP) by an interpretive structural modelling (ISM) approach in the pharmaceutical sector.

Design/methodology/approach – Delphi technique was used for identifying the most significant criteria, and the ISM method was employed for developing the interrelationship among the criteria. Also, the critical criteria for having high influential power were identified by using the Matrice d’Impacts Croisés Multiplication Appliqués à un Classement analysis.

Findings – The most significant factors, namely, capability of robust supply network/distribution network, quality certification and health safety, service quality and environmental quality certifications, were found to have a high driving power, and these factors demand the maximum attention of the decision makers.

Research limitations/implications – As the ISM approach is a qualitative tool, the expert opinions were used for developing the structural model, and the judgments of the experts could be biased influencing the reliability of the model. The developed hierarchical concept is proposed to help the executives, decision and policy makers in formulating the strategies and the evaluation of sustainable 3PLSP.

Originality/value – It is an original research highlighting the association between the sustainable 3PLSP evaluation criteria by employing ISM tool in the pharmaceutical industry. This paper will guide the managers in understanding the importance of the evaluation criteria for the efficient selection of 3PLSP.

Keywords Sustainability, Multi-criteria decision making, Evaluation, Pharmaceutical industry, Selection, Interpretive structural modelling, 3PL service providers

Paper type Research paper
such as prospective distributors, suppliers, buyers, manufacturers, etc. It may be noted that
the efficiency of the supply chain is determined by the effectiveness and accessibility of the
logistics network (Aguezzoul, 2014; Hsiao et al., 2010).

The importance of logistics is considered in today’s world by observing the amount of
interconnection established between the links of the supply chain. The logistics sector is
spread due to globalisation. For global distribution, logistics is enabling the flow of the
leading products/gadgets, medicines, life-saving vaccines, etc., within the strict time frame.
It has become the key driver of economic growth, wealth creation and jobs (Ceniga and
Sukalova, 2015; Cirpin and Kabadayi, 2015). In India, economic reforms, industrial growth,
 improved transportation infrastructure and trade co-operation are providing excellent
opportunities for the third party logistics (3PL) sector (Research and Markets, 2016).

Business has become a way too competitive and is much affected by the effectiveness of
logistics operation; proper supply chain management can gain the competitive advantage in
this competitive world (Gimenez and Ventura, 2005; Li et al., 2011). Therefore, outsourcing
logistics to third-party service providers has become a most suitable option. The third-party
logistics service providers (3PLSPs) take the necessary risk of services and delivery; in turn,
the organisations can concentrate on their core business activities (Lieb and Lieb, 2010;
Yeung, 2006). Also, subscribing to 3PLSPs reduces logistics cost (Li et al., 2012). 3PLSPs are
the independent enterprises who work on the contract with the manufacturer, retailer and
customer. They do not own any product or service but carries a responsibility of supply chain
for their client. 3PLSPs are not just the carriers or storage companies, like traditional logistics
organisation but they perform various value-added activities and offer diverse services such
as returning goods, order processing, customised packaging, labelling, barcode/RFID, etc.
(Modarress et al., 2009; Giri and Sarker, 2017; Liu and Wang, 2009; Liou and Chuang, 2010).

The logistics sector has significantly contributed to society and economy. However, it
needs to consider the aspect of the environment also. The triple bottom line approach needs
to be followed by the consistent growth in this domain. Climate change is impacting the
economy, and it is described by Stern (2007) that the estimated cost of 5-20 per cent of
global GDP will be consumed for climatic impacts. Sustainability is demanded in every
sphere of business, and logistics cannot be untouched by it. The logistics industry is the
most significant source of CO2 emission. Freight and personal transport contribute to the
13.1 per cent of total greenhouse gas (GHG) emission, as per the intergovernmental panel on
climate change (Bernstein et al., 2008). The logistics industry contributes 2.80m metric tons
of GHG emissions/year, which is 5.50 per cent of global GHG emissions. Road freight
contributes to 1,500 megatons of CO2-equivalent emissions, which is 60 per cent of total
emission from the logistics and transport sector. Air transport is also considered to be
the most carbon-emitting transportation mode, with most carbon efficient being rail and ocean
(Doherty and Hoyle, 2009; DHL, 2010).

The supply chain needs collaboration in the approach, where all stakeholders
understand the need for sustainability. Customers should create demand and incentivise for
sustainable products and services; investors should expect companies to adopt sustainable
measures and support them, employers need to incorporate sustainable behaviour from
come to corporate; political leaders should support stricter sustainability legislation and
standardise CO2 labelling and carbon pricing for logistics organisations. Carbon emission is
now considered as a part of an accounting measure and also in a decision-making process
(Ceniga and Sukalova, 2015). For a 3PLSP to involve sustainability measures, technology
solutions and local involvement are the need of time. Both these strands have to go hand in
hand to contribute towards sustainable goals (Narkhede et al., 2017).

Regarding value, the Indian pharmaceutical sector ranks tenth globally, and regarding
volumes, it is in the third position. It is predicted that this sector will grow to $55.0bn by
2020 from $12.60bn in 2009 (M&C, 2015). There is tremendous pressure on the global

The 3PLSP’s evaluation criteria
pharmaceutical companies for boosting the drug discovery potential, reducing costs along
the entire supply chain, and to reduce time to market. It may be noted that there is a
significant growth in India’s population. Additionally, the epidemiological profile of Indians
is changing considerably. Hence, the demand for drugs for the central nervous system,
cardivascular diseases and other chronic disorders is more likely to increase (PWC, 2010).
It is estimated that the population growth at 1.30 per cent per year will increase the patient
pool by 20 per cent by 2020 (M&C, 2015). Further, for boosting the affordability and local
access to the quality healthcare, the Indian Government has launched new programmes and
policies (PWC, 2010). A little consideration will show that there is a significant need to make
a pharmaceutical supply chain a sustainable entity to effectively cater the healthcare needs
of the various segments of the country and contribute to the growing economy.

Healthcare and pharmaceutical are critical areas of consideration for logistics. Healthcare
cost is shooting so high that it is beyond the reach of an ordinary man. There is a need to
reduce healthcare cost without compromising on customer service (Yu et al., 2010). The
management of procurement, storage, and distribution of pharmaceutical supplies is crucial
for hospitals and pharmaceutical companies from the economic and organisational point of
view (Bishara, 2006; Uthayakumar and Priyan, 2013). Customer service level is expected to
be 100 per cent: one-day delay in delivery is equivalent to medicine not reaching on time, and
it may impact the concerned person’s health. In pursuit of timely delivery, the network
optimisation, fleet charge, and sustainability are usually overlooked by industries (Kelle
et al., 2012; Uthayakumar and Priyan, 2013). Sustainable logistics in pharmaceutical and
healthcare sector is very much needed not only to reduce the negative influence on the
environment, but also to diminish the cost factor (Narayana et al., 2014; Xie and Breen, 2012).
Hence, there is a significant need to identify and evaluate the selection criteria for the
adequate selection of sustainable 3PLSP for the pharmaceutical sector. It is worth
mentioning that the selection of a sustainable 3PLSP enhances the overall performance and
competitiveness of the case supply chain.

Selecting a suitable 3PLSP is an essential decision for any organisation. After selecting a
service provider, its performance needs to be monitored too. There are several evaluation
criteria described in various empirical studies. Thus, 3PL service has become a reliable source
of logistics for most of the organisation and industries. In the present research, the selection
criteria for a sustainable 3PLSP were identified for a pharmaceutical industry through an
exhaustive literature review and expert opinions. The shortlisted criteria were modelled by a
multi-criteria decision making (MCMD) approach for the identification of interrelationship
between the criteria and to identify the most significant evaluation criteria, having high
influential power. The developed hierarchical concept is proposed to help the executives,
decision and policy makers in formulating strategies and policies for the selection of a
sustainable 3PLSP. The present study intends to address the following research questions:

RQ1. What are the selection criteria for a 3PLSP?
RQ2. How the shortlisted criteria are interrelated?
RQ3. Which are the most significant criteria?

As discussed earlier, the selection of a sustainable supplier helps to balance all three
dimensions of sustainability and ensures improved performance of the case sector. To
achieve this overall aim of evaluating the selection criteria, the objectives are divided into a
set of explicit target goals. The research objectives of this study are:

- RO1: to identify the critical selection criteria for a 3PLSP;
- RO2: to identify the mutual relationship between the identified criteria; and
- RO3: to identify the criteria for having high influential power.
The remainder of this paper is arranged in the following sequence – in Section 2, the literature review is covered, followed by the research methodology in Section 3. The case study is discussed in Section 4, and the analysis of 3PLSP’s selection criteria, discussion of results and conclusions are detailed in Section 5.

2. Literature review

Sustainability measures are enabling the logistics service provider (LSP) to change the way of their current working. The logistics provider has to look for low carbon economy, and their value proposition should include green supply chain, CO2 reduction and cost savings. Technological changes in the network are required for appropriate innovations and adoption of new business models, like the electric vehicle, smart grids to charge batteries, digital media in mail carriers, etc. This section of the paper discusses various papers published in the area of third-party logistics across different countries and tools and techniques employed for analysing the issues.

2.1 Third party logistics (3PL)

Consideration of sustainable logistics starts with the design of a suitable supply chain. It may be noted that the reverse logistics of any supply chain helps to achieve the sustainability and improves the overall performance of the supply chain. Hence, in this section, the papers published in the area of reverse logistics are also discussed.

For the development of reverse logistics network, Alshamsi and Diabat (2015) used mixed-integer linear programming, so that multiple factors like capacity, selection of sites and remanufacturing facilities can be acknowledged. The applied network designing methodology considered the impact on environmental, social, and economic factors. Korchi and Millet (2011) designed the channel structures of reverse logistics for less environmental impact and higher financial gains. By studying the existing network structure of reverse logistics, 18 general network frameworks were suggested. For designing the 3PL network, Suyabatmaz et al. (2014) proposed two hybrid simulation-analytical modelling methodologies: one is the problem-specific approach, and another is the generic approach. The impact of each solution under different parameters and scenarios was discussed.

Du and Evans (2008) suggested a bi-objective methodology for analysing the reverse logistics network. Minimisation of the total cost was the first objective and minimisation of total tardiness is another. Multiple algorithms were used to solve this bi-objective problem and suggested an optimal solution. Results showed that trade-off is required in two objectives because the optimisation of the first objective leads to centralised network structure, whereas the second results in a decentralised network. The selection of the third-party reverse logistics provider (3PRLP) by the use of the interpretive structural modelling (ISM) approach was proposed by Govindan et al. (2012). While selecting a 3PL provider, multiple dimensions and attributes were considered, and the relationship among the attributes was established. Guarnieri et al. (2015) discussed the multi-criteria perspective decision-making approach for 3PRLPs selection. This paper proposed a conceptual model used in recent previous literature, and also the proposal for the conceptual, methodological framework for decision makers and researchers was detailed.

Efendigil et al. (2008) worked on the selection of 3PL for green supply chain and suggested the most appropriate logistics provider based on artificial neural networks and fuzzy logic in a holistic manner. Göl and Çatay (2007) redesigned logistics operations for the selection of a global LSP in the Turkish automotive sector by employing the analytic hierarchy process (AHP). Prakash and Barua (2016) proposed the fuzzy AHP and fuzzy Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) methodologies for the evaluation and ranking of the third-party reverse logistics partner while achieving efficiency and effectiveness for the Indian electronics Industry. Azadi and Saen (2011) used...
chance constrained data envelopment analysis (CCDEA) for the 3PL selection and evaluation. CCDEA was performed by considering service quality experience, service quality credence and stochastic data of LSPs. Mathiyazhagan et al. (in press) reviewed the literature with a focus on the assessment of environmental criteria for 3PL selection. Also, the research gaps were identified, and future research directions were highlighted.

Asuquo et al. (2014) researched the selection of third-party shipment management by using the AHP approach. Primary selection criteria were analysed through the survey of Shipping Corporation of Brazil. Experience and reputation were found to be the most critical criteria in shipping. Wolf and Seuring (2010) analysed whether ecological issues from criteria for a supplier selection by studying nine cases in depth by collecting data from buyers and 3PL. Findings from the cases suggested that the performance measurement was still carried out based on the traditional parameter like time, cost, quality, etc., and companies were not looking at the broader perspective of environmental concerns. Colicchia et al. (2013) discussed the adoption of environmental initiatives by LSPs, and a set of frameworks for environmental sustainability measures were also detailed. The framework was applied to ten LSPs and in-detail interview of three finally selected companies were conducted.

Ugarte et al. (2016) studied the impact of lean logistics best practices on the environment. It was found that some practices like just in time, product postponement, etc., caused an increase in the frequency of transport, and thus increased the carbon and GHGs emissions. Ding et al. (2016) researched the supply chain operational strategies for producing eco-friendly products. Findings of the work suggested that the decisions of operating environmentally friendly products were dominantly subject to governmental policies and incentives. Mehmann and Teuteberg (2016) represented the general idea of implementing fourth party logistics into the transportation (planning) process, to achieve sustainable development goals. A case study on German agricultural bulk logistics sector suggested the implementation of sustainable development by the full truckload of transportation. Neto et al. (2008) developed a framework for designing a logistics network which is economically and environmentally viable by using multi-objective programming (MOP) approach. European paper and pulp industry were studied to introduce a technique which has commonalities between DEA and MOP for evaluating the efficiency of existing logistics network.

Sustainable logistics is not only concerned with industry and city but, also, to many logistics operate causing high carbon emission. Yang et al. (2016) worked on carbon tax constrained city logistics network design model in China. By adopting the suggested model, there was a 54.5 per cent decrease in carbon dioxide discharge in Beijing, and distribution operation costs were cut by 9.2 per cent during the full-service cycle. Lai et al. (2013) performed research on Chinese manufacturer to check if reverse logistics practices help in improving the triple bottom line. The results of the study showed that adoption of RL improves the environmental and financial benefits but not the social dimension. This study also extended the manufacturer knowledge by highlighting the emerging trends in upcoming logistics practices. Lee and Wu (2014) adopted a multi-methodological approach to measuring the sustainability performance of logistics and supply network. Results indicated that to improve sustainable performance, indicators of performance from a different perspective should be considered and needs to be integrated into one model of system measurement. Abbasi and Nilsson (2016) explored challenges and themes in developing environmentally sustainable logistics. The study was performed on ten logistic companies in Scandinavian countries. The challenges were observed in four broad categories: customer priorities, managerial complexity, network imbalance and technological and legislative uncertainties.

Jaller et al. (2016) studied the impact of sustainable logistics measures in the metropolitan area of the Mexico City valley. The impact on travel distance, travel time,
accidents, emissions and health was analysed. On similar lines, Fenton (2017) researched on low carbon urban development and sustainable mobility in the context of Denmark. Taskhiri et al. (2016) studied the wood industry’s logistics network for achieving sustainability. Findings of the study revealed that if wood utilisation is cascaded, then there will be the substantial reduction in CO₂ emission. Guarnieri et al. (2016) discussed the establishment of reverse logistics for the solid wastes such as electronic waste. The study was performed on Brazilian electronic industry and proposed a strategic options development analysis methodology for the evaluation. Jeffers (2010) worked on the use of information technology resources and used path analysis involving the sample of 3PL firms. The finding of the papers suggested focussing on IT and customer centrism to improve sustainable performance.

Evangelista (2014) investigated the environmental sustainability initiatives taken by 3PL firms and factors influencing them. In total, 13 Italian transportation and logistics companies were considered for the case study. The surveyed companies showed the different degree of involvement in green initiatives; this is because of difference in the portfolio of services offered and variation in their inhibitors and main drivers. Rajesh et al. (2012) proposed a set of strategies for the balanced scorecard of the 3PLSPs. Weights were given to different strategies, and evaluation was done using the Delphi method. Lun et al. (2015) studied the involvement of customers in the performance of logistics activities and achieving sustainable goals. Data were collected from Hong Kong to measure greening propensity. The theoretical contributions and implications of green measures were also elaborated.

Kishore and Padmanabhan (2016) employed the integrated AHP and TOPSIS methodologies in the fuzzy environment for the selection of LSP for a battery manufacturing company in the Indian context. Fuzzy AHP was used for ranking the ten selection criteria (price, region, collecting proof of delivery, resolving issues, quality of service, tracking status, placement percentage, number of customers handled, on-time delivery and customs clearance), and fuzzy TOPSIS was applied for ranking the service providers. Singh et al. (2017) utilised the hybrid fuzzy AHP and fuzzy TOPSIS methodology for the selection of 3PL for cold chain management for the Indian food industry. Fuzzy AHP was used for ranking the evaluation criteria, and fuzzy TOPSIS was employed for selecting the appropriate 3PL. Laghrabli et al. (2016) analysed the issue of transportation supplier selection in the context of pharmaceutical supply chain using the multi-attribute utility theory and AHP.

2.2 Research gaps
From the above literature survey, it is very much clear that a lot of research work has been carried out in various industries and across various countries in the third-party logistics domain. Past research activities focussed on development of reverse logistics network, design of channel structures, design of 3PL network, selection of 3PRLP, selection of green 3PLSP, impact of lean logistics best practices on the environment, sustainability performance measurement of logistics and supply network, challenges and themes in developing eco-friendly sustainable logistics, RL of E-waste, investigation on environmental sustainability initiatives taken by 3PL firms, influence of customers involvement on the logistics activities performance, 3PL selection for battery manufacturing industry, 3PL selection for cold chain management for the food industry, etc.

It may be noted that even after an extensive search, the authors could find only one research article in the selection of 3PLSP in the pharmaceutical industry context (Laghrabli et al., 2016). It indicates that the case area is arid and there exists a lot of research potential. In this paper, novel research of identifying and modelling sustainable third-party selection criteria by employing a MCDM approach, namely, ISM methodology, is presented in the
Indian pharmaceutical industry context. This methodology helps to establish the interrelationship between the shortlisted criteria, and the Matrice d’Impacts Croisés Multiplication Appliquées à un Classement (MICMAC) analysis helps to identify the driving and dependence power of each criterion. The ISM approach is a robust methodology that helps to present a complex structure in a simplified manner; to transform less comprehensible mental models of a structure into explicit, visible models; to identify structure within the system; to interpret the embedded object; and to answer “what” and “how” in theory building (Sushil, 2012).

Unlike other MCDM tools like AHP, ANP, DEMATEL, etc., in the ISM tool, while analysing the factors, the level of dominance or intensity of the relationship is not required, and only the inter-linkage (driving and driven relationship) between the identified criteria is needed. It decreases the level of biases in the experts’ judgments (Gardas et al., 2015). Hence, in the present study, ISM is employed for identifying the interrelationship among the identified criteria and modelling the same for identifying the most significant criteria, which need the maximum attention of the decision and policy makers. This research is intended to guide the decision and policy makers in understanding the mutual relationship between the identified criteria and to identify the most significant criteria by which the selection process of sustainable 3PLSPs can be carried out. Also, this study is useful in modifying the existing policies/strategies or formulating new effective selection strategies.

3. Research methodology

An ISM approach is an MCDM tool that helps in analysing the interrelationships between the factors/variables (Warfield, 1974). Also, it identifies the order and direction of the relationship (Diabat and Kannan, 2011; Gardas et al., 2017b; Hawthorne and Sage, 1975; Jha et al., 2018; Ravi and Shankar, 2005).

Steps involved in the ISM approach are given as follows (Kannan and Haq, 2007; Malone, 1975; Mudgal et al., 2009; Narkhede and Gardas, 2018):

1. Evaluation criteria for the selection of an efficient 3PLSP in the case sector were identified.
2. The interrelationship between the identified criteria was established, and the same was tabulated in the structural self-interaction matrix (SSIM).
3. The SSIM was then transformed into a binary matrix known as an initial reachability matrix (IRM).
4. The IRM was then modified to final reachability matrix (FRM) by adding transitive links. The transitivity rule means if a criterion “P” influences “Q” and “Q” affects “R”, then “P” can influence “R”.
5. The level partitioning of FRM was then carried out.
6. From the FRM, a directed graph (digraph) was drawn, and the links of transitivity were removed.
7. Lastly, the final digraph was transformed to a hierarchical structure by replacing node numbers with the criteria statements.

4. Case study – pharmaceutical industry

Pharmaceutical industry discovers, develops, produces and markets drugs. These pharmaceutical companies may deal in drugs as generic or branded medications and also work in medical devices. Most of the revenue source and competency of this industry is measured in their patenting, testing, safety, efficacy and marketing potential of drugs.
The Indian pharmaceuticals market increased at a CAGR of 17.46 per cent during 2005–2016 with the market increasing from US$6bn in 2005 to US$36.7bn in 2016, and is expected to expand at a CAGR of 15.92 per cent to US$53bn by 2020. Indian pharmaceutical industry ranks 3rd in world and 14th regarding value (India Brand Equity Foundation (IBEF) 2017).

XYZ is situated on the north-eastern side of the Maharashtra state, India. XYZ is a supplier and rising manufacturer representative of pharmaceutical ingredients, raw materials, flavours, food colours, API drugs, ingredients and chemicals. This organisation wanted to identify the critical evaluation criteria for shortlisting the 3PLSPs for the distribution of their products all across the country and at the global level.

For the development of the structural model of 3PLSPs evaluation criteria, an ISM approach has been applied. Various stages leading to the elaboration of the ISM hierarchical model are detailed next.

4.1 Identification of the 3PLSP’s evaluation/selection criteria

The critical evaluation criteria were identified for the modelling purpose by reviewing the literature and through expert opinions from the case industry. For the identification of the selection criteria, search engines, namely, Emerald Insight, IEEE Explorer, Google Scholar, Google, Inderscience online, Science Direct (Elsevier), Springer, Taylor and Francis group and Wiley online library, were explored. The keywords used for the search were selection criteria, evaluation criteria, third-party logistics, sustainability, 3PL service provider, the pharmaceutical industry and MCDM methodologies. After reviewing the journal articles, magazines, white papers, newspapers, book chapters and conference proceedings, 18 selection criteria were identified. Then, the Delphi study was conducted by taking the experts inputs. After carrying out three rounds, 14 critical criteria were shortlisted for the further analysis.

The experts’ team consisted of four procurement managers from the pharmaceutical sector, four supply chain and logistics managers, three professors from the operations and supply chain management department. In the literature, Robbins (1994) suggested that for the qualitative analysis, the number of experts should be in the range 5–50. Hence, in the present investigation, 11 experts were invited to the efficient decision-making process. The 14 identified factors along with the sustainable dimensions are detailed in Table I.

4.2 Development of SSIM

For establishing the mutual relations among the critical evaluation criteria, the SSIM (Table II) was formulated by taking experts inputs. The following four symbols were used for showing the direction of influence between the criteria (i and j), “O”– no relationship; “X” – both influence each other; “V” – element i causes element j; and “A” – element j causes element i.

4.3 Formation of reachability matrix

For the development of IRM from the SSIM, the following guidelines were used. If the SSIM has the value “V” for i, j, then IRM will have i, j value as 1, and the value of j, i will be “zero”. If the SSIM has the value “A” for i, j, then IRM will have i, j value of “zero”, and the value of j, i will be 1. If the SSIM has the value “X” for i, j, then both i, j and j, i values will have 1. For i, j value of “O”, the IRM will have both i, j and j, i as “zero”. The IRM for the present case study is shown in Table III. The FRM (Table IV) was formulated from the IRM by applying the rules of transitivity as mentioned in step 4 of Section 3.

4.4 Level partitions

From the FRM, the reachability and antecedent sets were identified for each criterion (Gardas et al., 2017a; Kannan et al., 2009). A criterion having both the sets identical was eliminated and given the top (first) position in the hierarchical structure (Gardas et al., 2018c;
<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Criteria</th>
<th>Description</th>
<th>Economic</th>
<th>Ecological</th>
<th>Social</th>
<th>Author(s) and year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cost of wastage, distribution cost, cost of training, etc.</td>
<td>In the highly competitive pharmaceutical industry reduction of cost is a main objective of the organisational mangers. The strategies of waste reduction, distribution cost reduction, or reduction of training cost is a big advantage for 3PLSP.</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>Alshamsi and Diabat (2015), Du and Evans (2008)</td>
</tr>
<tr>
<td>2</td>
<td>Service quality</td>
<td>The good service quality helps to improve the long-term relationship and reduces wastage. It includes confirmation of ecological issues, control of quality, commitment to continuous improvement, etc.</td>
<td>✓</td>
<td></td>
<td></td>
<td>Bottani and Rizzi (2006), Moberg and Speh (2004), Narkhede et al. (2017), Yeung (2006)</td>
</tr>
<tr>
<td>3</td>
<td>Quality certification and health safety</td>
<td>The certifications of the quality ensure quality of products and services, it includes ISO standards. The health and safety measures ensure the safety of the workforce and helps to balance the social dimension of sustainability.</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>Experts input</td>
</tr>
<tr>
<td>4</td>
<td>Technology innovation and IT capability</td>
<td>The innovation of technology and IT capability improves overall performance of the pharmaceutical supply chain. The IT capability of 3PLSP includes electronic data interchange, vehicle loading optimisation, vehicle routing packages, enterprise resource planning and RFID.</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>Qureshi et al. (2008), Rahman (2004), Vaidyanathan (2005)</td>
</tr>
<tr>
<td>5</td>
<td>Healthy relationship with employee and customers</td>
<td>It develops trust, helps to improve compatibility, alliance, dependence and reliability. Also, helps to share rewards, incentives and risks.</td>
<td>✓</td>
<td></td>
<td></td>
<td>Bottani and Rizzi (2006), Moberg and Speh (2004), Mortensen and Lemoine (2008), Qureshi et al. (2008)</td>
</tr>
<tr>
<td>6</td>
<td>Agility and flexibility</td>
<td>It is the capability of the service provider to adopt fluctuating demands of the customers. It provides responsiveness to the industry and increases service quality, which, in turn, improves pharmaceutical industries business performance.</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>Bottani and Rizzi (2006), Knemeyer and Murphy (2004), (2005), Moberg and Speh (2004), Yeung (2006), Luthra et al. (2017)</td>
</tr>
<tr>
<td>7</td>
<td>Expansion capacity into health management distribution service</td>
<td>It provides a competitive advantage to the industry. It includes market coverage, international reach, geographical specialisations and the range of services provided by the 3PLSP.</td>
<td>✓</td>
<td></td>
<td></td>
<td>Bottani and Rizzi (2006), Moberg and Speh (2004), Tsai et al. (2007)</td>
</tr>
<tr>
<td>8</td>
<td>Capability of robust supply network/distribution network</td>
<td>It includes the optimisation of the distribution network, which will reduce the delivery time, polute less, improve reputation and cost less. The geographical spread of the 3PLSP simplifies the transportation processes.</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>Experts input</td>
</tr>
</tbody>
</table>

(continued)
<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Criteria</th>
<th>Description</th>
<th>Economic</th>
<th>Ecological</th>
<th>Social</th>
<th>Author(s) and year</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Satisfaction level of the employee</td>
<td>A satisfied employee improves the performance of the overall supply chain as every employee is an integral component of a company</td>
<td></td>
<td></td>
<td></td>
<td>Experts input</td>
</tr>
<tr>
<td>10</td>
<td>Environmental certifications</td>
<td>Environmental measures need to be updated regularly and returns are realized in long term. Cost involved turns into liability as a standard measure. 3PLSPs need to obtain environmental certifications which ensure less damage to the ecology</td>
<td></td>
<td></td>
<td></td>
<td>Wolf and Seuring (2010)</td>
</tr>
<tr>
<td>11</td>
<td>Governmental rules and regulations and political stability</td>
<td>The necessary approvals should be taken from the government from time to time, and the activities or services offered by the 3PLSP should be as per the regulatory norms. The management of the organisation is responsible for taking timely approvals from the governing bodies. Industry policies revolve around tax norms and other government policies. Support from government in green initiatives is as crucial as industry measures</td>
<td></td>
<td></td>
<td></td>
<td>Ding et al. (2016)</td>
</tr>
<tr>
<td>12</td>
<td>Financial performance</td>
<td>A sound financial status of the 3PLSP indicates the continuation in quality services and regular upgradation of machinery, training the manpower, etc.</td>
<td></td>
<td></td>
<td></td>
<td>Bottani and Rizzi (2006), Sasananan et al. (2016), Zhou et al. (2008)</td>
</tr>
<tr>
<td>13</td>
<td>Sustainable eco-friendly process/recycling</td>
<td>For sustainable practices recycling of products can contribute to green initiatives. In pharmaceutical industry, packaging cartons and plastics can be recycled after proper sanitation</td>
<td></td>
<td></td>
<td></td>
<td>Alshamsi and Dialat (2015)</td>
</tr>
<tr>
<td>14</td>
<td>Availability of cold storage vehicles and suitable drivers</td>
<td>Sufficient availability of the cold storage facilities/vehicles for the biopharmaceutical supply chains is an advantage for the 3PLSPs</td>
<td></td>
<td></td>
<td></td>
<td>Experts input</td>
</tr>
</tbody>
</table>

Table 1. The 3PLSP's evaluation criteria
Mandal and Deshmukh, 1994; Raut, Narkhede and Gardas, 2017). Similarly, all the criteria were iterated for obtaining various levels. Level partitioning of the evaluation criteria is shown in Table V.

### 4.5 Formation of the ISM model

From the FRM, a structural model was developed, and by removing the transitive links from the same, a final hierarchical model was structured (Figure 1).

The developed structural model may be classified into three clusters namely most significant, moderately significant, and less significant factors. In the first cluster of the most important criteria, there are three factors, namely, capability of robust supply network/distribution network; quality certification and health safety; and service quality. These are the driving factors influencing the factors above them and grab the maximum attention of the decision and policy makers. It may be noted that the most significant criteria driving all
Other criteria is "Capability of robust supply network/distribution network" as it has the potential to influence health and safety measures, improves service quality by enhancing the operational and delivery performance, helps to acquire environmental certifications, provides agility and flexibility to the customers, improves relationship with the customers, increases satisfaction level of the employee and improves financial performance of the organisation. The second most significant criterion was found to be the quality certification and health safety. This criterion ensures good service quality with a reduction of waste and distribution cost. It also influences the top management to adopt IT services, improves relationships with customers by offering quality services, offers flexibility and agility, helps to expand into the health management distribution services, encourages management to
apply for environmental quality certifications, improves financial status of the organisation, focusses on the sustainable practices and ensures the availability of cold storage vehicles. At the fifth level, a criterion namely service quality was found to be the sign. This criterion is dependent on the criteria below them and can influence the criteria above it the hierarchical model. It is worth mentioning that the service quality of a 3PLSP improves customer relationship and encourages the decision makers to adopt IT services and opt for environmental certifications. It helps to increase the market share, improves the satisfaction level of the employees, and the economic performance of the organisation, and ensures the availability of the cold storage services.

In the segment of moderately essential criteria, there are five criteria, namely, healthy relationship with employee and customers, agility and flexibility, environmental quality certifications, the satisfaction level of the employee, and governmental rules and regulations and political stability. These factors are getting driven by the factors below them and have the capability to drive the factors situated above them in the hierarchy. With an intention to improve the relationship with customers, the organisation may adopt IT facilities; to indicate a green image of the organisation, they may go for environmental certifications, and green practices, which, in turn, enhance the economic status, and market share of the company. Agility and flexibility, which are at the fourth level in the hierarchy, reduce the wastage, distribution cost, and 3PLSPs may adopt IT facilities, green practices and environmental certifications, thus improving the financial status of the organisation. It may be noted that the environmental quality certifications reduce the wastage and cost of distribution, encourage the organisations to opt for eco-friendly practices, guide the governmental organisations to implement strict policies for balancing the environmental dimension of sustainability, boost 3PLSPs to adopt information technology and help to expand distribution services. This criterion also ensures that wastage of pharmaceutical
products due to unavailability of cold storage vehicles is reduced, hence improving the financial strength of the 3PLSP. Also, the satisfied employee helps to reduce distribution cost, and wastage cost focuses on the sustainable aspects, helps to increase the market share and makes the supply chain agile and flexible, which, in turn, increases profits. The governmental organisations may encourage the organisations to adopt the IT facilities and green practices for improving the service quality and environmental performance.

The less critical factors in the hierarchy having less influential power are: cost of wastage, distribution cost, the cost of training, etc., financial performance, sustainable, eco-friendly process/recycling, availability of cold storage vehicles and suitable drivers, technology innovation and IT capability, and expansion capacity into health management distribution service. It may be noted that these criteria are dependent on the levels 3–7 criteria and demand less attention from the decision makers.

4.6 Matrice d’Impacts Croisés Multiplication Appliqués à un Classement analysis

The MICMAC approach analyses and explains the evaluation criteria based on their driving and dependence power. The driving power (influential power) of a particular criterion is calculated by taking the sum of all the 1s in the row, and dependence power by taking the sum of all 1s of the column. The driving and dependence power values of all the criteria are shown in Table V. The power matrix (driving and dependence power diagram) is shown in Figure 2. It has four segments, namely, driving, linkage, dependent and autonomous. The autonomous cluster comprises of the criteria having low driving and low dependence power; the dependent segment consists of criteria having low driving and high dependence power; and the linkage cluster consists of criteria having high influential power and high dependency. Lastly, the criteria of the driving cluster are very significant as they have
high influential and weak dependence power (Raut, Narkhede, Gardas and Raut, 2017; Sage, 1977). It is worth mentioning that the driving cluster attracts the significant attention of the decision/policy makers. The power matrix for the 3PLSP’s evaluation criteria is shown in Figure 2.

The autonomous cluster consists of criteria having low driving and low dependence power, which are less significant in the developed model. There are six factors in this cluster namely cost of wastage, distribution cost, the cost of training, etc., healthy relationship with employee and customers, satisfaction level of the employee, governmental rules and regulations and political stability, availability of cold storage vehicles and suitable drivers, and expansion capacity into health management distribution service. In the second cluster of dependent factors, three criteria are having high dependence and low driving power, namely, financial performance, sustainable, eco-friendly process/recycling, and availability of cold storage vehicles and suitable drivers. In the linkage cluster, there is a single factor having high driving and high dependence power, namely, agility and flexibility. The most important segment of power matrix is the driving cluster, which has four criteria, namely, capability of robust supply network/distribution network, quality certification and health safety, service quality and environmental quality certifications. These are the factors having low dependence and high driving power, and can influence other factors of the model.

5. Conclusions
In the present research, for analysing the selection criteria of a 3PLSP for a pharmaceutical supply chain, 14 criteria, namely, cost of wastage, distribution cost, cost of training, etc., service quality, quality certification and health safety, technology innovation and IT capability, healthy relationship with employee and customers, agility and flexibility, expansion capacity into health management distribution service, capability of robust supply network/distribution network, satisfaction level of the employee, environmental quality certifications, governmental rules and regulations and political stability, financial performance, sustainable eco-friendly process/recycling, and availability of cold storage vehicles and suitable drivers were identified through literature review and expert opinions. The interrelation between the shortlisted criteria was established by employing the ISM approach. The MICMAC analysis was used for identifying the driving power and dependency of all criteria. The most significant factors having high driving power are: the capability of robust supply network/distribution network, quality certification and health safety, service quality and environmental quality certifications, and these criteria demand the maximum attention of the decision makers.

In the present analysis, 14 criteria were modelled, and the developed model was validated by the experts from the academia and case sector. However, there could be other relevant factors which are not considered in the development of the hierarchical model. Considering more criteria in other research activities would provide better results. It may also be noted that the inclusion of more factors in the model development would make the analysis tedious and complicated. The ISM approach does not highlight the causality of links and the interpretation of the links is partial.

Moreover, in the elaboration of the SSIM, the inputs were taken from the experts and these judgments could be biased influencing the final results of the model. To overcome this limitation and to improve the reliability and accuracy of the structure, integrated approaches (the TOPSIS, analytic network process, decision making trial and evaluation laboratory, AHP, interpretative ranking process, total ISM, etc.) may be employed along with the ISM tool. All these tools can also be integrated with the ISM approach in the fuzzy environment.

Moreover, the integrated methodologies help in validation of the developed model (Gardas et al., 2018a; Mishra et al., 2018; Raut, Gardas, Jha and Priyadarshinee, 2017).
Also, for validating the robustness of the model, sensitivity analysis may be conducted. In further studies, the authors may employ the structural equation modelling methodology for validating the ISM approach results statistically (Gardas et al., 2018b; Pawaskar et al., 2018; Priyadarshinee et al., 2017). Additionally, in future investigations, the authors would like to consider the country-specific expertise of 3PLSP, knowledge of customs and taxation, number distribution centres, etc., for the selection of a globally sustainable 3PLSP.

5.1 Practical implications of the study
The ISM model of sustainable 3PLSPs selection criteria provides vital information about the significance of evaluation criteria for the formulation of policies and strategies for the active selection. This study helps the organisational managers, decision and policy makers, and prospective 3PLSPs in understanding the importance of the selection criteria and ranks of the same.

By results obtained through the investigation, the most significant factors having high driving power are the capability of robust supply network/distribution network, quality certification and health safety, service quality and environmental quality certifications. These findings imply that the 3PLSPs should focus on enhancing the supply network/distribution network, which helps in improving the operational and delivery performance. Also, they should opt for the quality and environmental certifications; these certifications highlight the quality of the services offered and their concern towards the environment. These certifications provide a competitive edge over other service providers and the positive green image attracts more customers. The 3PLSPs need to offer a safe and healthy working environment, which enhances the performance of the workforce. Additionally, 3PLSPs should focus on improving their service quality; this helps in building the excellent relationship with the customers. 3PLSPs can use the findings of this study for the public purpose by highlighting their strengths through this study.

It also helps in the formulation of the active organisational strategies and policies for the selection of the efficient 3PLSP based on the aspects of sustainability. This study guides the organisational managers, decision and policy makers in understanding the interrelationship between the shortlisted selection criteria. The organisational managers can select the best 3PLSP from a list of potential 3PLSPs based on the 3PLSPs robust supply network/distribution network, quality and environmental certifications, health and safety measures, and service quality. The decision and policy makers can formulate strategies and policies giving more emphasis on the critical selection criteria identified through the application of the ISM approach. Also, weights can be assigned to the evaluation criteria based on their significance and criticality.

5.2 Theoretical implications of the study
This study contributes to the existing knowledge base of the 3PLSPs selection and guides the academicians by modelling the critical selection criteria in the case of developing economies pharmaceutical supply chains. The findings imply that the robust supply network/distribution network, quality and environmental certifications, health and safety measures, and service quality are the essential selection criteria. Researchers working in this domain can carry out research activities for enhancing or improving the supply and distribution network, analysing the issues related to the quality and environmental certifications, the benefits of and barriers to health and safety measures, and exploring various methods of improving service quality. The guidelines for the fair selection of the 3PLSP can be detailed. Also, as this study identified the mutual relationship between the selection criteria, this can be extended to the next stage of the 3PLSPs selection from the pool of 3PLSPs. The same can be done by applying AHP, VIKOR, TOPSIS, etc. Also, researchers can employ other MCDM tools (DEMATEL, IRP, TISM, etc.) for the analysis of
the shortlisted selection criteria for the validation of the results and check reliability and accuracy of the developed structural model. Further, all the mentioned MCDM methodologies may be applied in the fuzzy environment. The statistical analysis may also be employed by formulating the relationship hypothesis based on the interrelationship explored in the present study for validation.

As the selection criteria and their relative importance may vary from industry to industry, hence, the findings of this study cannot be generalised. Even though the results may vary, however, the same approach may be applied to other domains such as the hotel industry, banking, automobile, FMCG, etc. In future studies, additional sustainable criteria, such as usage of non-conventional energy sources, reusable and recyclable packaging materials and changes in quality of service measures, may be considered.

It is worth mentioning that the selection of sustainable 3PLSP helps in balancing all three pillars of sustainability namely ecological, economic and social. Also, efficient 3PLSP helps to improve the overall performance of the supply chain, decreases consumption of energy, pollutes less, reduces final products cost, provides the positive brand image, and financial benefits to the company.

5.3 Social implications of the study
This study has developed a decision-making model for the selection of a sustainable 3PLSP in the pharmaceutical supply chain content. This investigation considers several criteria which fall under the social dimension of the sustainability. This study guides the 3PLSPs to focus on the social dimensions for enhancing the overall efficiency of the supply chain. The essential selection criteria with a focus on the social aspects are robust supply chain/distribution network, environmental and quality certifications, and health and safety measures. It may be noted that efficient distribution network ensures the timely delivery of the pharmaceutical products which is a foremost requirement of the pharmaceutical supply chains towards the society.

This study highlights that selection of a sustainable 3PLSP ensures the health and safety policies at the 3PLSP’s end. Also, a sustainable 3PLSP needs to have an efficient distribution network that not only reduces the transportation time but also improves air quality by reducing emissions. The training sessions need to conduct for the manpower regarding all the activities undertaken by the 3PLSP. The proper training reduces the distribution cost, and wastage, which finally helps to reduce the price of the products. Training regarding the adoption of information technology helps to maintain proper inventory of the stock and helps to identify the best routes for commutation which improve the delivery performance. Also, training and knowledge sharing helps to improve the service quality and competitiveness, which ultimately improves the relationship with customers.

Additionally, a sustainable 3PLSP needs to offer the best salary packages and incentives and provide an amicable environment to ensure that the workforce’s satisfaction level is at the peak. A satisfied employee offers his services with utmost sincerity and tries to improve the overall performance of the supply chain. In the present framework, a criterion, namely, the satisfaction level of the employee, is found to have a significant dependency on other essential criteria.

References


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Mediation effects financial performance toward influences of corporate growth and assets utilization

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Abstract
Purpose – The purpose of this paper is to measure the effects of corporate financial performance toward the influences of corporate growth and company asset utilization on the corporate market value.
Design/methodology/approach – This research is an explanatory research that describes the influences of one or more variables on other variables based on secondary data. This research took place in Indonesia and was carried out from 2011 to 2016.
Findings – The findings of this study are corporate growth has a significant influence on the corporate market value, implying that companies should consider the short-term and long-term profitabilities before making any investment decision; asset utilization has been confirmed to have a positive and significant influence on financial performance. Insights into asset utilization effectiveness and efficiency are important for company managers to consider in making strategic decisions upon operational activities of the company. Also, financial performance has a positive and significant influence on the corporate market value.
Originality/value – Research originality offered in this research is in the form of empirical evidence upon the influence of company asset utilization on the financial performance and corporate market value of a company. The finding of this research is expected to provide a better understanding on the role of company asset utilization in determining corporate financial performance which is known to be certain.
Keywords Financial performance, Corporate growth, Asset utilization, Corporate market value

1. Introduction
Companies are established to achieve the main function, improving shareholders’ wealth through the improvement of corporate market value (Keown et al., 1999, p. 2). The board of managers is trusted to manage a company in order to obtain profits that eventually increase the wealth of company owners. Companies use private equity and debt at the same time, including short-term debts and long-term debts for fund operational activities of the companies.

The operational activities of a company utilize company’s assets allocation of which has been determined. A better utilization of company assets increases the sales, resulting in higher profit (Gopal, 2009). The board of managers is incharge of making decisions related to asset utilization; besides, they are also required to maintain the operational activities of the company. Decisions to make investment determine the amount of assets to be spent on operational activities. Operational activities use the assets to run the sale in order to make profit, which contributes to the wealth of company owners. The utilization of company assets is an important key to achieve company goals. Assets utilization refers to the use of company assets that have been allocated in such ways to produce products or services offered to the consumers in order to achieve the company goals. For instance, activities in the management of company assets include maintaining supplies, accounts receivable, fixed assets and other assets in the most effective and efficient way to make profits as expected and to increase the wealth of company owners (corporate market value). The success and failure of a company in utilizing its assets are reflected by its financial condition. The financial conditions of manufacturing companies registered in Indonesia Stock Exchange are presented in Table I.
Table I shows the development and percentage of the change in assets of manufacturing companies registered in Indonesia Stock Exchange during 2010–2015. As presented in the table, the most significant change in assets occurred in 2013 as much as 21.69 percent, while the lowest change of 5.47 percent occurred in 2015. Viewed from its growth, the total Activa tends to decrease from 2013 to 2015. The decrease in company assets happened due to the decline in the sale and company profit. This condition reflected low market demand of the products offered by manufacturing companies. There was stagnancy in the development of company assets in 2015. The development and the change in the debt ratio of manufacturing companies in Indonesia Stock Exchange from 2010 to 2015 included the highest percentage of debt ratio occurring in 2013 as much as 25.46 percent, while the lowest one as much as 2.53 percent in 2015. There were decreases in the debt ratio of manufacturing companies in Indonesia Stock Exchange during 2011–2015 for market demands on the products were low, causing a major decline in the company sales. In such conditions, companies need to decrease their debts in order to decrease the debt interest they should pay and to avoid higher expenses. The development and changes in the percentage of company assets of manufacturing companies registered in Indonesia Stock Exchange during 2010–2015 included the highest change in company equity occurring (21.13 percent) in 2011 and the lowest change (8.42 percent) in 2015. Viewed from its growth perspectives, the total equity decreased from 2011 to 2015. There was a decline in the equity of manufacturing industries during 2010–2015 due to lower sales and profits, which led to a lower rate of corporate growth. Lower sales indicated lower market demands on the products offered by the companies. The development and changes in the sales of manufacturing companies in Indonesia Stock Exchange during 2010–2015 included the highest improvement in company sale occurring in 2011 exceeding 20.54 percent and the lowest one (0.96 percent) in 2015. The development and changes in the profit obtained by manufacturing companies in Indonesia Stock Exchange during 2010–2015 included the highest change occurring in 2011 (19.21 percent) and the lowest (−10.72 percent) in 2015. In 2015, the sales and profit obtained by manufacturing companies in Indonesia Stock Exchange were in crisis.

The rate of growth refers to the ability of a company to maintain its position in the economic and industrial development where the company operates (Pakpahan, 2010). Well-developing companies tend to show positive growth. A sustainable and positive development is the main goal of companies, which has to be achieved in order to maintain competitiveness, increase company owners’ wealth and offer excellent products or service for the consumers.

Corporate growth can be achieved through gradual processes of expanding the enterprise, product development, diversification, increasing the number of workers, improving the sales, and increasing the company profit and assets (Vijayakumar and Devi, 2011). Corporate growth is indicated by increases in company sales, profit and asset development (Oppong-Boakye et al., 2013; Saeed et al., 2014). The owners of a company

<table>
<thead>
<tr>
<th>Variables</th>
<th>Year 2010</th>
<th>Year 2011</th>
<th>Year 2012</th>
<th>Year 2013</th>
<th>Year 2014</th>
<th>Year 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Activa Total</td>
<td>454,919</td>
<td>552,454</td>
<td>644,818</td>
<td>784,683</td>
<td>854,301</td>
<td>901,060</td>
</tr>
<tr>
<td>Growth (1)</td>
<td>–</td>
<td>21.41%</td>
<td>16.72%</td>
<td>21.69</td>
<td>8.87%</td>
<td>5.47%</td>
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<tr>
<td>(2) Dept Ratio Total</td>
<td>219,928</td>
<td>267,782</td>
<td>314,306</td>
<td>394,337</td>
<td>427,456</td>
<td>438,264</td>
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<tr>
<td>Growth (2)</td>
<td>–</td>
<td>21.76%</td>
<td>17.37%</td>
<td>25.46%</td>
<td>8.40%</td>
<td>2.53%</td>
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<tr>
<td>(3) Equity Total</td>
<td>235,013</td>
<td>284,671</td>
<td>330,512</td>
<td>389,499</td>
<td>426,845</td>
<td>462,796</td>
</tr>
<tr>
<td>Growth (3)</td>
<td>–</td>
<td>21.13%</td>
<td>16.10%</td>
<td>17.85%</td>
<td>9.59%</td>
<td>8.42%</td>
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<tr>
<td>(4) Income Total</td>
<td>482,428</td>
<td>581,517</td>
<td>669,452</td>
<td>758,332</td>
<td>805,786</td>
<td>798,045</td>
</tr>
<tr>
<td>Growth (4)</td>
<td>–</td>
<td>20.54%</td>
<td>15.12%</td>
<td>13.28%</td>
<td>6.26%</td>
<td>−0.96%</td>
</tr>
<tr>
<td>(5) Profit Total</td>
<td>54,697</td>
<td>65,204</td>
<td>71,831</td>
<td>72,932</td>
<td>72,932</td>
<td>64,606</td>
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<tr>
<td>Growth (5)</td>
<td>–</td>
<td>19.21%</td>
<td>10.16%</td>
<td>1.53%</td>
<td>−0.78%</td>
<td>−10.72%</td>
</tr>
</tbody>
</table>
expect the company to have a better ability to maintain sustainable development and increasing the amount of company assets in running their enterprises. The amount of company assets can only be improved when the sales and profits are improved.

The growth rate of a company determines its funding mechanism. Funding mechanism leads to the preference for using internal or external fund resources. When a company decides to use external fund, it has to choose between using corporate debt or equity. The pecking order theory proposed by Myers and Majluf (1984) explains the ideal order of using fund resources considering the costs to pay. Based on the theory, internal fund should be the first choice as it is free of cost, followed by the use of debts as it costs less, and the last choice should be the issuance of new shares as it costs higher (Prihadi, 2011, 2013).

Research carried out by Oppong-Boakye et al. (2013), Masoud (2014), Balmer (2017) found a negative and significant influence of corporate growth on the corporate capital structure. On the contrary, Sangeetha and Sivathaasan (2013) and Anake et al. (2014) found a negative but insignificant correlation between those variables. A company with an adequate amount of internal fund but lower investment may use its internal fund to decrease its debts.

In addition to the corporate capital structure, corporate growth also determines the amount of profit expected by a company. Furthermore, corporate growth increases the corporate profitability that is the indicator of the corporate financial performance (Kouser et al., 2012; Çoban, 2014). The measurements of company financial performance can be observed from the financial ratios of the company (Keown et al., 1999, pp. 77-78).

Financial performance is the result of continuous attempts made by a company in utilizing and managing its resources in the most effective and efficient way to achieve certain goals. The indicators of financial performance include return on asset (ROA), return on equity (ROE), and net profit margin (NPM). The return of asset reflects the ability of a company to manage its asset to obtain higher net profit for a better corporate financial ability to make investments in projects which are considered “present net in a positive value” (Barakat, 2014).

Chandler and Jansen (1992) and Cowling (2004) stated that corporate growth positively influences the corporate profitability. In addition, Jang and Park (2011) believed that improving corporate growth increases the corporate profitability at the same time. Kouser et al. (2012) also found out that corporate growth has a positive and significant influence on profitability. These facts give a theoretical implication that improvement in corporate growth improves the financial performance of a company.

Otherwise, Reid (1995) found that corporate growth negatively and significantly influences corporate profitability. This leads to theoretical implication in which improvement in corporate growth decreases the profit obtained by a company. Markman and Gartner (2002), Smith (2016) and Coad (2007) stated that as an indicator of profitability, productivity does not correlate with corporate growth. The higher corporate growth and higher amount of investment also take a longer time to receive the return. A company might not make sufficient amount of profit within a short-term period, yet it will make higher profit in the future.

Corporate growth determines the corporate market value as better corporate growth is expected to give a higher profit that improves the wealth of company owners in the future. The corporate market value is reflected in the stock price of a company. The total corporate market value is calculated by the number of shares times the price per share. The increase in the stock price improves the corporate market value and vice versa (Kamaludin and Indriani, 2012, p. 4).

Myers (1977) and Kester (1986) explained that corporate growth plays an important role in the improvement of the corporate market value. Both internal and external developments of a company should be seen as future investment opportunities. Companies with higher growth opportunities are able to give positive signs of their prospective future. Investors are
always interested in investing their fund in companies with higher growth opportunities than in the ones with lower growth opportunities (Al-Najjar and Peter, 2008).

The utilization of company assets influences its corporate market value. Leverage irrelevance theory (Modigliani and Miller, 1958) explains that the corporate market value is determined by the success of investment made by a company, while the success of an investment cannot be separated apart from the utilization of company assets in funding operational activities including the production of goods or services that give a company income or profit. The profit from the sale adds up to the wealth of company owners. Therefore, the main objective of company asset utilization is to obtain higher profit that improves the corporate market value. How a company utilizes a higher amount of assets shows the efficiency of its asset management (Kamaludin and Indriani, 2012, p. 44). Thus, besides decisions to make investment, the utilization of company assets also determines the success of a company in achieving the expected profit which at the same time improves the corporate market value. The theoretical implication of assets utilization toward the corporate market value is the increase in the ratio of asset utilization that improves the corporate market value.

Leverage signaling theory (Ross, 1977) mentions that debt is a credible sign reflecting the quality and the prospects of a company in the future, triggering positive reactions from the market upon the stock price of the company. A research carried out by Chowdhury and Chowdhury (2010), Bleck (2018), Oluwagbemiga (2013), Vengesai and Kwenda (2018) and Isaac (2014) confirmed that the capital structure has a positive and significant influence on the corporate market value. Trade-off theory (Modigliani and Miller, 1963), pecking order theory (Bhama et al., 2016), and leverage signaling theory (Ross, 1977) have been empirically proven. The theoretical implication from the fact is that the increase in the capital structure up to a certain level is able to improve the corporate market value of a company.

On the other hand, research carried out by Ghalandari (2013), Adi et al. (2013), Asiri and Hameed (2014) and Chen (2018) found out that the capital structure has a negative and significant influence on the corporate market value, which is contradictory to the trade-off theory (Modigliani and Miller, 1958), pecking order theory (Myers and Majluf, 1984) and leverage signaling theory (Ross, 1977).

Financial performance influences the corporate market value as explained in the signaling theory (Ross, 1977) in which it is stated that the publication of information related to companies’ financial performance is seen as a sign of trustworthiness among those who need to know the financial report of the companies. Investors also believe that companies with a better financial performance tend to have better prospects in the future, leading to a higher stock price of the companies. In addition, companies that make high profits tend to use internal fund in financing the corporate development and their dividends are expected to increase the wealth of the owners.

Many investors are interested in buying the shares of companies with high performance. In companies with high performance, a higher number of investors who are interested in buying the shares increase the stock price. However, it will happen the other way around for companies with low performance. Ghosh and Arijit (2008) stated that financial performance positively influences the corporate market value. Increase in the profit obtained by a company reflects better control and operational activities performed by a company, resulting in higher equity. Adi et al. (2013) and Asiri and Hameed (2014) found out that financial performance has a positive and significant influence on the corporate market value. The theoretical implication of this fact is that the improvement in financial performance increases the corporate market value.

Irrelevance theory (Modigliani and Miller, 1958) proposes that the decisions to make investment and the utilization of company assets determine the company performance and influence the corporate market value. High utilization of company asset reflects the efficiency of a company in managing its assets which later increases its corporate market value.
Regarding the current theories and the results of previous research, there has not yet been any agreement (gaps still exist) upon variables that determine the financial performance and corporate market value. This research was conducted upon the belief that there has been an agreement whether or not corporate decisions to make investment maintain, decrease, or improve the corporate growth, improve the asset utilization, precisely maintain the corporate liquidity, effectively manage the business risks and how it influences the capital structure with low costs and how it determines the financial performance and corporate market value of a company. It is assumed that there is a comprehensive link among corporate growth, asset utilization, financial performance, and corporate market value. Thus, this research involved those four aspects as the research variables that were investigated based on the available theories and previous research.

The weakness of previous research, where only one indicator was employed to represent other indicators in the variable measurement, was revised in the model developed in this research. This revision was made because the use of only one indicator would not be able to analyze the data related to the research variable in the most structured way for too many indicators were being measured (weakness related to the data analysis instruments). In this research, a more comprehensive concept was being developed, in which more indicators were added to represent each research variable, and a new research variable was involved. In analyzing the data, the generalized structured component analysis (GSCA) was carried out as it is regarded as an effective technique in analyzing research data of a certain research variable in the most structured way, in which a more number of indicators were included into the analysis.

The novelty of this research can be seen from the involvement of the utilization of company assets as a new variable that is assumed to have certain influences on the corporate financial performance and corporate market value, the variable of which has never been taken into consideration in previous research. As a matter of fact, the utilization of company assets determines the corporate financial performance and corporate market value as well. The utilization of company assets refers to the use of company assets to fund any operational activities of the company to obtain more income and higher profit that are expected to improve the financial performance and the corporate market value of the company. Research originality offered in this research is in the form of empirical evidence upon the influence of company asset utilization on the financial performance and corporate market value of a company. The finding of this research is expected to give a better understanding on the role of company asset utilization in determining corporate financial performance which is known to be certain.

Regarding this explanation, this research was carried out to measure the effects of corporate financial performance toward the influences of corporate growth and company asset utilization on the corporate market value. This research objective was then implemented in a model that reflects three relationships: first, the influence of corporate growth on corporate financial performance; second, the influence of company asset utilization on corporate financial performance; and third, the influence of corporate financial performance on the corporate market value.

This research involved manufacturing companies which have been registered in Indonesia Stock Exchange within the consideration that manufacturing industries play vital roles in the economic development of Indonesia. As stated by the Ministry of Industry, the government targets the growth of non-oil/gas manufacturing industries by 2016 to be around 6.9 percent. This sector is expected to contribute up to 21 percent in the GDP of Indonesia by 2016 (Strategic Plans of the Ministry of Industry Year 2016).

2. Conceptual framework and hypothesis building
This research was carried out to measure and explain the influences of corporate growth, company asset utilization toward the corporate financial performance and corporate market value (Y2), as illustrated in Figure 1. Theoretical foundation underlying the hypothesis formulation in this study is presented in this section.
The influence of financial performance on corporate market value

Financial performance has been known to have certain influences on the corporate market value as stated in the signaling theory (Ross, 1977) in which conveying company financial report to the public is seen as a positive sign that might enhance the trust of the reader upon the company. Investors also share a belief that companies with high financial performance also have a better prospect in the future, making the price of company shares higher. It is also important to note that companies with high profitability have a sufficient amount of internal funds that can be used for the growth of the companies, while the dividend improves owners’ wealth.

Many investors are interested in buying the shares of companies, the performances of which are considered excellent. The more the investors are interested in the shares, the higher the price of the shares will be. Yet, in companies with poor performances, the opposite phenomena occur. Ghosh and Arijit (2008) explained that financial performance positively affects the corporate market value. Improvement in the amount of company profit reflects that a company applies better control and operational activities that improve the equity value. Research carried out by Adi et al. (2013) and Asiri and Hameed (2014) confirmed that financial performance has a positive and significant influence on the corporate market value. This fact generates a theoretical implication that improvement in financial performance improves the corporate market value:

H1. Financial performance significantly influences corporate market value.

The effect of mediation in financial performance on the influences of corporate growth on the corporate market value

The true intention of a company making more investment is to rapidly grow the company to be able to face competitions in a broader economic scale in order to make more profit and to generate maximum wealth for the company owners. Corporate growth is able to improve the corporate financial performance (Kouser et al., 2012; Çoban, 2014). Better corporate growth reflects the ability of a company to dominate broader market, making higher sale and obtaining higher corporate profit.

The permanent income hypothesis (Friedman, 1957) explains that the expected amount of income to be obtained in the future determines the amount of the current assets to be used for funding the company. The expectation of a certain amount of profit can be achieved by making more investments which potentially give sufficient income that finally improves the
corporate market value in the future. Chandler and Jansen (1992) and Cowling (2004) used
the increase in sales to predict company growth, the result of which shows that corporate
profit and increase in sales are positively correlated. A study carried out by Konser al.
(2012) has confirmed that corporate growth has a positive and significant influence on
corporate profitability. The theoretical implication that can be inferred from the fact is that
improvement in corporate growth improves corporate profitability. Regarding the essence
of the permanent income hypothesis (Friedman, 1957) and the findings of previous research,
corporate growth has certain influence on corporate growth. In accordance with the
explanation on \( H1 \) testing, the second hypothesis of this research was formulated as follows:

\[ H2. \text{ Corporate growth has a significant influence on corporate financial performance; }
\text{ besides, it indirectly influences the corporate market value, which indicates that}
\text{ corporate financial performance mediates the influence of corporate growth on the }
\text{ corporate market value.} \]

The influence of company asset utilization on corporate financial performance
As stated by Gopal, improvement in company asset utilization improves corporate financial
performance. Company assets are used to fund sales from where a company earns its profit.
More efficient asset management improves the sales, which at the same time improves the
profit. The activity ratio is also called the turnover ratio. The activity ratio is calculated by
dividing total sales by total asset. The activity ratio is used to evaluate the efficiency of
company asset management. The capability of a company in managing its assets
determines the increase in sales (Gopal, 2009, 2012). Higher sales generate higher profit,
making corporate financial performance better.

The leverage irrelevance theory (Modigliani and Miller, 1958) states that investment
decision determines the amount of profit. Investment decision considers the type, amount,
timing and place of making investments. After an investment is made, a company should
focus on enhancing the production process using the predetermined amount of asset
allocated for production sector to produce quality goods or services for consumers in order
to make higher profits from the sales. Investment decision makes company asset
utilization more effective and efficient in obtaining higher profit, leading to a better
corporate financial performance.

DuPont analysis provides an analytical framework that relates the activity ratio and
NPM to determine the ROA. Furthermore, the ROA and debt ratio determine the ROE
(Hanafi, 2010, pp. 51-52). An intensive use of company asset reflects the effectiveness and
efficiency of a company in managing its assets and decreases its costs, leading to higher
profits and significant improvement in company owners’ wealth (Kamaludin and Indriani,
2012, p. 44).

The effectiveness of a company in managing its current assets, fixed assets and asset
structure determines the return on the investment. The activity ratio is an item that
measures the effectiveness of corporate operational activities. The activity ratio shows the
extent to which a company uses its assets to finance their sales in order to get higher profit.
More effective and efficient asset utilization leads to increases in sales which results in a
higher profit. The theoretical implication generated by this insight is that better asset
utilization improves corporate financial performance. Regarding the result of \( H1 \) testing, \( H3 \)
was formulated as follows:

\[ H3. \text{ Company asset utilization significantly influences corporate financial performance, }
\text{ and it indirectly influences the corporate market value which indicates that}
\text{ financial performance mediates the correlation between asset utilization and }
\text{ corporate market value.} \]
3. Research method

This research is an explanatory research that describes the influences of one or more variables on other variables based on secondary data. This research took place in Indonesia and was carried out from 2011 to 2016. The period of 2011–2016 was chosen to be studied because, during the years, Indonesia experienced a lot of economic turmoil. A purposive sampling was employed to select samples that matched these following criteria: samples were manufacturing companies as classified by Indonesia Stock Exchange, samples were registered as permanent manufacturing companies in Indonesia Stock Exchange in 2011–2016, samples regularly published their yearly financial reports during 2010–2016. A total of 146 companies were selected from the multi-stage sampling using the purposive sampling and saturated sampling techniques. Purposive sampling is a sampling technique that allows researchers to select their samples based on certain criteria or objectives as determined by the researchers (Indriantoro and Supomo, 1999). From the list of research population, the researcher determined the number of samples from the population. Since there were only 84 companies matching the criteria, all of them were taken as research samples (saturated sampling). The 84 companies were then observed for six years, resulting in 504 yearly financial reports to be analyzed. Codes of the 84 sample companies listed in Indonesia Stock Exchange are shown in Table II.

These reports were analyzed using a structural equation model with the GSCA approach. The advantages of GSCA are that it can be used to analyze freely distributed data that can be in the form of nominal data, categories, intervals and ratios; assess the overall model ability; analyze both large and small sample data; confirm theories with empirical data and explain whether there is a relationship between latent variables; analyze constructs formed by reflexive indicators and formative indicators all at once; estimate large and complex models with hundreds of variables and thousands of indicators; analyze mutually correlated variables (indicating a multicollinearity); and analyze variables with a recursive relationship pattern in which the causal relationship is unidirectional and maybe reciprocal (Hwang, 2009). A latent variable is a construct formed by the indicator group. A construct can be solved by variance-based structural equation modeling. The measurement criteria needed to accept or reject research hypotheses are based on the significance level of loading factors or path coefficients (standardized $\beta$) referring to $t$- and $p$-values. If the (CR*) value is equivalent to the statistical $t$-value of $\geq 1.96$ and the $p$-value of $\leq 0.05$, it can be concluded that the hypothesis is significant and accepted. If a structural model measurement is significant, it means that the effect of one latent variable on another latent variable can be generalized (Solimun, 2008, p. 8).

<table>
<thead>
<tr>
<th>Company code</th>
<th>Company code</th>
<th>Company code</th>
<th>Company code</th>
<th>Company code</th>
<th>Company code</th>
</tr>
</thead>
<tbody>
<tr>
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<td>MASA</td>
<td>VOKS</td>
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<td>LPIN</td>
<td>SCCO</td>
<td>ULTJ</td>
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</tr>
</tbody>
</table>

Table II. Codes of sample companies
This research measured four research variables: corporate growth, asset utilization, financial performance and corporate market value. The operational definition of each variable is described as follows: first, corporate growth refers to the capability of a company in creating sustainable development that increases its assets from time to time. The indicators of corporate growth include sales growth, profit growth and asset growth. Second, asset utilization refers to how a company uses its assets which have been allocated to produce quality product or services to achieve company goals. Asset utilization is measured from current asset turnover (CATO), inventory turnover (ITO), accounts receivable turnover (RTO), fixed asset turnover (FATO) and total asset turnover (TATO). Third, financial performance refers to the extent to which a company successfully manages its assets to make higher profit. Financial performance is measured from the ROA, ROE, NPM and gross profit margin. Fourth, corporate market value refers to the company’s shares price and book value of equity. The indicators upon corporate market value include closing price (CP), price to book value, and Tobin’s q. CP is the final price per share of a company in the stock market in a trading day (Yulianto et al., 2014).

4. Results of data analysis

There were four variables used in this research, namely, Corporate Growth, Asset Utilization, Corporate Financial Performance and Corporate Market Value. Each variable was measured by several indicators. The results of the descriptive statistical test are shown in Table III.

GCSA analysis measures the preciseness of an indicator (outer model) in measuring its latent variable and to find out the influence or correlation among latent variables, or to test the hypothesis (inner model). Inferential statistical analysis is used in hypothesis testing. In this research, a structural equation model through the GSCA was employed. GSCA is a variance-based or component-based approach which is a predictive analysis that is used to confirm certain theory using empirical data.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Indicator</th>
<th>Total</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>SD</th>
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<tr>
<td>Corporate growth</td>
<td>PP</td>
<td>225</td>
<td>−0.683</td>
<td>1.145</td>
<td>0.157</td>
<td>0.230</td>
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<td></td>
<td>UP</td>
<td>225</td>
<td>24.204</td>
<td>32.119</td>
<td>27.888</td>
<td>1.450</td>
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<tr>
<td></td>
<td>KM</td>
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<td>0.000</td>
<td>0.208</td>
<td>0.008</td>
<td>0.028</td>
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<td>Asset utilization</td>
<td>CATO</td>
<td>225</td>
<td>0.002</td>
<td>0.240</td>
<td>0.057</td>
<td>0.028</td>
</tr>
<tr>
<td></td>
<td>ITO</td>
<td>225</td>
<td>0.279</td>
<td>1.640</td>
<td>1.077</td>
<td>0.181</td>
</tr>
<tr>
<td></td>
<td>RTO</td>
<td>225</td>
<td>−0.066</td>
<td>0.574</td>
<td>0.056</td>
<td>0.076</td>
</tr>
<tr>
<td></td>
<td>FATO</td>
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<td>−1.254</td>
<td>3.000</td>
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<td>0.409</td>
</tr>
<tr>
<td></td>
<td>TATO</td>
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<td>0.000</td>
<td>0.314</td>
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<td>0.049</td>
</tr>
<tr>
<td>Corporate financial performance</td>
<td>AD</td>
<td>225</td>
<td>−0.296</td>
<td>0.690</td>
<td>0.030</td>
<td>0.122</td>
</tr>
<tr>
<td></td>
<td>BDA</td>
<td>225</td>
<td>−0.493</td>
<td>1.433</td>
<td>−0.009</td>
<td>0.262</td>
</tr>
<tr>
<td></td>
<td>BPA</td>
<td>225</td>
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<td>0.008</td>
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<tr>
<td></td>
<td>PA</td>
<td>225</td>
<td>−1.030</td>
<td>1.678</td>
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<td>Corporate market value</td>
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<td>1.533</td>
</tr>
<tr>
<td></td>
<td>PBV</td>
<td>225</td>
<td>3.689</td>
<td>12.408</td>
<td>7.262</td>
<td>1.704</td>
</tr>
<tr>
<td></td>
<td>TQ</td>
<td>225</td>
<td>−345.000</td>
<td>65,000.000</td>
<td>304.712</td>
<td>4,332.539</td>
</tr>
</tbody>
</table>

Table III. The result of statistics test description
The result of the goodness of fit model shows the FIT value at 0.819 which means that the latent dependent variable is explained by latent independent variable within the structural model up to 81.9 percent. In another word, the model explains the empirical phenomena as much as 81.9 percent within the variables observed in this research, while the rest 18.1 percent is explained by other variables which were not included in this research or by errors.

The result of analysis using the GSCA shows the result of hypothesis testing as presented in Table II (CR > 1.96 shows significant correlation): the influence of financial performance (Y1) on the corporate market value (Y2) is positive and significant, the influence of corporate growth (X1) on financial performance (Y1) is positive and significant, financial performance (Y1) mediates the influence of corporate growth (X1) on the corporate market value (Y2), asset utilization (X2) has a positive and significant influence on financial performance (Y1), financial performance (Y1) mediates the influence of asset utilization (X2) on the corporate market value (Y2) (Table IV).

5. Discussions

The effect of financial performance in mediating the influence of corporate growth on the corporate market value

First of all, the influence of corporate growth (X1) on financial performance (Y1) has been found to be significant with a positive coefficient. It implies that higher corporate growth improves financial performance. Second, the influence of financial performance (Y1) on the corporate market value (Y2) is significant with a positive coefficient, generating a theoretical view that better financial performance improves the corporate market value since it allows companies to have a better capability in earning higher profits that contribute to a higher equity value.

Corporate growth guarantees higher profit in the future; besides, it is one of corporate goals to be achieved through various attempts. Investment makes a company grow to a certain level where a company has better capability to compete in a broader economic market to earn higher profit. Corporate growth can be accelerated by improving the corporate financial performance (Kouser et al., 2012; Çoban, 2014) for better financial performance gives maximum contribution to the wealth of company owners. The result of this research supports the permanent income hypothesis (Friedman, 1957) which states that expectation toward future income determines the amount of assets to utilize. The target income can be achieved by making more investment that generates higher income in the future. The finding of this research also goes in line with Kouser et al. (2012) and Çoban (2014) who also found that corporate growth has a positive and significant influence on corporate profitability. Chandler and Jansen (1992) and Cowling (2004) also stated that corporate growth positively influences corporate profitability. The result of this research goes contradictory with the one found by Reid (1995) which stated that the influence of corporate growth on profitability was negative and significant, resulting in a theoretical view that improvement in corporate growth decreases the amount of profit.

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Structural path</th>
<th>Estimate</th>
<th>SE</th>
<th>CR</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1</td>
<td>Y1 → Y2</td>
<td>0.959</td>
<td>0.009</td>
<td>106.56*</td>
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</tr>
<tr>
<td>H2</td>
<td>X1 → Y1</td>
<td>0.223</td>
<td>0.023</td>
<td>9.69*</td>
<td>Significant</td>
</tr>
<tr>
<td>H2</td>
<td>X1 → Y1 → Y2</td>
<td>0.214</td>
<td>0.043</td>
<td>4.97*</td>
<td>Significant</td>
</tr>
<tr>
<td>H3</td>
<td>X2 → Y1</td>
<td>0.714</td>
<td>0.027</td>
<td>26.44*</td>
<td>Significant</td>
</tr>
<tr>
<td>H3</td>
<td>X2 → Y1 → Y2</td>
<td>0.685</td>
<td>0.039</td>
<td>17.56*</td>
<td>Significant</td>
</tr>
</tbody>
</table>

Table IV. The result of hypothesis testing

Note: CR*, significant at 0.05 level
obtained by a company. Meanwhile, Markman and Gartner (2002), Goddard et al. (2004) and Coad (2007) believed that productivity as a means to measure profitability did not positively correlate with corporate growth.

The result of this research shows that corporate growth influences the corporate market value through financial performance. The theoretical implication of this empirical fact is an insight that better corporate growth increases the corporate market value. Positive corporate growth results in a higher company asset which is the main goal of every company. The corporate growth of a company attracts investors to buy the shares of the company that leads to higher stock prices.

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The finding of this research also supports the permanent income hypothesis (Friedman, 1957) which states that a company’s expectation of its future profit determines the amount of assets to be allocated for operational activity. Future expected profit can be obtained by making a more profitable investment which increases the corporate market value later on. Corporate growth is able to determine the corporate market value for it will give higher profit that increases the wealth of company owners in the future.

Myers (1977) and Kester (1986) also added that corporate growth plays an important role in the improvement of corporate market value. Any kind of corporate development either internal or external development should be seen as investment opportunities. Companies that display a stronger sign of higher growth tend to have more prospective development in the future. Thus, more investors will be interested in investing their fund in companies where growth opportunities are higher compared to those with low growth opportunity (Al-Najjar and Peter, 2008).

This finding is in line with Ghalandari (2013) and Oluwagbemiga (2013) who investigated the influence of corporate growth on the corporate market value, results of which show that corporate growth positively and significantly influences the corporate market value. Investors perceive the corporate market value as an aspect which is closely related to the stock price. Market price refers to the price of shares offered. In the capital market, the stock price is formed by the elasticity of demand and supply.

The result of this research does not support Chowdhury and Chowdhury (2010) and (Pakpahan, 2010) who found that corporate growth negatively influences the corporate market value. In this sense, the negative correlation proposed that improvement in corporate growth decreases the corporate market value. Meanwhile, a number of theoretical and empirical explanations confirm the existences of both positive and negative influences of corporate growth on the corporate market value.

The effect of financial performance in mediating the influence of corporate growth on the corporate market value

First of all, the influence of corporate growth (X1) on the corporate market value (Y2) has been found to be significant with a positive coefficient. This implies that improvement in asset utilization triggers better financial performance as the improvement in the NPM reflects the effectiveness of a company in running its operational activities that accelerates the cash receipts. Promptly cash receipts give a higher amount of fund to be re-invested in order to make profit. Second, the influence of financial performance (Y1) on the corporate market value (Y2) has been found to be significant with a positive coefficient. Thus, the higher the number of investors who are interested in buying a company’s share within the consideration that the company has adequate financial performance, the higher the price of the shares. However, the other way around occurs to companies with poor financial performances. Ghosh and Arijit (2008) stated that financial performance positively influences the corporate market value. Improvement in the amount of profit obtained by a company makes its financial performance better and increases the equity value of company owners.
Company assets should be utilized in the most effective and efficient way because they give maximum profit for the company. A better utilization of company assets takes good planning, controlling the use of company assets including current assets and fixed assets and a proper amount of fund allocated for each of asset element. An inadequate amount of fund allocated for operational activities might obstruct the liquidity and continuity of the enterprise, whilst an excessive amount of fund would lead to a higher amount of idle fund. Companies with intensive operational activities do not have idle funds, thus requiring lower costs for management policies, which lead to higher profits.

Leverage irrelevance theory (Modigliani and Miller, 1958) states that investment decisions determine corporate profit. After an investment is made, a company should focus on enhancing production process using the predetermined amount of asset allocated for the production sector to produce quality goods or services for consumers in order to make higher profits from the sales. Investment decision makes company asset utilization more effective and efficient in obtaining higher profit, leading to better corporate financial performance.

Investment decisions also result in a better use of company assets in terms of effectiveness and efficiency in giving a company higher profit and enhanced financial performance. DuPont analysis proposes an analytical framework which connects the activity ratio and NPM in determining ROA. Furthermore, the ROA and debt ratio determine the ROE (Hanafi, 2010, pp. 51-52).

Intensive utilization of company assets reflects the effectiveness and efficiency of a company in managing its assets, decreasing the amount of costs which result in higher profit and stronger contribution to the wealth of company owners (Kamaludin and Indriani, 2012, p. 44). The effectiveness of a company in managing its current assets, fixed assets and asset structure enhances the return on investment. The activity ratio is used to measure the effectiveness of operational activities performed by a company. The activity ratio reflects the extent to which a company utilizes its asset to improve its sales in order to obtain higher profit. A more effective and efficient use of company assets improve the sales, leading to higher profit.

Asset utilization influences the corporate market value through financial performance. It implies that improvement in asset utilization increases the corporate market value. This phenomenon occurs since higher sales accelerate cash receipts. Promptly cash receipts deposit a higher amount of fund available to be re-invested in order to make more profit and improve the corporate market value. The corporate market value is determined by the ability of a company in utilizing its available assets to make higher sales and obtain higher profit.

6. Research findings and contributions

Research findings
This research is expected to give practical contribution to companies and investors in making business decisions. The findings of this research also give beneficial recommendations for companies in making proper decisions, effective financial policies, and efficient asset utilization. This research has resulted in these following findings: first, corporate growth has a significant influence on the corporate market value, implying that companies should consider the short-term and long-term profitabilities before making any investment decision. The growth of current investment will result in company profit in the future. Corporate growth and corporate profitability can be used as indicators to predict corporate prospects in the future. Second, asset utilization has been confirmed to have a positive and a significant influence on financial performance. Insights into asset utilization effectiveness and efficiency are important for company managers to consider in making strategic decisions upon operational activities of the company. Companies with effectively and efficiently managed operational activities are able to reduce costs and improve the profit. The utilization of company asset and financial performance is crucial in determining the corporate market value. Thus, financial performance is a valid sign that reflects companies’ future market prospects. Financial performance
described in companies’ yearly financial reports also reflects the attitude of company managers in managing company assets. Third, financial performance has a positive and significant influence on the corporate market value. This information is beneficial for company managers in making strategic decisions for the best financial performance considering the fact that those aspects determine the stock price in the market. Decisions made for better operational activities will be able to improve corporate profitability and enhance the financial performance which shows better credibility of the company in the market. Companies are also able to use financial information as a mechanism to create a financial report in such a way to meet the needs of certain subjects and the needs of capital market.

**Implications**

Practically, this research has positive implications. For future researchers, this research can be as a reference in adding other variables that were not included in this research model. For manufacturing companies listed in Indonesia Stock Exchange, this research can provide inputs in making financing decisions or policies and asset utilization activities. Theoretically, this research can contribute to the development of financial management science, especially about the decision-making process of capital structure, especially theories about the capital structure decision-making process after going through the process of understanding the variables influencing capital structure decisions that can improve financial performance and corporate values optimally or increase the welfare of corporate owners and stakeholders.

**Research contribution**

This research is expected to give a significant contribution to companies in making certain business decisions or policies related to corporate finance. The board of managers should take corporate growth, liquidity, business risks and asset utilization into account before making any relevant decisions. The results of this research suggest that first, corporate growth opportunity can be used as an indicator to determine corporate funding mechanism, either a company should use internal funds or external funds. It is suggested that companies use internal fund as the most-preferred choice before using external fund considering the fact that the use internal fund does not add the cost of debt interest. Second, companies should also put business risk into consideration for business risk is a gamble that might give negative influences on corporate financial performance and corporate market value. Third, companies are also able to enhance their asset utilization by improving their sales and making their operational activities more effective and efficient in order to decrease the amount of debt interest. Within this ideal condition, companies will be able to enhance their financial performances that lead to a higher corporate market value. Fourth, companies are recommended to use debt at the lowest amount possible in order to avoid generating higher expense for the company to pay and to prevent the risk of failure from occurring. Fifth, it is suggested that companies maintain and enhance their financial performance as financial performance is a strong variable that determines the corporate market value. Investors also tend to value the shares of companies with adequate financial performance at significantly higher rates.

**References**


A two-way causal chain between lean management practices and lean values

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Abstract

Purpose – Organizations have varied levels of success with Lean implementation and many did not see tangible results. Some scholars believe the reason has to do with weak Lean culture or Lean values (LVs). The purpose of this paper is to study the relationship between Lean implementation practices and LVs. The research goes further to study the nature of this relationship; does LVs affect Lean practices only or do they affect each other in a reciprocal manner?

Design/methodology/approach – Literature regarding Lean implementation in various sectors was reviewed. Representatives from several organizations were surveyed. Results from both approaches are compared and presented to highlight the key challenges and drivers facing Lean implementation.

Findings – Lean works well on enhancing organization performance (OP) but the implementation has to be preceded by careful nourishment of the proper Lean culture and LVs. The relationship between Lean implementation and LVs is of a complex nature and driven by OP.

Practical implications – The study has important managerial implications that is if Lean is going to be sustained, continuous efforts has to be exerted by Lean professionals to engage leaders and decision makers in the organization and ensure proper values are nurtured.

Originality/value – This is the first study to examine the reciprocal relationship between Lean implementation practices and LVs while focusing on OP by employing a structural statistical model.

Keywords Organizational performance, Lean, Lean management, Lean values, Quality improvements

Paper type Research paper

1. Introduction

Lean manufacturing as learned from Toyota motor company has a philosophy that focuses on doing more with fewer resources, fighting operational waste and improving efficiencies. Based on literature review of Lean definitions (Womack et al., 1990; NIST, 2000; Cooney, 2002; George, 2003; Hopp and Spearman, 2004; Liker, 2004; Shah and Ward, 2007; Hallgren and Olhager, 2009; Radnor, 2010), one can restate Gupta et al. (2016) definition as “an integrated multi-dimensional approach encompassing bundles of management practices based on values or principles.” Furthermore, Bhasin and Burcher (2006) asserted that the values or principles are needed in the organization for the successful application of Lean. Therefore, Lean becomes a way of thinking, which adopts the values, whereas practices are the tools to action these values (Gupta et al., 2016).

Organizations have varied levels of success with Lean and many failures are recorded (Tiwari et al., 2007) when implementing Lean. Firms use Lean tools or Lean management practices (LMP) such as 5S and visual management when adopting Lean. These tools however, cannot be used in absence of proper nurturing culture (Pedro and Gerolamo, 2017) or Lean values (LVs) such as customer focus and supportive leadership. Finally, the whole point of using Lean practices is to enhance organizational performance (OP) (Panwar et al., 2017) and make the results of Lean measurable. Literature defined OP as a multidimensional set of metrics used to quantify both the efficiency and effectiveness of organizations’ actions (Neely et al., 2005; Shepherd and Gunter, 2006) to achieve its set of goals, and consequently plays a mediating role. In addition, in managing the Leanness journey of a firm, OP plays an important role as it delivers the information necessary for decision-making actions through
a feedback mechanism for realizing the benefits of the Lean adoption concept (Marvel and Standridge, 2009; Kuhlang et al., 2011).

Lean literature has a tendency to assume the adoption and presence of LVs or principles as the eventual outcomes of the Lean concept journey (Radnor and Walley, 2008; Shook, 2010; Emiliani, 2010; Karim and Arif-Uz-Zaman, 2013). However, this study argues that LVs could have a proactive role in determining OP, and have a bearing on the maturity of LMP. This has implications for our understanding of the Lean concept journey. Consequently, adoption and presence of LVs is no longer strictly an end toward Lean journey, but could become a means to influence other forms and results of Lean, such as OP and LMP. The literature is rich with examples of Lean implementation in various fields (Guilherme et al., 2017). Some focused on the impact of LMPs on OP (Panwar et al., 2017). Others focused on how LVs affect LMPs (Van Dun et al., 2017; Håkansson et al., 2017) and others focused on the effect of LMPs on LVs (Zhu, 2016), but to the authors’ knowledge the literature did not explore the two way reciprocal relationship between all three constructs.

The available literature indicates a very low rate of successful lean implementation (Yadav et al., 2010; Bhasin, 2012; Kumar and Kumar, 2014; Jadhav et al., 2014), due to improper understanding of barriers (Sharma et al., 2014; Nordin et al., 2010; Kumar, 2014; Bhamu and Sangwan, 2014). Toward this end, this study adds an understanding of the type of interactions and relationships among investigated three constructs (LMP, LVs and OP) is of paramount importance to increase the probability of Lean implementation success. Consequently, the aim of this study is to present an examination of the reciprocal relationship between LMP and LVs in Saudis manufacturing sector, with the OP as a mediating variable. Based on the results of this examination, the current study objective is to make four important contributions toward the LMP-LVs literature. First, it contributes toward redefining the Leanness goal beyond that of adoption and presence of LVs. Second, the study sheds more light on the how LVs affects LMPs through a multidimensional analysis of the constructs involved in this study. This stretched further by integrating the mediating role of OP, which contributes toward the relationships between LMP and LVs. Third, the study contributes to the literature by providing a methodological framework for determining the bilateral relationship between LMP and LVs. Although the applied multivariate techniques well known in literature, the use of structural equation modeling (SEM) in a two-way environment is quite original. Fourth, the study contributes toward advancing the theoretical base of the field by exposing the linkages within the LMP-LVs connection and transforming them into managerial decisions.

The rest of the paper is organized as follows; the second section is devoted to the study model and hypotheses. The research methodology discussed in Section 3. The results and discussions are presented in Sections 4 and 5, respectively. Finally, conclusions presented in Section 6.

2. Research model and hypotheses
The idea of Lean has protracted to all systems in the organization, and not only the manufacturing floor, as the philosophy thrives on creating value in an efficient manner (Womack and Jones, 2005). This gave rise to the Lean enterprise, which is a group of individuals and functions legally separated, but operationally synchronized (Murman et al., 2002). The aim of Lean concept is to achieve the optimal desired performance at the enterprise level via deploying human-related values or principles and process-related practices or tools. These values and practices deployed across different subsystems such as individuals, activity, processes or organizations. The impact of each subsystem on the other subsystems and the impact of values and practices on the enterprise level
performance may not follow common sense always. Moreover, a Lean system should consist of simple and clearly defined interdependencies between system components (Spear and Bowen, 1999).

Literature on Lean implementation and different success factors have been addressed to study the benefits of Lean on the organizational level (Wan and Chen, 2009; Fullerton and Wempe, 2009; Kuhlmann et al., 2011; Rocío et al., 2018). Most of previous research on understanding Lean interrelationships was one-way analysis (Lewis, 2000; Shah and Ward, 2003; Fullerton and Wempe, 2009; Shahram and Cristian, 2011; Pernilla and Mårtensson, 2014; Sharma and Gandhi, 2017). To the authors’ knowledge, the literature did not investigate a two-way reciprocal relationship between all three constructs; LMP, LVs and OP. Furthermore, the authors believe a high percentage of lean implementation failure cases are due to a lack of a holistic reciprocal view of the relationships and interdependencies as there could be a two-way relationship between the three constructs (LMP, LV and OP).

Based on the above discussion, this study adopted and modified a conceptual integrated framework developed by Ridderstaat et al. (2014) to investigate causal relationships as shown in Figure 1. In particular, this study adopts Ridderstaat et al. (2016) approach of examining and investigating such two-way causal relationships. Figure 1 specifies a series of possible direct and indirect associations between LMP and LVs, with OP as a mediating variable. The figure shows nine hypotheses, where the first six (H1–H6) describe direct bilateral connections between LMP-LVs, LMP-OP and LVs-OP, respectively. Hypotheses (H7 and H8) address the indirect relationships between LMP and LVs, through OP. However, hypothesis (H9) is a control variable. We used such variable to insure validity of analysis and results (Boselie et al., 2005). The proposed nine hypotheses are as follow.

2.1 Direct bilateral relation

H1. LMP has an impact on the LVs.
H2. LVs has an impact on LMP.
H3. LMP has an impact on OP.
H4. OP has an impact on LMP.
H5. OP has an impact on LVs.
H6. LVs has an impact on the OP.

2.2 Indirect bilateral relation

H7. LMPs indirectly influence LVs through the mediating role of OP.
H8. LVs indirectly influence LMPs, through the mediating role of OP.
H9. Controls (type of manufacturing) influence the LMP-LVs relationship.

3. Methodology

3.1 Sample

The study is based on selected manufacturing companies in Saudi Arabia, which represents one of the vast markets in Asia and Africa. Many researchers considered the Saudi market to be great place for research in the area of quality practices, continuous improvement, Lean, Six Sigma, etc. Several Saudi private and public organizations have been adopting such practices broadly (Alsaleh, 2007; Alsmadi et al., 2012; Ateekh-ur-Rehman, 2012; Al-Darrab et al., 2013; Noorwali, 2013; Abdelhadi, 2014; Mariotti et al., 2014). Accordingly, a systematic random sampling used to target Saudi manufacturing firms that have been implementing Lean for at least three years. In order to determine the selected sample for this study, a set of criteria were determined (Chakrabarty and Chuan Tan, 2007; Antony and Desai, 2009; Alsmadi et al., 2012) such as years of deploying Lean; Lean training conducted; and the existence of quality department. A final selection of 430 organizations was determined as the proper sample for this study as they meet the set criteria. Then, data for this research collected from targeted sample in May and June of 2017. The sample of respondents to the survey included employees from different areas and hierarchies within the organization: customer service, engineering, production, senior managers and mid-level managers.

This study is exploratory in nature since it investigates the nature of the different relationships in the proposed adapted conceptual model. Appendix section reveals the questionnaire filled by the targeted companies. We used closed questions, with a fixed range of possible answers, which relied on the use of a five-point Likert scale where 1 = totally disagree, and 5 = totally agree. The questionnaire consists of three parts: LVs, LMP and OP as discussed in the following paragraphs.

Lean values. Lean founded on a number of principles and values (Liker, 2004; Emiliani, 2010), and Womack and Jones (2003) have specified five values or principles, while Liker (2004) described Lean through 14 principles divided into four parts of a pyramid. In addition, several studies (Henderson and Larco, 1999; Bhasin and Burcher, 2006) have ascertained the need for the presence of these values or principles for the successful application of Lean in any firm. Therefore, this study will adopt a model developed by Ingelsson and Martensson (2014) to assess the presence of these values in an organization. They developed a questionnaire to measure the presence of the LVs such as “long-term thinking,” “system thinking,” “elimination of waste,” “customer focus” and “lean leadership” and the TQM values such as “leadership commitment” and participation of everybody in an organization (Ingelsson et al., 2010). The full survey is shown in the Appendix section.

Lean management practices. Many claim that Lean is still lacking a focused implementation (Shah and Ward, 2007). This study adopts Nawanir et al. (2013) tool to measure the extent of Lean Management implementation in an organization. They compiled the most commonly used practices proposed by several past studies into nine practices as shown in Appendix.
Organizational performance. Any organizational initiative, including Lean, should ultimately lead to enhanced OP on the long term (James et al., 2018). A number of prior studies have measured OP using both financial and market criteria, including return on investment (ROI), market share, profit margin on sales, the growth of ROI, the growth of sales, the growth of market share and overall competitive position (Vickery et al., 1999; Zhang, 2001). In line with the mentioned literature, this study adopted a measure used by Nawanir et al. (2013) to measure OP over the last three years as shown in the Appendix. This section of the questionnaire only distributed to top management since they have the necessary knowledge to answer such questions.

3.2 Method of analysis

This study followed a three-step analysis consistent with Ridderstaat et al. (2016) methodology of investigating such relationships in order to assess the relationship between LVs and LMP. The first step used exploratory factor analysis (EFA) in order to derive a latent variable (unobserved) factor that could account for the covariance relationship of an observed large set of variables (Loehlin, 2004; Mulaik, 2009). Furthermore, Fabrigar et al. (1999) asserted that EFA must be conducted as a basis for confirmatory factor analysis (CFA).

In the second step, CFA is used to determine the underlying dimensions of the constructs included in the study. CFA examines the relationships between latent constructs by testing the hypothesis that the items are associated with specific factors (Jackson et al., 2009). Furthermore, CFA requires the researcher to determine all aspects of the factor model based upon a strong empirical or conceptual foundation (Brown, 2006).

In the third step of the analysis, SEM is used in order to produce estimates of all the hypothesized relationships among the selected variables in the theoretical model (Maruyama, 1998). The SEM is a confirmatory approach and, thus, gives an accurate estimate of the structural relationships between latent variables. The specification of a SEM antecedently requires applying a CFA (Brown, 2006).

4. Empirical results

The authors applied Stata version 12.1 to perform the necessary calculations and present the results.

4.1 Respondent profile

A questionnaire sent to 430 organizations to be filled by the manager, the head of department, the director and other middle and top management positions who are familiar with Lean activities and performance. A minimum of three responses (one per construct) from each organization considered valid and included in the sample. In total, 201 questionnaires were completed and returned with a response rate of 47 percent. This number, however, went down to 149 after filtering out few missing values and outliers. The companies represent a wide variety of industries; paper products (13.51 percent); chemical (12.07 percent); rubber and plastic products (17.11 percent); non-metallic mineral products (8.47 percent); metal products (13.51 percent); industrial machinery (7.76 percent); electronic, electrical equipment and components (18.55 percent); and instrumentation (9.02 percent).

4.2 Exploratory factor analysis (EFA)

Researchers have to ensure validity and reliability of the data for further analysis (Cooper and Schindler, 2003). Accordingly, EFA was carried out on each construct separately (Hair et al., 2010; Ridderstaat et al., 2016), and items with a factor loading of at
least 0.45 were retained. Factor analysis conducted using 21 items that represent the six
dimensions of LVs, 40 items that represent the nine dimensions of LMP and 11 items that
represent the three dimensions of OP. The loadings for each of the elements shown in
parentheses in the Appendix. All items loaded on their respective factors with most
loadings above 0.70, while the cumulative variance explained by the dimensions are 51.77,
65.73 and 41.32 percent for LV, LMP and OP, respectively. The Bartlett’s test and the
Kaiser-Meyer-Olkin (KMO) were used to test whether the data were adequate for the EFA
to proceed. All the KMO values for the investigated constructs are greater than 0.50
(Kaiser, 1974) indicating a stronger correlation between items, and thus, the EFA would be
appropriate. In addition, The Bartlett’s test is significant at \( \alpha = 0.05 \) for all the constructs,
implying the variables are highly correlated to provide a reasonable basis for the EFA
(Coakes and Steed, 2007). Therefore, the constructs used are valid and eligible. In addition,
multiple-question loadings for each factor in excess of 0.50 demonstrate convergent
validity (Bagozzi et al., 1991), and discriminant validity supported, since none of the
questions in the factor analyses has loadings in excess of 0.40 on more than one factor.
Moreover, the reliabilities of LVs, LMP and OP assessed with Cronbach’s \( \alpha \) (Cronbach,
1951) for testing the internal consistency of the constructs. The reliability values for all
constructs ranged from 0.73 to 0.93, which are adequate internal consistency and
reliability (George and Mallery, 2003), whereas the communalities were also high, varying
between 0.749 and 0.856. Table I presents the testing results of the three constructs
stemming from the EFA analysis.

4.3 Confirmatory factor analysis (CFA)
In order to have an acceptable measurement model to apply CFA, a strong base stemming out
of the results of the EFA must be acceptable. According Hair et al. (2010) and Ridderstaat et al.
(2016) both point out that the “EFA findings provide a strong base for applying a CFA, which
allows for testing how well the measured variables represent the constructs.”
The results of EFA as presented in Table I shows all standardized factor loadings were
significant at the 1 percent level, and were larger than the 0.7 benchmark as suggested by Hair
et al. (2010), and Ridderstaat et al. (2016). Accordingly, this study consistent with Ridderstaat
et al. (2016) will use the scales resultant from EFA and evaluated per a CFA for their
appropriateness to represent the three constructs under investigation (Gerbing and Anderson,
1988). In order to evaluate the measurement model, Hair et al. (2010), and Ridderstaat et al.
(2016) points out that “the \( \chi^2 \) value and degree of freedom, together with the Comparative Fit
Index (CFI) or Tucker-Lewis Index (TLI), and the Root Mean Squared Error of Approximation
(RMSEA) will generally provide adequately unique information to evaluate a measurement
model.” Accordingly, the calculated ratio between the \( \chi^2 \) and its degrees of freedom was
1.683, which is accepted according to Schreiber et al. (2006) “(\( \chi^2 < 3.0 \))” and Hair et al. (2010)
“(\( \chi^2 < 2.0 \) → very good; 2.0 < (\( \chi^2 \)/degrees of freedom) < 5.0 → adequate).” Moreover, the TLI of
0.972 was higher than the 0.95, is indicating a good fit according to both Schreiber et al. (2006)
and Hair et al. (2010). The CFI of 0.961 was also higher than the 0.95 acceptance benchmark
suggested by Schreiber et al. (2006) and Hair et al. (2010), whereas the RMSEA of 0.049 was
smaller than the “0.06 rule” of acceptance of Schreiber et al. (2006). These findings indicate that
the CFA has adequate goodness of fit (Ridderstaat et al., 2016), and as a result the
measurement model is, therefore, acceptable as shown in Table I.

4.4 Descriptive statistics and linear correlation between variables
In Table II, the descriptive statistics showed the means of LV, LMP and OP
ranging from 3.18 (OP) to 4.38 (LMP), with the standard deviation ranging between 0.33
and 0.87. This indicates that at a certain level, Saudi manufacturers have been
implementing or adopting LMP, and have moderate presence of LVs. In addition, all the
<table>
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<th>Lean values (LV)</th>
<th>Standardized loading</th>
<th>t-values (all significant to ( p &lt; 0.000 ))</th>
<th>Construct reliability</th>
<th>Average variance extracted</th>
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Table I. Confirmatory factor analysis of underlying dimensions (continued)
### Table I.

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**Notes:** Goodness of fit indicators: \( \chi^2 (52) = 87.541 \ (p = 0.000) \rightarrow \) ratio \( \chi^2 \) to df = 1.683 (criterion: < 5); Tucker–Lewis index = 0.972 (criterion: ≥ 0.950); Comparative fit index = 0.961 (criterion: ≥ 0.950); Root mean squared error of approximation = 0.049 (criterion: < 0.06)

### Table II.

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<th></th>
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<th>(OP)</th>
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<td>(OP)</td>
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constructs are positively associated with one another and are significant at $\alpha = 0.01$, with the correlation coefficient ($r$) values ranging from 0.46 to 0.56. These positive relationships assert the previous consensus that LVs need to be present in the organization if Lean is going to be sustained (Radnor et al., 2006). In addition, this result strongly agrees with previous studies that the better the implementation of LMP, the better the OP (Fullerton and Wempe, 2009).

4.5 Structural equation modeling (SEM)

The third step in the analysis encompassed applying SEM analysis to test the structural model, and to explain the relationships between the constructs LMP, LV and OP. The analysis integrated those factors identified from the EFA and CFA procedures, and was applied to the sample. One challenge is to find a way of examining possible two-way relationships between the constructs potentially containing both cause and effect elements. Accordingly, the study estimated two SEMs simultaneously instead of one. The first structural model estimated the direct and indirect effects of LMP on LV (LMP $\rightarrow$ LV, and LMP $\rightarrow$ OP $\rightarrow$ LV). The second structural model aimed to estimate the direct and indirect effects of LV on LMP (LV $\rightarrow$ LMP, and LV $\rightarrow$ OP $\rightarrow$ LMP). Figures 2 and 3 show the results of both models. Both figures excluded the items' factor loadings with a view to improve the visibility and understanding of results. All item loadings were statistically significant at 1 percent. Before proceeding with the analysis, there are no significant correlations between the control variable (type of manufacturing) and the rest of the variables used in the study, giving thus no support for $H9$ (omitted from the diagrams). The results from Figure 2 reveals that LMP has a positive significant direct influence on LVCF, LVCI, LVEW and LVLT, but not on LVSL, and LVSV (omitted from the diagram). Furthermore, LMP has a positive significant direct impact on OPP, and OPC, but not on OPS. Moreover, OPP, and OPC has a negative significant impact on LVSV, and LVSL, but not on LVCF, LVCI, LVEW and LVLT. OPS has a positive significant impact on LVCF, LVCI, LVEW and LVLT, but not on LMP. The indirect effect analysis shows that LMP a significant negative impact on LVSL, and LVSV, but not on

![Figure 2](image-url)

**Notes:** ***,**** Significant at 10, 5 and 1 percent levels, respectively
LVCF, LVCI, LVEW and LVLT. The indirect relationship found with LVSL, and LVSV validate the role of OP as a mediating variable. The findings from Figure 3 suggest that LVCF, LVCI, LVEW, LVLT, LVSL and LVSV (omitted from the diagram) has no significant direct impact on LMP. However, LVCF, LVCI, LVEW, LVLT has a significant positive effect on OPP, OPC, OPS. Alternatively, LVSL, and LVSV has a significant negative impact on OPP, and OPC. The latter factors, in turn, has a significant positive impact on LMP, but OPS has no significant effect on the LMP. Analysis of the indirect effects reveals that LVCF, LVCI, LVEW, LVLT, have a significant positive impact on LMP, and the indirect effect of LVSL, and LVSV on LMP is negatively significant. Again, the indirect relationships confirm the position of OP as a mediating variable.

The model’s diagnostics of both estimations in Figures 2 and 3 suggest proper structural model fit. The ratio between the $\chi^2$ and the degrees of freedom are in both instances below 5, whereas both TLIs and CFIs are larger than the minimum criterion of 0.95. The RMSEA in both instances are smaller than the benchmark of 0.06. The SEM outcomes suggest acceptance of all hypotheses, except for $H2$ (Table III). The latter means that LVs does not directly affect OP. Validation of $H1$ and $H3$–$H8$ implies that:

- LMP has both a direct impact ($H1$) on LVCF, LVCI, LVEW, LVLT, and indirect impact ($H7$) on LVSL, and LVSV;
- LMP has a direct impact on OP ($H3$);
- OP has a direct impact on both LMP and LVs ($H4$ and $H5$, respectively);
- LVs has a direct impact on OP ($H6$); and
- LVs has an indirect effect on LMP ($H8$).

The rejection of $H2$ can be explained through Selznick’s (1992) conception of values, which states, “The first principle of a naturalist ethic is that genuine values emerge from experience. They are discovered and not imposed.” It is inferred that practices influence the presence of values and not vice versa, but values could influence practices through a mediating variable ($H8$).
5. Discussion and findings
The results reveal that LMP affect LVs under investigation, both through the direct (LMP → LVs), and indirect connection (LMP → OP → LVs). However, the direct influence is only related to the LVs dimensions of (LVCF, LVCI, LVEW, and LVLT). With respect to the indirect influence of LMP on LVs, the study found an imprint in the LVs dimensions of (LVSL, LVSV) and the mediating negative sign suggest that LMP seems to cause some measure of impairment to these values indirectly. This suggests that Lean practices directly affect operational and customer-related aspects in a positive way and indirectly affects the operational system through the eyes of leadership negatively. In other words, if leaders or upper management personnel not trained well, their actions could hurt successful Lean implementation. These results are consistent to the findings of previous studies (Lawrence and Hottenstein, 1995; Cua et al., 2001; Shah and Ward, 2003; Jayaram et al., 2008; Robb et al., 2008; Rosemary et al., 2014; Anvari et al., 2010).

Alternatively, LVs does not influence LMP in a direct way, but rather in an indirect manner. The indirect effects of LVs spread to all dimensions of LMP, whereas the negative
outcome of LVSL and LVSV on OPP, and OPC has a negative effect on LMP if this effect outweighs other LVs dimensions. The mediating role of the OP construct occurs through LMP → OP (OPP, OPC) → (LVSL, LVSV) or LMP → OP (OPS) → (LVCF, LVCI, LVEW, LVLT). This suggests that the mediating role of OP is selective when impacting LVs: the dimensions of OP (Profitability of the organization (OPP), and Customer satisfaction (OPC)) negatively impact the supportive leadership (LVSL) and the system view (LVSV), while the OP dimension of Sales (OPS) positively impact the rest of LVs dimensions. This is quite important. It literally emphasize the following fact: Leaders of the organization care much about financial return and level of customer satisfaction, yet this matter is taken for granted after a while and become expected. It becomes a negative force especially if it does not provide positive results consistently and in turn, it can hurt efforts to apply more LMP and get better OP results. These results are consistent with previous research (Shah and Ward, 2007; Desiree and Celeste, 2016; Zhang et al., 2017).

6. Conclusion
The aim of the study was to investigate and explore the direct and indirect two-way relationship between LMPs and LVs with OP as a mediating variable by adopting Ridderstaat et al. (2016) methodology of investigating such relationships. To our knowledge, this is the first study to examine the reciprocal connections between these three constructs in the field of lean philosophy by employing a structural model. The findings are important for many reasons. First, the findings show a multifaceted link between LMP, LVs (LVs) and OP. Furthermore, the findings points out those LVs do effect LMP, and OP. Second, the findings confirm that not all sub-dimensions of the three investigated constructs were of statistical significance in determining the outcome of the relationships among the three constructs. This means that each construct (LMP, OP and LVs) contain a heterogeneous of multiple dimensions that could affect or be affected by this multi-dimensionality of the three constructs. Third, this type of findings according to Ridderstaat et al. (2016) offer new insights for theory development in a holistic feedback relationship between LMP, LVs and OP. Specifically, the theoretical propositions stemming from this study are:

- LMP and LVs have a natural two-way relationship in which the strength and the consequences of such two-way connection depend on their sub-dimensional representation of the constructs.

- OP has a mediating role between LMP and LVs, depending on its sub-dimensional representation of the constructs.

In summary, Lean works well on improving OP (Fullerton and Wempe, 2009) but the implementation has to be preceded by careful nourishment of the proper Lean culture and LVs (Radnor et al., 2006). This by itself is not enough; the study has important managerial implications that is if Lean is going to be sustained, continuous efforts has to be exerted by Lean professionals to engage leaders and decision makers in the organization. Otherwise, negative notions could spoil all efforts. Leaders care about performance results, and so a concrete system of measuring performance has to be implemented and updated.

This study, as other previous studies, produces logical results, yet has limitations. It was constrained to Saudi Arabian Manufacturing companies; therefore, validation of the conclusions presented in relation to other countries and other sectors. Future research should consider expanding this line of investigation. First, toward other organizations implementing Lean with a view to obtain a broader perspective of the nature of the bilateral relationship between LMP, LVs and OP. Second, future investigation should consider the effect of other variables affecting LMP and LVs such as organizational culture and other philosophies or techniques implemented in an organization.
References


NIST (2000), Principles of Lean Manufacturing with Live Simulation, Manufacturing Extension and Partnership, National Institute of Standards and Technology, Gaithersburg, MD.


Further reading


Appendix

Measurement items of Lean values (LV)

System view (LVSV)

- I know what over-all goals the organization has (LVSV1) (0.816).
- I know how the work I do is connected to other parts of the organization (LVSV2) (0.764).
- I know how my work contributes to the over-all goals of the organization (LVSV3) (0.841).

Long-term thinking (LVLT)

- We have a common vision for the company (LVLT1) (0.709).
- Management decisions are based on long-term thinking, even at the expense of short-term financial goals (LVLT2) (0.692).
- We have other purposes with our business than purely financial profit (LVT3) (0.809).

Eliminate waste (LVEW)

- To eliminate waste is something we work with continuously (LVEW1) (0.718).
- I know how to identify waste in my work (LVEW2) (0.731).
- We solve problems when and where they arise (LVEW3) (0.816).

Continuous improvement (LVCI)

- We are constantly working on getting better in everything we do (LVCI1) (0.871).
- We have time to work with improvements in everyday work (LVCI2) (0.608).
- There is a standardized way of working with improvement in everyday work (LVCI3) (0.759).
- We focus on how we can improve things not on who made a mistake (LVCI4) (0.867).

**Customer focus (LVCF)**

- I know who our customers are (LVCF1) (0.622).
- I know what creates value for our customers (LVCF2) (0.821).
- I know what our customers’ needs are (LVCF3) (0.783).

**Supportive leadership (LVSL)**

- Our managers take responsibility for their actions (LVSL1) (0.739).
- Our managers are constantly working to improve their own ways of working (LVSL2) (0.653).
- Our managers are present in everyday work (LVSL3) (0.756).
- There is a clear demand from our management that we should work with continuous improvements (LVSL4) (0.648).
- Our managers are supporting us in our work with continuous improvements (LVSL5) (0.612).

**Measurement items of lean management practices (LMP)**

**Flexible resources (LMPFR)**

- Many problems have been solved through small-group sessions (LMPFR1) (0.790).
- One operator handles several different tasks in a workstation (LMPFR2) (0.850).
- Our plant operates the machines that can perform a number of operations (LMPFR3) (0.925).
- When a machine is stopped, our workers are not idle (LMPFR4) (0.829).
- When one machine is stopped, we can use a different type of machine to perform the same tasks (LMPFR5) (0.863).

**Cellular layouts (LMPCL)**

- Our processes are located close together, so that material handling and part storage are minimized (LMPCL1) (0.885).
- We have laid out the shop-floor so that processes and machines are in close proximity to each other (LMPCL2) (0.847).
- The cells/work centers/machines are arranged in relation to each other so that material movement, material handling, and transit times are minimized (LMPCL3) (0.817).
- Our processes physically move closer together and transportation between stations runs simply (LMPCL4) (0.890).

**Pull system (LMPPS)**

- We use a production system in which items are produced only when called for by the users of those items (LMPPS1) (0.790).
- We use a production system in which items are produced only in necessary quantities, no more and no less (LMPPS2) (0.843).
- We use kanban to authorize the production or withdrawal the goods (LMPPS3) (0.765).
To authorize the order, we use a supplier kanban that rotates between factory and suppliers (LMPPS4) (0.883).

Production at a workstation is performed based on the current demand of the subsequent workstation (LMPPSS) (0.680).

**Small lot production (LMPSP)**
- We emphasize producing small quantity of items together (LMPSP1) (0.843).
- We are aggressively working to lower lot sizes in our plant (LMPSP2) (0.850).
- We emphasize small lot sizes to increase manufacturing flexibility (LMPSP3) (0.842).
- We reduce the average level of inventory by producing in more frequent but smaller lot size (LMPSP4) (0.778).
- We tend to have small lot-sizes in our master schedule (LMPSP5) (0.645).

**Quick setups (LMPQS)**
- Our shop-floor employees perform their own setups to reduce the time required (LMPQS1) (0.761).
- We have converted most of our machine setups to external setups that can be performed while the machine is running (LMPQS2) (0.773).
- We have low machine setup times in our plant (LMPQS3) (0.741).

**Uniform production level (LMPUL)**
- We make every model of product every day to anticipate customer demand variability (LMPUL1) (0.837).
- We usually meet the production schedule each day (LMPUL2) (0.719).
- In our master schedule, we produce more than one product model from the hour-to-the hour and day-to-day basis (LMPUL3) (0.725).
- Our company always maintains some quantity of a product to respond to the variation in customer demand (LMPUL4) (0.739).

**Quality at the source (LMPQ)**
- Statistical process control is used to identify and prevent quality problems by correcting the process before it starts producing defects (LMPQ1) (0.743).
- We implement the visual control system as a procedure or mechanism that makes the problems visible (LMPQ2) (0.687).
- Statistical techniques are used to identify and reduce process variances (LMPQ3) (0.659).
- Charts showing quality problems are used on the shop-floor (LMPQ4) (0.665).
- When quality problems are detected, they can be traced to their source and remedied without reworking too many units (LMPQ5) (0.645).

**Total productive maintenance (LMPTM)**
- Our equipment is in a high state of readiness for production at all times (LMPTM1) (0.629).
- We scrupulously clean equipment, tools, workspaces, and machines to make unusual occurrences more noticeable (LMPTM2) (0.590).
We dedicate a periodic inspection and maintenance system to keep machines in operation (LMPTM3) (0.838).

We dedicate a system of daily maintenance, periodic inspection, and preventive repairs designed to reduce the probability of machine breakdown (LMPTM4) (0.837).

**Supplier networks (LMPSN)**

- We regularly solve problems jointly with our suppliers (LMPSN1) (0.836).
- We emphasize to work together with suppliers in a close relationship for mutual benefits (LMPSN2) (0.807).
- We can depend upon on-time delivery from our suppliers (LMPSN3) (0.797).
- We have long-term agreements with our suppliers (LMPSN4) (0.783).
- We strive to establish long-term relationships with suppliers (LMPSN5) (0.738).

**Measurement items of organizational performance (OP) (during the past three years)**

**Profitability (OPP)**

- Profit margin has increased (OPP1) (0.765).
- Our return on investment reflects sound investments (OPP2) (0.753).
- Our profitability has exceeded our competitors (OPP3) (0.629).
- Our revenue growth rate has exceeded our competitors (OPP4) (0.827).

**Sales (OPS)**

- Market share has increased (OPS1) (0.670).
- Our revenue growth has been outstanding (OPS2) (0.636).
- Our market share growth has exceeded our competitors (OPS3) (0.773).

**Customer satisfaction (OPC)**

- Customers are satisfied with the overall quality of our products (OPC1) (0.715).
- Customers are satisfied with our company’s delivery lead time (OPC2) (0.752).
- Customers are satisfied with our company’s response to sales enquiries (OPC3) (0.652).
- Customers are satisfied with our products’ competitive prices (OPC4) (0.722).

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