

# **Coalescing the Lean and Circular Economy**

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## **Abstract**

Growing population along with technological advancement to pace the production speed like never before has raised alarming concerns and attracted attention globally. Circular Economy, a fairly new concept has emerged to address such issues by proposing a closed loop system in contrast to a linear system. While the concept of Circular Economy presents a great potential, there yet remain a challenge for its adaptation in the existing manufacturing sector, especially at SMEs level. Many new techniques, methods and models are being developed, many of which require a complete change in the existing system, which not only have capital requirements but also upskilling labour. For SMEs, it is challenging to have such transition due to higher capital and skills requirements. This research explores the possibility to combine the existing concept of Lean with Circular Economy for speedy and easy adaptation of Circular Economy principles within the manufacturing sector, especially at SMEs level. A novel conceptually developed framework is proposed to merge the vitality of Lean and Circular Economy.

## **Keywords**

Circular Economy, Lean, Operations Management, Framework.

## **1. Introduction**

The distance between academia and industry is often lengthened due to the lack of comprehensive methodologies (e.g. frameworks) to implement the theory/concept (Chay et al., 2015). At the same time, the existing potential of earlier developed models is often ignored, and efforts/resources are wasted in re-inventing the wheel. Scholars do acknowledge that generally, the concepts do have massive potential to benefit its users, as in the case of Circular Economy (CE); but a major factor contributing to failure or ineffectiveness of a concept is the ill-defined implementation stage (Chay et al., 2015), despite investment of resources (Garza-Reyes et al., 2015). Thus, there is a strong need to have a systematically developed framework for the implementation of holistic sustainability principles proposed under the concept of CE, while benefiting from the strengths of the other models/concepts such as Lean.

The two concepts of Lean and CE, have a greater synergy to benefit the manufacturing sector. Moreover, with their common elements to eliminate waste and create value, although with a different focus, complement each other in producing effective outcomes, therefore, their combination seems natural. The CE model presents an ideal solution to the current global problems of resource scarcity (Nadeem et al., 2017), environmental damages (van Loon et al., 2017) and to establish a closed-loop economic system (Webster, 2015). Lean on the other hand has been a proven success to eliminate waste and to create value (Mostafa et al., 2013) by achieving efficiency and the economic benefit.

Yusof and Aspinwall (2000) describe that a model defines '*what is*' and a framework defines '*how to*'. On a similar note, Anand and Kodali (2010) define a framework as the '*guiding torch*' to manage the implementation of any change. Therefore, the aim of this research is to develop and present a comprehensive framework by integrating the best practices of the two concepts of *Circular Economy (CE)* and *Lean*, to allow the adoption of CE's principles within the operations management of manufacturing sector, especially at SMEs level.

With the above aim, the objective of this study is to integrate the best practices of both CE and Lean to develop a novel conceptual framework, providing a systematic approach with step-by-step guidance to manage and maintain CE's adoption in the manufacturing sector especially at SMEs level; by utilising CE and Lean, tools and methods.

With this scope, the remaining paper is structured in five sections of framework development methodology (2); principles of the framework (3); conceptual framework (4); conclusions, limitations and future research directions (5).

## 2. Framework Development Methodology

Conceptual development of the framework was done in two major stages of comprehension and conception (see figure 1), also known as intelligence and conception (Moreira et al., 2015). At comprehension stage an exhaustive literature review was conducted, ensuring that the most current and relevant theoretical knowledge is explored and embedded (Chen and Lyu, 2009), to map out the spectrum of CE and its implications. This stage explored the characteristics of both the concepts of CE and Lean; their interrelated nature and synergetic properties to complement each other for effective adaptation in manufacturing operations. This stage defined the need for an integrated comprehensive framework by identifying the gap in the academic literature for a systematic approach.



Figure 1 Stages of developing a conceptual framework

Literature review mingled with author's experience (i.e. hospital/business management) and knowledge honed the conception of the proposed conceptual framework. The need for CE's implementation is evident in the face of present-day challenges of resource scarcity (Nadeem et al., 2017), fast production and consumption pattern (Ghisellini et al., 2016), with minimal to no responsibility and procedures for resource management (Geng and Doberstein, 2010), especially at the end of life cycle of products (Ghisellini et al., 2016).

This conceptual framework was developed using a systematic phase by phase approaches learned from the scholars' published articles (Cherrafi et al., 2017; Garza-Reyes et al., 2015, 2016; Mostafa et al., 2013). This phase by phase (also called stages) approach is often utilised by scholars (Cherrafi et al., 2017; Mostafa et al., 2013) to explicitly identify/segment key activities necessary to reach the aim/objectives. Completion and output of one phase become an input for the next. The phases in their macro level are adapted/inspired from the DMAIC approach of Lean Six Sigma (George et al., 2005), as well as the frameworks proposed by Cherrafi et al., (2017) and Mostafa et al., (2013). However, there are differences at Macro and Meso levels within each phase. Moreover DMAIC's and the proposed framework's purposes are different, as the former focuses on problem-solving (Garza-Reyes et al., 2014; George et al., 2005; Hammer and Goding, 2001) and the latter focuses on CE's adaptation in the existing manufacturing operations, for which the system does not necessarily have a problem, although that could be one source of motivation. Manufacturing companies might want to adopt CE inspired by the growing awareness, demand and regulations.

## 3. Principles of the Framework

The framework hinges on the principles of CE and Lean, to propose a holistic approach to deal with the present-day challenges of resource scarcity and environmental damages. These principles are briefly discussed below.

### 3.1.1 Circular Economy Principles

CE requires and proposes a contrasting proactive approach of 'roundput' instead of 'throughput' (Webster, 2015) to replace the traditional linear system of Take – Make – Dispose (Ellen MacArthur Foundation, 2015a). Natural resources are preserved by re-utilising an earlier extracted resource to ensure that the resources are used but not used up (Webster, 2015). This closed-loop system ensures resource recovery (Gregson et al., 2015; Li et al., 2013; Singh and Ordoñez, 2016), resource efficiency and effectiveness (Hu et al., 2011; Schulte, 2013), sustainable consumption and production, industrial symbiosis, urban metabolism, zero waste, eco-design, design for recycling, up/down-cycling and cascade models, remanufacturing, waste prevention and minimisation (Velis, 2015); are the key highlights to incorporate at the very design stage and throughout the life cycle of the product. The distinctive feature of CE is that it gets to the root cause of the problem instead of managing it at surface level (Webster, 2015). At the very core of CE are optimisation of resource utility (Geng and Doberstein, 2008), resource conservation by minimising virgin material usage and maximise re-utilisation of previously extracted resources (Singh and Ordoñez, 2016) by optimising their lifespan (Pialot et al., 2017) and/or virtualise the use of resources (Jabbour et al., 2017).

Another of the key principles to embrace is systems thinking and foster systems effectiveness. It requires the participants of any economy to understand how different elements influence one another within a whole system (Romero and Noran, 2015) and not just focus on the company itself individually. Systems thinking is not an option but a requirement for sustainability (Murray et al., 2015). It requires businesses to regard themselves in the setting of overall supply chain and its impact while thinking in cascades (Elia et al., 2017; Kobza and Schuster, 2016; Murray et al., 2015). The natural environmental system around (biomimicry) (Romero and Noran, 2015) has a lot to offer and

to learn from, where the focus is on optimising the overall system and not the individual components alone (Webster, 2013). It is vital for the companies to engage in systems thinking where no functional division works in isolation or in subgroups but have common strategic goals to achieve in a responsible manner. The framework ensures the Systems thinking to be an important element to incorporate at every stage of its implementation.

### 3.1.2 Lean Principles

Taiichi Ohno (Ohno, 1988) developed the concept of Lean while Toyota faced fierce competition by its US rivals, after world war II (Garza-Reyes, 2015). The concept has five major principles of identifying value, mapping the value stream, creating flow, establishing pull, and seeking perfection (Mourtzis et al., 2016; Womack and Jones, 2003). These principles focus on two elements of waste elimination and value creation (Womack et al., 2007). These principles flow in a sequential order and are briefly described below:

- i. Value is identified from the customer's perspective (Omogbai and Saloniitis, 2016; Pampanelli et al., 2014).
- ii. Identification/ mapping of value stream (Pampanelli et al., 2014) as per earlier defined value (Mostafa et al., 2013).
- iii. Create a smooth flow of both the information and materials/goods while creating value (Seth et al., 2017).
- iv. Establishing pull is another way to eliminate the overproduction and minimise inventory, where the production is not dependent upon scheduled but on customers' demand (Sundar et al., 2014).
- v. And finally seeking perfection through the implementation of continuous improvement culture (Vlachos, 2015) while seeking to eliminate any successive layers of waste (Pampanelli et al., 2014).

Lean principles have been widely adopted in various industries with positive results. There are two mutual interests between CE and Lean, Waste elimination and Value creation. Thus, they have a lot in common to benefit each other.

### 3.1.3 Interrelatedness of the Circular Economy and Lean Principles

Lean and CE have different approaches to their two major common elements of 'waste elimination' and 'value creation'. Lean approach is not as holistic as CE and lacks the closed-loop system, a distinguishing characteristic of CE. Table 1 provides an overview of approaches of both concepts to their common elements of value and waste.

Table 1. Waste and Value as per Lean and CE

	Lean approach	CE approach
Waste	<ul style="list-style-type: none"> <li>Is an activity that does not add value to the customers (Campos and Vazquez-Brust, 2016)</li> <li>"anything other than the minimum amount of equipment, materials, parts, space and time which are absolutely essential to add value to the product" (Russell and Taylor III, 2011)</li> <li>Is inefficiency and is measured by KPI's (Sternberg et al., 2013)</li> </ul>	<ul style="list-style-type: none"> <li>Waste = food (raw material) (Ellen MacArthur Foundation, 2015b; Webster, 2015)</li> <li>Is seen in 4 dimensions: Wasted resources, wasted lifecycles, wasted capability, wasted embedded values (Lacy and Rutqvist, 2015).</li> </ul>
Value	<ul style="list-style-type: none"> <li>Value is perceived from customer's perspective (Martínez León and Calvo-Amodio, 2017)</li> <li>Customer's requirement (Hines et al., 2004)</li> </ul>	<ul style="list-style-type: none"> <li>Reduce waste by recycling and source from waste (van Buren et al., 2016)</li> <li>Prevent resources from exiting the economy (van Buren et al., 2016)</li> <li>Has 4 dimensions: Cost reduction, revenue generation, resiliency, legitimacy and image (Park et al., 2010).</li> </ul>

Given the common goals of the two concepts, their combination seems natural to complement each other and greatly benefit CE's application to be realistic, smooth and easy. Therefore, the proposed framework combines the best of Lean and CE principles, characteristics and tools to develop a comprehensive framework for operations management in a systematic manner. Figure 2 portrays the interrelated nature of these principles.

Lean's focus on process optimisation limits itself to within a specific supply chain. However, under CE's perspective of systems effectiveness and thinking, the supply chain is expanded to a much bigger perspective, where value identification and the stream is not limited to one life cycle of the product or supply chain but continues to evolve.

CE's focus on preserving and enhancing natural capital can be achieved by Lean's principle of mapping value stream in the resource and creating flow within the closed loop system as well as to seek perfection through continuous improvement. In a similar manner, the resource yield optimisation can be achieved by establishing pull by producing only what is demanded, and creating closed-loop flow while seeking perfection through continuous improvement.

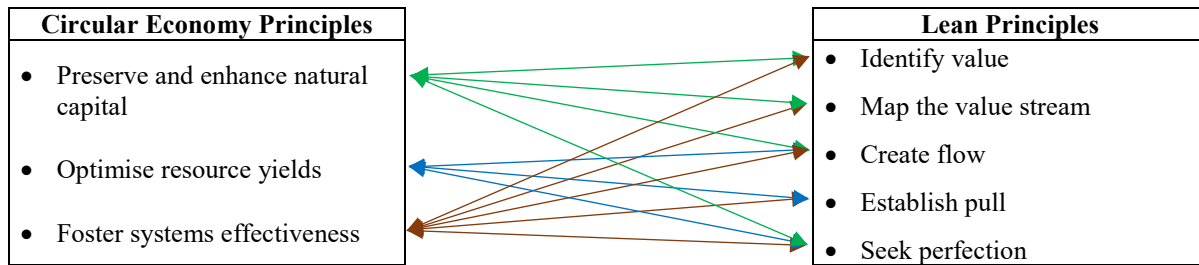


Figure 2 Interrelatedness of the Circular Economy and Lean Principles

The proposed framework is developed to strongly promote/ encourages continuous improvement culture with flexibility for adaptability as needed. Therefore, the processes, design and strategies are to evolve throughout the organisation and can be developed by inter-organisation learning and cooperation. The focus is to utilise the knowledge from any and all sources that are available (e.g. nature, man-made developments, etc.) and build on them.

#### 4. Conceptual Framework

The proposed framework consists of six phases that include: phase 0 Delineate, phase 1 Analyse/ identify, phase 2 Plot, phase 3 Execute, phase 4 Evaluate, and phase 5 Control. Subsequently, these phases are broken down into 14 steps (activities) for a systematic implementation of all phases (see figure 3).

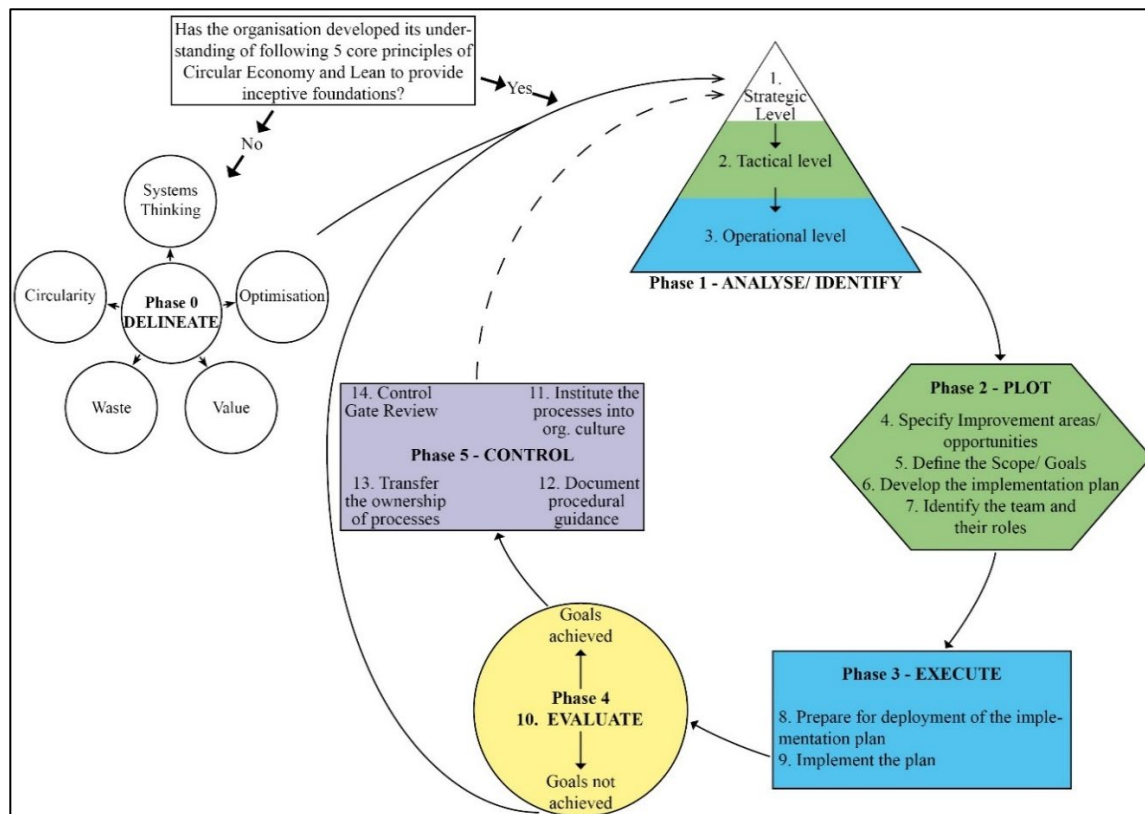


Figure 3 Conceptually developed framework

It is vital to emphasise the need for a person specifically assigned to lead the process as a coordinator or manager and serve as a point of reference and decision maker. The following sections further provide guidance into the 6 phases.

##### 4.1.1 Phase 0 – Delineate

For any framework, it is best to delineate the core principles of the concepts that it is moving towards/adopting. This enables an effective understanding of an efficient and well-grounded approach while implementing the framework. With this scope, this phase is called phase 0, as it will only be necessary if the adopting organisation has not previously developed its foundational understanding of these 5 core and key principles (Systems Thinking, Optimisation,

Circularity, Waste, Value) of CE and Lean. If the organisation has already developed the understanding of these 5 principles, then it can skip this phase, however, it is highly recommended to skim through the phase 0.

In order to complement the two concepts of Lean and CE, their core features might need updating to a hybrid version of definitions to elaborate on the developed ideas. In this scope, researchers consider the five overarching principles (Systems Thinking, Optimisation, Value, Waste, and Circularity) of CE and Lean (see figure 3 [Phase 0]) in need of re-definition. These elements bear equal importance; thus no sequential order is identified in this phase.

#### **4.1.1.1 Systems Thinking**

Most business activities would make a direct or indirect impact on their customers, suppliers and the community/environment they operate in; which creates the whole system. CE stresses the need for businesses to regard themselves in the setting of overall supply chain and its impact, while thinking in cascades (Elia et al., 2017; Kobza and Schuster, 2016; Murray et al., 2015). Businesses have a lot to learn from natural environmental system around (biomimicry) (Romero and Noran, 2015), where the focus is on optimising the overall system and not the individual components alone (Webster, 2013). It is vital for companies to engage in systems thinking where no functional division works in isolation or in sub-groups but have common goals to achieve in a responsible manner.

In the purview of systems thinking, the identification of stakeholders for a business is a necessary element (Billgren and Holmén, 2008; Soma and Vatn, 2014). Stakeholders' participation, influence and input is vital (Colvin et al., 2015; Soma and Vatn, 2014) to develop and maintain circularity in business operations, as it helps to explore multiple dimensions/challenges (Billgren and Holmén, 2008) and enhances the acceptability of decisions/strategies of the business (Fischer et al., 2014; Hall et al., 2013). In the broad spectrum of this framework stakeholders selection criteria is suggested to be in the bounds of who is and/or can be affected and impacted by the business (Billgren and Holmén, 2008; Fischer et al., 2014; Reed et al., 2009) and who might be interested in the activities of the business (Colvin et al., 2016; Soma and Vatn, 2014). In this context following stakeholders are identified in their broader spectrum:

- **People** – In the general understanding of the stakeholder, people are those who are either directly (e.g. customers, supplier, etc.) or indirectly (e.g. community around etc.) impacted by the business and/or have interest in the business and its activities. This framework further expands these boundaries to include the people who are not born yet, meaning future generations; as the businesses, today dealing with resources are impacting them by either adding value and/or by increasing depletion/scarcity of resources.
- **Planet** – Identifying planet Earth and its environment as a stakeholder is necessary as all resources are extracted from it, so Earth is the supplier and any business activity/outputs have a direct impact on it in the long/short run.

#### **4.1.1.2 Optimisation**

CE and Lean both focus on optimisation. CE aims to optimise the lifecycle and end of the lifecycle of the resources at the very design stage as well as throughout the product life cycle by enhanced and preventive maintenance (Ellen MacArthur Foundation, 2015c; Jabbour et al., 2017) while maintaining the maximum utility of resources. The goal is to reduce the waste (Geng and Doberstein, 2008) through strategies such as reuse, disassembly and refurbishment (Singh and Ordoñez, 2016). On the other hand, Lean's approach to optimisation is related to process (Hu et al., 2015) by minimising variations in process (Tokola et al., 2017) and creating flow (Mehrsai et al., 2014), through value stream mapping and its optimisation (Seth et al., 2017). The contrasting difference between Lean and CE is that Lean focus is in terms of the immediate usage of the resource within a specific process, however, CE takes a more holistic approach from a systems perspective, as to optimise the utility of the resource even after one life cycle of the product. Therefore, for the convenience of the adopters of this framework, a redefinition of optimisation is provided as follows:

*“Making every effort to maximise the output/ utility of a given resource (material, time, energy, and creativity) at all different stages of the lifecycle in a closed loop system, while eliminating/ minimising any non-value adding impacts, throughout the lifecycle of any resource.”*

#### **4.1.1.3 Value**

For any given material or product, Lean's definition of value is very subjective, as it highly denotes to owners'/ customers' need and willingness/desire to acquire a product or material (Lucato et al., 2014; Neap and Celik, 1999). Its defining scope is further extended within the context of supply network management, from external (customers) to internal and is linked to product and service characteristics (Adamides et al., 2008). On the other hand, CE defines value as utilising highest utility of the resource at all times (Ellen MacArthur Foundation, 2015a), by caring for, contributing to, and expanding the natural system (Greyson, 2015). Mostly, the value of a product is only assumed from the perspective of one lifecycle that it is being utilised for; however there remain utilisable residual value.

This limited view of the value is the core contributor to the speedy depletion and scarcity of resources. Therefore, it would be best to re-define value while focusing on the lifecycle of a resource and not just the product alone:

*“Any activity/output that utilises its required resources in a manner that maximises its utility at all stages of its lifecycle including the afterlife, as well as to ensure the longevity of its lifecycle while satisfying the needs/demands of the stakeholders (People [present and future] and Planet) and making impact for them.”*

#### 4.1.1.4 Waste

Waste as per Lean is anything that does not add value (Banawi and Bilec, 2014), also defined as any non-value adding activity that the customer is not willing to pay for. On the contrary, CE defines waste as food where waste from one product becomes food (raw material) for the other (Webster, 2015). Within this scope, waste can be re-defined as:

*“Any activity that leads to the harmful outputs for the stakeholders (People [present and future] and Planet) and does not incorporate the sustainability of the two in long-term, is a wasteful activity.”*

#### 4.1.1.5 Circularity

CE endeavours to develop the closed-loop system, where resources are used but not used up (Webster, 2015). Therefore, businesses need to understand and revisit the concept of the product life cycle (PLC). Traditionally the PLC has begun with the introduction of a product, led by growth and maturity and eventually ending with decline. At the end of life cycle mostly the products are doomed to be scrapped and dumped, leading to both the environmental damage as well as loss of residual value of resources used in that product. In the scope of CE and Lean, this framework proposes a new approach (see figure 4) with following additions to the two stages of existing PLC model:

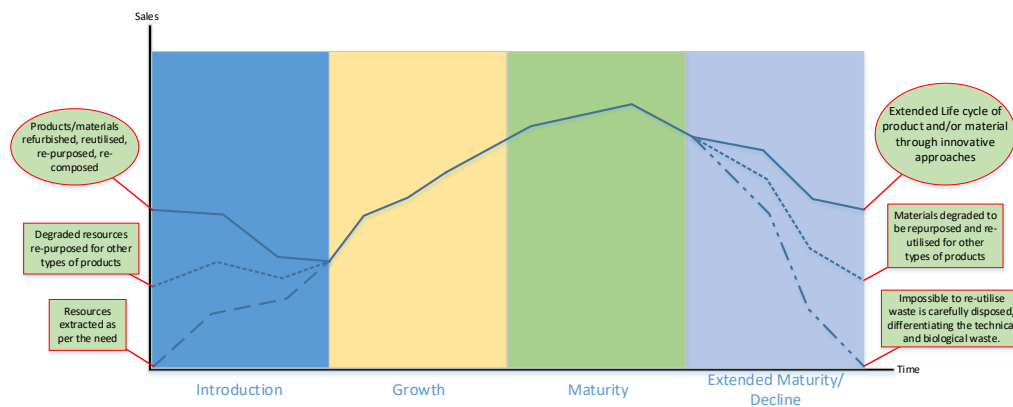


Figure 4 Re-defined Product Life Cycle according to the Framework

- At the ‘introduction’ stage of the product, sourcing is redefined and extended from three sources:
  - Material for production is sourced from re-utilisation of recovered products/ materials
  - Degraded material from another industry which still meets or exceeds the quality standards required for the product under consideration is re-purposed/re-utilised to ensure the utility of their residual value
  - When and only if needed, the virgin raw material to be extracted to produce new components
- The ‘Decline’ stage is renamed to ‘Extended Maturity/Decline’ stage with three possibilities for products:
  - The extended life cycle of the product/material through the adaption of innovative approaches
  - Degradation of resources/materials used in a product to be re-utilised as raw material for other production.
  - The materials/products not good for further use and re-utilisation must be disposed responsibly while differentiating the technical and biological waste, and that also to be specified at the design stage.

With a sound understanding of the earlier discussed 5 principles of CE and Lean, the users can then move to the next phase. In all of the upcoming phases different Lean and other tools/methods are recommended for guidance purpose only and must not be considered bounding/ restricting to those tools only. It is important to avoid “paralysis by analysis”, utilising a lot of effort/ resources to collect irrelevant data; thus, the tools/ methods must be carefully chosen.

#### 4.1.2 Phase 1 – Analyse/ Identify

For any given organisation, three interlinked levels: Strategic, Tactical and Operational (see figure 3 [Phase 1]) are fundamental to its existence. Strategic level deals with the overall directions of the company. Tactical level ensures that strategic goals/directions set by the top-level management become realistic through proper planning and management of resources. Operational level carries out the plans/goals established by the Tactical level.



**Team Action:** At this stage, an overarching analysis approach of VMOST (Vision, Mission, Objectives, Strategy, and Tactical) can be adopted while utilising other tools/ methodologies to explore as much detail as possible. The goal is to analyse the organisation as a whole and to identify gaps/shortcomings at any one or all levels that are contrary to CE principles and can be changed/ modified to improve/ optimise the output for all stakeholders.

#### **4.1.2.1 Step 1 – Analysis/ Identification at Strategic Level**

The organisation needs to be analysed in light of predefined and/or re-defined understandings as per the framework phase 0. Any inconsistencies must be documented for further examination/ action. For this purpose, the company's vision and mission statement, as well as the strategic plan, can be included in the analysis. Besides the interviews with CEO/ other top-level management, can be conducted. For this step, the user(s) can deploy any of the following tools in any combination or stand alone but are not limited to *Balance Scorecard, Strategy Map, PEST Analysis*.

The results of analysis from this level will provide an understanding of where the company stands and where it aspires to be in terms of its strategic direction. This will assist to define the scope of analysis at the tactical level.

#### **4.1.2.2 Step 2 – Analysis/ Identification at Tactical Level**

Tactical level serves as a bridge between the strategic and operational level and ensures the realisation of the organisation's mission and vision. Any major or minor gaps are to be identified and documented. For this step, the user(s) can also deploy any of the following tools in any combination or stand alone but are not limited to *Force Field Analysis, Strategic Planning Gap, SWOT Analysis*. For the purpose of analysis following steps are to be followed:

1. Obtain the company's goals and strategies to achieve those goals
  - a. If the documentary evidence does not exist, then the manager(s) at the tactical level to be interviewed.
2. Identify and document any discrepancies that negatively impact the environment and/or do not keep the resources at their highest utility, and/or have a different understanding of value, waste, cost/profit and product lifecycle.

Analysis from this level will provide an ample understanding of the company's way of realising the strategic directions and aspirations. Based upon the results from this analysis, the scope for analysis at the operational level can be defined.

#### **4.1.2.3 Step 3 – Analysis/ Identification at Operational Level**

Operational levels are the hands and feet of the organisation, bringing the vision/ mission into physical existence. Any major or minor gaps are to be identified and documented to be considered for future improvement and change. For this, the user(s) can deploy any of the following tools in any combination or stand-alone but are not limited to *Value Stream Mapping (VSM), Causes and effect relationship, Strategic Planning Gap, Root Cause Analysis*. VSM is highly recommended, however, any other tool can be utilised along with following procedure accompanied by Gemba walk:

1. Obtain the company's product development process guidelines
2. Obtain the company's recorded data on generated waste (waste handling procedure/ records)
3. Obtain the company's understanding of their responsibility for the product life cycle and end of life cycle.
4. Identify and document any discrepancies that negatively impact the environment and/or do not keep the resources at their highest utility, and/or have the different understandings of value, waste, cost/profit and product lifecycle.

The output of the analysis at these three levels will help to identify the areas requiring improvements/ modification/ change. The user then can move into the next phase to prioritise, plan and develop the roadmap for improvements.

### **4.1.3 Phase 2 – Plot**

At this phase, four steps need to be followed (see figure 3 [Phase 2]).

#### **4.1.3.1 Step 4 – Specify Improvement Areas/ Opportunities**

The coordinator/ manager and the person/ team alongside him/her need to prioritise the identified areas/ aspects requiring change/ modification/ improvements. For this purpose, the user(s) can deploy any of the following tools in any combination or stand alone but are not limited to *Pareto Analysis, Action Priority Matrix, Project Selection Matrix, Decision Matrix Analysis, Eisenhower's Urgent/ Important Principle, The Modified Borda Count*.

Once the areas for interventions are prioritised and chosen, it is crucial to involve top management to obtain their consent as they might not agree for the proposed directions and it would result in the wasted effort if the team continues without management's support. If the top management disagrees with the proposed areas for interventions, the review is to be done again along with top management's personnel and consensus to be reached. Once the top management has consented, the team then can move to the next step to define the scope of the change/ modification/ improvement.

#### **4.1.3.2 Step 5 – Define the Scope/ Goals**

Having a clear idea of which areas to improve and which opportunities to exploit on, the team then needs to define the scope of improvement by defining what changes, modifications and intervention to work on and specifying goals/task for their achievement. For this purpose, the team can also look for best practices case studies available already to avoid re-inventing the wheel and/or to benefit in developing more robust goals. The goals must be SMART (Specific, Measurable, Achievable, Realistic, Time-bound). Besides having SMART goals, it is best to conduct Failure Modes and Effect Analysis (FMEA) to identify potential risks and formulate mitigations strategy at this stage. Once the goals are developed and risk analysis is conducted; then implementation strategy can be developed.

#### **4.1.3.3 Step 6 – Develop the Implementation Plan**

This step aims to develop the implementation plan. Different planning tools can be utilised, among which project management tools such as *Gantt chart*, *resource planning* etc. are highly recommended. Different Lean and its extensions' tools can be deployed dependent upon need, strategy, skills/capabilities, and availability of resources. The implementation plan would provide a clear picture of what type of personnel are needed to execute the planned intervention. The team can then move to the next step to identify the team and define their roles.

#### **4.1.3.4 Step 7 – Identify the Team and their Roles**

At this step when the process map has been developed; another important bit is to identify the right person who will take the lead on the implementation. Some important features to consider while choosing the team are:

- Skills of the personnel and their ability to take responsibilities and be team player
- Knowledge of their functions and the organisation
- Willingness/ motivation for CE
- Ideally, the experience of participation in improvement/ change management projects

The number of personnel for the team to implement the intervention can vary, as it completely depends on the type of activities, level of implementation, required skills and other factors related to the plotted intervention. There might be a need to recruit new staff and/or consultant if the required skills are not available in-house. Once the coordinating team has identified/ recruited the implementation team members, they can then move on to the next phase, Execute.

#### **4.1.4 Phase 3 – Execute**

At this phase (see figure 3 [Phase 3]) the following steps are to be followed.

##### **4.1.4.1 Step 8 – Prepare for Deployment of the Implementation Plan**

At this step, the team members must prepare for deployment of the implementation plan with a clear understanding of the tasks. Preparation can include but is not limited to:

- All the team to have orientation, guidance and training (if necessary)
- Ensuring all resources are available
- Ensuring that any disruption in the regular operations are planned in line with expected outputs
- The contingency plan must be in place to avoid any problems and interruptions.

Once the team is prepared and ready, they then can move to the next step of implementing the plan.

##### **4.1.4.2 Step 9 – Implement the Plan**

With all the resources in place and preparation, the implementation step must begin. The coordinator/ manager must oversee all the process and provide full support and guidance to the implementation team. A progress record must be kept on a regular basis to later analyse any trends, deviation, build upon best practice or avoid any mistakes happened. The ground rule of continuous improvement must be kept in mind and any of the following Lean tools can be deployed to ensure the effective execution of planned interventions: *5S* (*Sort, Set in Order, Shine, Standardise, Sustain*), *Kaizen*, *KPIs to monitor*, *PDCA* (*Plan, Do, Check, Act*), *Poka Yoke*. After implementation, the team needs to evaluate.

#### **4.1.5 Phase 4 – Step 10 – Evaluate**

At this phase, only one step is involved to evaluate the impact against the defined goals (see figure 3 [Phase 4]). If the goals are achieved, then the team move to phase 5 Control. The coordinator/ manager along with top management needs to define the criteria for goals achieved. For instance, if the goals were achieved by 90% or 80%, then move onto control and if not then move on to re-analyse. In case of goals not being achieved, the mistakes and shortcomings are to be documented and the team should move to Phase 1 to re-analyse/ re-identify, or phase 2 to Plot again, or phase 3 to execute the same plot again. The decision would solely depend on the circumstances and need. Upon achieving success the team can then move to the final phase to sustain the implemented intervention.



#### **4.1.6 Phase 5 – Control**

At this phase, the coordinator/manager needs to ensure that the completion/success of the framework's implementation is made sustainable through systematic adherence to following steps (see figure 3 [Phase 5]).

##### **4.1.6.1 Step 11 – Institute the Processes into Organisational Culture**

Since the CE's actual potential cannot be fully realised without systems thinking, therefore it is important to begin within the company first by embedding and replicating the CE's adaptation throughout the organisation. For this step to take an effect and produce results would not happen overnight but would require similar efforts as done in the first intervention. Thus, it is important to document the procedural guidance, the next step.

##### **4.1.6.2 Step 12 – Document Procedural Guidance**

Documenting the procedural guidance in contextualised form would benefit for the future adaptation within the organisation. It will also serve as evidence of success achieved; lessons learned and would be a point of reference to build on for future improvements and adaptation. The team can start to prepare to transfer the ownership of the process.

##### **4.1.6.3 Step 13 – Transfer the Ownership of Processes**

All the documented details and procedural guidance are to be handed over to right personnel for the continuity of its implementation at the organisational level. All three levels (Strategic, Tactical and Operational) of the organisation are to be involved on as needed basis and the process of transferring the ownership is to be documented for future reference. Once the transfer of ownership is done, the team can then do one last final checklist of control gate review.

##### **4.1.6.4 Step 14 – Control Gate Review**

The DMAIC process of control gate review will highly benefit to ensure the sustainability of the framework and its outputs. For this purpose, the coordinator/ manager needs to ensure that:

- Reports of before and after scenario are documented and made available to the right personnel
- Process maps, control plans and procedural guidance are documented and in place
- Process owners as well as the management has taken over the process and are committed to its implementation
- Summary of lessons learned and any issues/opportunities for future implementation are documented

Successful completion of this framework's phases and productive output would confirm and encourage further adaptation. Moreover, there must be periodical reviews for the purpose of continuous improvement.

## **5. Conclusions, Limitations and Future Research Directions**

The concept of CE has great potential and its widespread adaptation is the only way to see its promising outputs, as all different components in a system needs to function together to make the system completely operational. Although the concept of CE is relatively new and provides a completely contrasting approach to existing linear economic model, it does not necessarily disqualify existing concepts and their possible combination with CE. Thus, this study develops a conceptual framework by integrating the best of both the concepts of CE and Lean, to provides a mechanism for systematic adaption of CE in manufacturing operations management. The goals and benefits are summarised below:

- The developed framework and its criteria are non-prescriptive. The intent is not to dictate the process but to focus on the end result achieved through a systematic approach utilising different tools as per the need and context.
- The criteria heavily focus on continuous development, which gives the place for learning from the past, focusing on the present with innovation, and heading towards future in a pro-active manner rather than reactive.
- The goal is for the organisation(s) to embrace/adapt circularity by:
  - Making the move form Linear economic model to the CE model
  - Maximise resources utility and conservation by minimising the usage of virgin material
  - Decreasing negative environmental impact
- By doing so the companies can utilise the framework to achieve the following outputs, but are not limited to:
  - Become a leader in adopting a systematic approach to CE's adaptation
  - Economic growth mingled with a holistic sustainable approach
  - Model, Inspire, and Challenge others for innovation and drive towards CE model
  - Increase productivity and market share

The framework is developed solely based on literature and author's expertise/knowledge of operations management. It is strongly believed, and every effort is made to ensure its usefulness and practical relevance, however before it could be implemented, it is best to verify the conceptually developed framework by conducting Delphi study or any other method; to ensure that any miss-alignments, errors, or missing elements are incorporated.

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