Universidade do Minho
Escola de Engenharia

José Carlos Vieira de Sá

Estudo do Impacto da Excelência Operacional na Segurança e na Sustentabilidade

Maio de 2024

José Carlos Vieira de Sá Estudo do Impacto da Excelência Operacional na Segurança e na Sustentabilidade

UMinho | 2024

Universidade do Minho
Escola de Engenharia

José Carlos Vieira de Sá

Estudo do Impacto da Excelência Operacional na Segurança e na Sustentabilidade

Tese de Doutoramento em Engenharia Industrial e de Sistemas

Trabalho efetuado sob a orientação de:
Professor Doutor José Dinis Carvalho

Maio de 2024

DIREITOS DE AUTOR E CONDIÇÕES DE UTILIZAÇÃO DO TRABALHO POR TERCEIROS

Este é um trabalho académico que pode ser utilizado por terceiros desde que respeitadas as regras e boas práticas internacionalmente aceitas, no que concerne aos direitos de autor e direitos conexos.

Assim, o presente trabalho pode ser utilizado nos termos previstos na licença abaixo indicada. Caso o utilizador necessite de permissão para poder fazer um uso do trabalho em condições não previstas no licenciamento indicado, deverá contactar o autor, através do RepositóriUM da Universidade do Minho.

Atribuição-NãoComercial
CC BY-NC-SA
https://creativecommons.org/licenses/by-nc-sa/4.0/

Agradecimentos

Nesta trajetória, eu tive o prazer e a satisfação de contar com pessoas que me apoiaram, inspiraram e desafiaram no meu dia-a-dia. A essas pessoas, eu quero deixar o meu profundo agradecimento.

Ao meu orientador, professor Dinis Carvalho, agradeço todos os seus preciosos contributos, paciência, orientação e inspiração durante todo o processo de orientação do trabalho.

À minha família, a minha esposa Olga e aos meus filhos Afonso e Diogo, pela sua paciência e por estarem sempre presentes comigo, com o seu apoio e suporte, em todos os momentos, o meu muito obrigado! Aos meus pais, por todas as oportunidades que me proporcionaram ao longo da via!

Agradeço a todos os que trabalharam comigo ao longo desta investigação, e contribuíram com as suas ideias, experiência, e acima de tudo com a sua paciência e amizade!

A vocês todos, o meu muito OBRIGADA.

Dedico este trabalho à minha esposa Olga e aos meus filhos Afonso e Diogo

DECLARAÇÃO DE INTEGRIDADE

Declaro ter atuado com integridade na elaboração do presente trabalho e confirmo que não recorri à prática de plágio nem a qualquer forma de utilização indevida ou falsificação de informações ou resultados em nenhuma das etapas conducente à sua elaboração.

Mais declaro que conheço e que respeitei o Código de Conduta Ética da Universidade do Minho.

Estudo do Impacto da Excelência Operacional na Segurança e na Sustentabilidade

Resumo

O desafio da sustentabilidade nas empresas tem sido um tema largamente debatido em congressos científicos, eventos empresariais e outros eventos. Existe neste tema grande diversidade de opiniões expressas nos media e em artigos científicos publicados, com diferentes pontos de vista sobre que soluções deverão ser adotadas para responder da melhor forma possível a esse desafio. Os diversos modelos de excelência operacional como o *Toyota Way*, a filosofia *Lean*, o Modelo EFQM e o Modelo de Shingo, têm implicitamente princípios de sustentabilidade nas suas três dimensões: social, económico e ambiental. A segurança é um dos fatores importantes na dimensão social, tendo relevância particular neste estudo. O desafio neste estudo passa por compreender de forma clara, como estes modelos de excelência operacional podem, em termos gerais, contribuir para a sustentabilidade em geral das empresas e em particular para a segurança dos seus trabalhadores. Este projeto de investigação inclui então as seguintes questões de investigação: "De que modo os diferentes modelos de excelência operacional podem contribuir para a melhoria da sustentabilidade das organizações?" e "De que modo os diferentes modelos de excelência operacional podem contribuir para a melhoria da segurança?". Para responder às questões de investigação é proposto modelo conceptual ***OpEx SafeSustain***, que enquadra a lógica de relacionamentos entre vários corpos de conhecimento relevantes para este estudo. Este trabalho começa por abordar o tema *B Corporation* e os *Science Based Targets*, propondo um modelo onde alarga estes indicadores para as três dimensões da sustentabilidade (*Triple Bottom Line*), com o objetivo de definir quais são os contributos que estes modelos podem trazer para a sustentabilidade. Para avaliar de que forma os modelos de Excelência Operacional (OpEx) têm impacto na segurança, foi desenvolvido um inquérito, tendo-se obtido 59 respostas válidas, e um caso de estudo onde foi avaliado através do - Safety Value Stream Mapping (SVSM), qual o impacto da filosofia *Lean* na segurança. Tendo por base as questões de investigação, e de acordo com os resultados obtidos nas várias ações reportadas nos artigos que compõem esta tese, é possível concluir que os modelos OpEx contribuem de forma positiva para a sustentabilidade das organizações nos seus três pilares (TBL), e também para a melhoria da segurança dos trabalhadores, que são o suporte das organizações e também do modelo conceptual ***OpEx SafeSustain***.

Palavras-chave: Lean; Lean Safety; Sustentabilidade; EFQM; Modelo Shingo, Excelência Operacional

Study of the Impact of Operational Excellence on Safety and Sustainability

Abstract

The challenge of sustainability in businesses has been a widely debated topic in scientific conferences, business events, and other forums. This subject encompasses a broad diversity of opinions expressed in the media and published scientific articles, each presenting different viewpoints on the best solutions to address this challenge. Various models of operational excellence, such as the Toyota Way, Lean philosophy, EFQM Model, and Shingo Model, inherently incorporate principles of sustainability across its three dimensions: social, economic, and environmental. Safety is, on the other hand, a crucial factor within the social dimension, and it holds particular significance in this study. The main challenge in this study is to clearly understand how these operational excellence models can generally contribute to the overall sustainability of businesses and specifically to the safety of their workers. This research project, therefore, includes the following questions: "*How can different models of operational excellence contribute to the improvement of organizational sustainability*?" and "*How can different models of operational excellence contribute to the enhancement of safety?*". To address the research questions, the conceptual model ***OpEx SafeSustain*** is proposed, framing the relationships between various bodies of knowledge relevant to this study. This work begins by discussing the topic of B Corporations and Science Based Targets, proposing a model that extends these indicators to the three dimensions of sustainability (Triple Bottom Line), aiming to identify the contributions these models can make to sustainability. To evaluate how Operational Excellence (OpEx) models impact safety, a survey was conducted, yielding 59 valid responses, and a case study was performed to assess the impact of the Lean philosophy on safety through Safety Value Stream Mapping (SVSM). Based on the research questions and the results obtained from the various actions reported in the articles comprising this thesis, it can be concluded that OpEx models positively contribute to organizational sustainability across its three pillars (TBL) and also enhance worker safety, which supports both the organizations and the conceptual model ***OpEx SafeSustain***.

Keywords: Lean; Lean Safety; Sustentainability; EFQM Model; Shingo Model; Operational Excellence.

ÍNDICE

ÍNDICE DE FIGURAS

ÍNDICE DE TABELAS

LISTA DE ABREVIATURAS, SIGLAS E ACRÔNIMOS

3M - Muda, Mura e Muri

B Corp - B Corporation

CDP - Carbon Disclosure Project

CS - Corporate Sustainability

CSR - Corporate Social Responsibility

EFQM - European Foundation for Quality Management.

EUA - Estados Unidos da América

ISO - International Organization for Standardization

KPI - Key Performance Indicator

NP - Norma Portuguesa

OEE - Overall Equipment Effectiveness

OpEx - Operational Excellence

SBT - Science Based Targets

SEVSM - Safety Efficiency Value Stream Mapping

SVSM - Safety Value Stream Mapping

TBL - Triple Bottom Line

TPS - Toyota Production System

TQM - Total Quality Management

UN - United Nations

UNGC - United Nations Global Compact

VSM - Value Stream Mapping

WCED - World Commission on Environment and Development WHO -

World Health Organization

WoS - Web of Science

WRI - World Resources Institute

WWF - World Wide Fund for Nature

"Pouco conhecimento faz com que as pessoas se sintam orgulhosas. Muito conhecimento, que se sintam humildes. É assim que as espigas sem grãos erguem desdenhosamente a cabeça para o céu, enquanto as cheias as baixam para a terra, sua mãe."

Leonardo Da Vinci

1 INTRODUÇÃO

O presente capítulo apresenta o Enquadramento da investigação, Objetivos da Investigação, a Metodologia e a estrutura utilizada para a elaboração da presente tese.

1.1 Enquadramento

1.1.1 Sustentabilidade

A sustentabilidade é um tema que tem sido bastante abordado ao longo dos últimos anos, na sequência das alterações climáticas e das catástrofes naturais que têm surgido um pouco por todo o mundo. As alterações climáticas que se têm registado ao longo dos últimos anos, têm tido impacto real no dia-a-dia das populações um pouco por todo o mundo. Muito provavelmente temos tido como consequência um crescente número fenómenos extremos como incêndios florestais de grandes dimensões, degelo dos glaciares, aparecimento com maior frequência de secas extremas e chuvas torrenciais, causando catástrofes humanitárias.

O conceito de sustentabilidade, contudo não se limita à dimensão ambiental, o conceito também abrange a dimensão económica e a dimensão social. O conceito de desenvolvimento sustentável, que surgiu em 1987 no Relatório Brundtland "*Our common future*" (Burton, 1987), da Comissão Mundial para o Ambiente e o Desenvolvimento (*World Commission on Environment and Development - WCED*), liderada pela então Primeira-Ministra da Noruega Gro Harlem Brundtland, tinha como objetivo conciliar o desenvolvimento económico e a proteção dos equilíbrios sociais e ambientais. A Comissão Brundtland das Nações Unidas (*WCED*) definiu sustentabilidade como "*satisfazer as necessidades do presente sem comprometer a capacidade das gerações futuras de satisfazerem as suas próprias necessidades*".

Ao longo dos últimos anos, tem-se verificado um aumento notável da quantidade de literatura e investigação académica que tem abordado as questões ambientais e a necessidade premente de estabelecer um futuro sustentável (Marien, 1992). Este crescimento reflete uma consciência global das questões ecológicas, das alterações climáticas e da importância de desenvolver práticas que preservem os recursos naturais para as gerações futuras.

Atualmente o conceito da sustentabilidade refere-se à capacidade de manter, preservar e equilibrar sistemas ecológicos, económicos e sociais a longo prazo, por forma a satisfazerem as necessidades das gerações atuais, sem comprometer a capacidade das gerações futuras de

atenderem às suas próprias necessidades (Tsalis et al, 2020). Este conceito estabelece a ideia de que a sustentabilidade consiste na procura de um equilíbrio entre os pilares ambiental, económico e social, muitas vezes designados por "três pilares da sustentabilidade" (Figura 1).

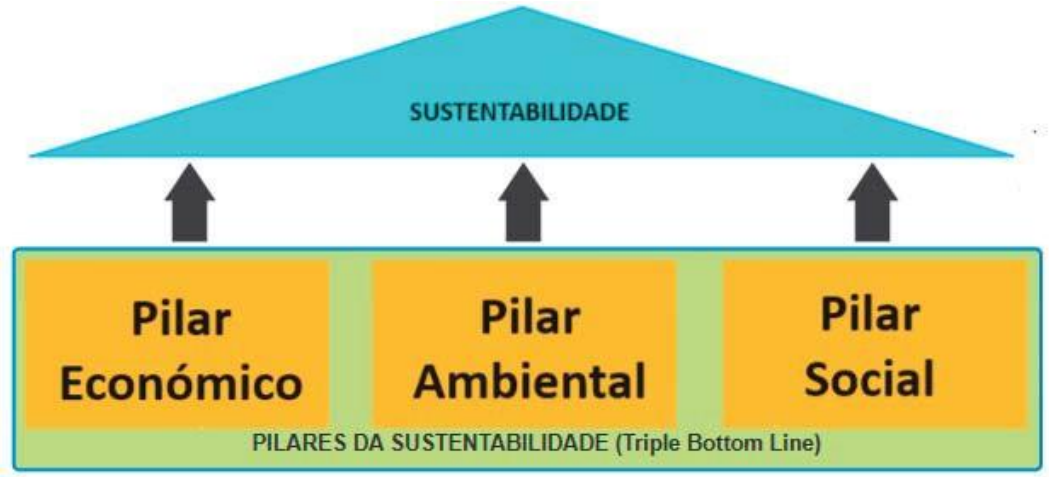


Figura 1 - Os três pilares da sustentabilidade

O âmbito de cada um dos três pilares da sustentabilidade, estão bem destintos, e focam-se nos seguintes aspetos (Bebbington & Unerman, 2018):

- Pilar Ambiental: Foco na preservação e na gestão responsável dos recursos naturais, como água, solo, biodiversidade, ar limpo e clima. Passando pela redução da pegada ecológica, na redução dos níveis de poluição, a na conservação e preservação dos ecossistemas críticos, e ainda na promoção de práticas que não esgotem os recursos naturais.
- Pilar Económico: Tem como objetivo a criação de sistemas económicos que sejam viáveis a longo prazo, tendo por base uma gestão de negócios responsável. O objetivo é que não sejam considerados apenas os lucros a curto prazo, mas também os impactos a longo prazo na sociedade e no meio ambiente. O principal objetivo do pilar económico, passa por assegurar que a prosperidade económica seja duradoura e equitativa.
- Pilar Social: Tem como alvo garantir a equidade, ao nível da justiça social e na qualidade de vida da sociedade. Para isso, promove o acesso igualitário a oportunidades educacionais, serviços de saúde, segurança, emprego e uma participação democrática na tomada de decisões. O foco na inclusão social e no respeito pelos direitos humanos são fundamentais para este pilar.

Neste sentido, a sustentabilidade pretende promover um elevado nível de qualidade de vida, que seja ambientalmente responsável, economicamente viável e que garanta justiça social, para desta forma conseguir garantir que o planeta e a humanidade, consigam prosperar por muito tempo.

Neste contexto e por forma a materializar o melhor possível o movimento da sustentabilidade, a avaliação do desempenho das empresas não se deve limitar a desempenho económico e financeiro. John Elkington (1998) no livro "*Cannibals with Forks: The Triple Bottom Line of 21st Century Business*", introduz o conceito do "*Triple Bottom Line*" (TBL), o qual propõe um modelo de avaliação de desempenho para as empresas, que não assente apenas no desempenho económico e financeiro. Segundo ele, a avaliação do sucesso das organizações deve incluir também a avaliação de desempenho da organização para com as pessoas (social) e o planeta (ambiental). O TBL veio a tornar-se num modelo de avaliação reconhecido e utilizado na avaliação de desempenho, devido ao facto de incluir as questões relacionadas com a responsabilidade social e ambiental, para além do desempenho económico e financeiro (Gimenez et al., 2012).

Com o aparecimento deste novo modelo de avaliação de desempenho, as organizações passaram a abranger as três dimensões do TBL, por forma a conseguirem ter processos sustentáveis. O maior desafio que tem surgido às empresas neste processo, tem passado por conseguirem definir indicadores relevantes para cada dimensão, e na compreensão de como esses indicadores se podem relacionar entre si, por forma a ajudarem as empresas a alcançarem processos sustentáveis (Helleno et al., 2017). Esta nova abordagem de avaliação de desempenho (TBL), tem permitido às empresas que têm pretendido atingir a excelência operacional (OpEx), compreenderem que a sustentabilidade tem um papel fundamental no seu sucesso a longo prazo. A sustentabilidade não é apenas uma tendência ou moda, mas sim um tema que veio para ficar. A dificuldade que tem surgido às organizações, tem sido na definição de indicadores relevantes para cada uma das dimensões, e na compreensão de como esses indicadores se podem relacionar entre si, por forma a alcançarem processos verdadeiramente sustentáveis (Helleno et al., 2017).

As organizações que adotam modelos de excelência e de melhoria contínua, sabem que a eficiência é determinante para a sustentabilidade económica. No entanto, a busca pela excelência operacional, como se pode constatar nos princípios adotados pelos principais modelos, não se foca apenas em aspetos financeiros, mas também nas dimensões sociais, ambientais e de segurança. Além da dimensão moral, a segurança, é também um pilar de suporte na construção de um modelo de excelência operacional, dado serem os trabalhadores que promovem e garantem

a excelência operacional, numa empresa. A segurança está diretamente relacionada com a eficiência, uma vez que a existência de um ambiente de trabalho seguro, garante a ocorrência de um menor número de acidentes de trabalho e consequentes perdas na dimensão humana (motivação, comprometimento com a organização, ...) além das paragens dos processos, reduzindo desta forma os tempos de inatividade (muda) e dos respetivos custos (Kavouras et al., 2022). Atingir a excelência operacional por parte das empresas, requer um compromisso contínuo da gestão na identificação de riscos e na implementação de ações de segurança, através da dinamização de uma cultura interna de segurança. Num modelo de gestão, que tenha como objetivo atingir a excelência operacional, a segurança e a sustentabilidade são parte integrante da cultura da empresa. Isto deve-se ao facto da segurança e a sustentabilidade, serem fundamentais para fortalecerem a base para o sucesso a longo prazo, garantindo desta forma que a organização é responsável e resiliente num mercado global em constante evolução (Nawaz et al., 2019).

1.1.2 Modelos Excelência Operacional (OpEx)

Atualmente existem vários modelos de excelência e de melhoria contínua amplamente reconhecidos a nível mundial, o "Modelo de Shingo" (Kelly & Hines, 2019), filosofia *Lean* (Womack et al., 2007), "Modelo EFQM" (Menezes, et al., 2022) e *Toyota Production System* (TPS) (Ohno, 1988), designado atualmente como *Toyota Way* (Liker, 2004) sendo que os dois modelos têm as suas origens em filosofias de gestão, que promovem a excelência e a eficiência operacional.

1.1.2.1 Modelo Shingo

O Modelo de Shingo surgiu em 1988, tendo sido desenvolvido pela *Jon M. Huntsman School of Business da Utah State University*, em reconhecimento ao Dr. Shigeo Shingo. Atualmente o Modelo de Shingo encontra-se disseminado por vários países, tendo sido já atribuídos 368 prémios *Shingo Prize*, a empresas localizados em 29 países. Na tabela abaixo (Tabela 1), é possível observar os 15 países onde se encontram localizadas o maior número de empresas por ordem decrescente, às quais foram atribuídos o *Shingo Prize*, as quais representam 96,2% dos prémios atribuídos. Apesar de em primeiro lugar encontrar-se os EUA com 58,7% (216) dos prémios, verifica-se que os outros países do que fazem parte top 15, encontram-se em continentes mais distantes.

Tabela 1 - Os 15 países com mais prémios Shingo Prize obtidos mundialmente

	PAÍSES	NÚMERO DE EMPRESAS
1	Estados Unidos da América	216
2	México	73
3	Irlanda	14
4	Brasil	11
5	Costa Rica	8
6	Canadá	7
7	Reino Unido	6
8	Índia	4
9	Austrália	3
10	China	3
11	Chile	2
12	França	2
13	Rússia	2
14	Países Baixos	2
15	Dinamarca	1

Na figura abaixo (Figura 2) é possível observar a distribuição geográfica dos prémios *Shingo Prize* atribuídos a nível mundial.

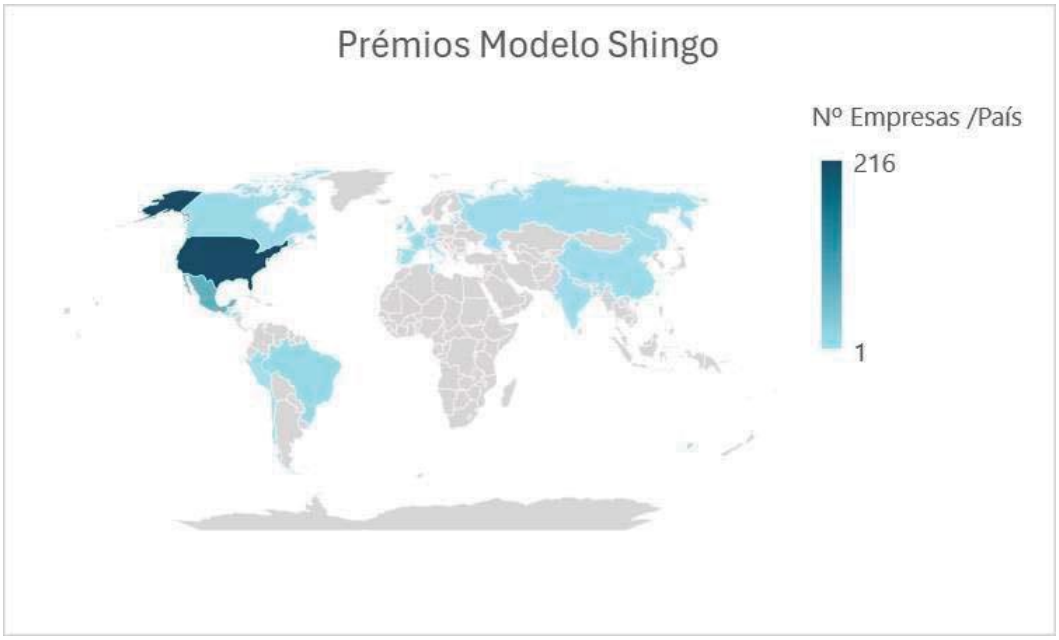


Figura 2 - Distribuição geográfica mundial da atribuição do Shingo Prize

O Modelo de Shingo (Figura *3*) foi desenvolvido com base nos princípios da produção da *Toyota*, tendo como objetivo orientar as organizações para uma transformação cultural, por forma a que estas consigam atingir os resultados ideais (Shingo Institute, 2023).

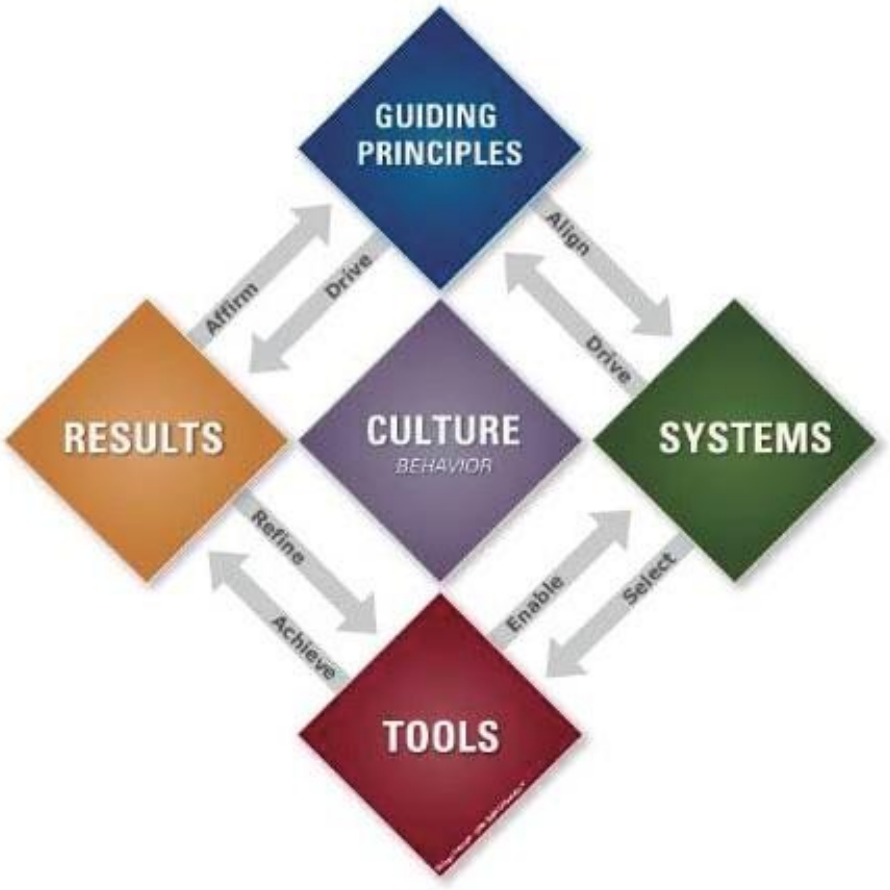


Figura 3 - Modelo de Shingo (Shingo Institute, 2023)

O Modelo de Shingo (Figura *4*) assenta num conjunto de princípios orientadores designados de "*Shingo Guiding Principles*" (Pramjeeth & Mutambara, 2022) que são a base para a construção de uma cultura sustentável de excelência organizacional.

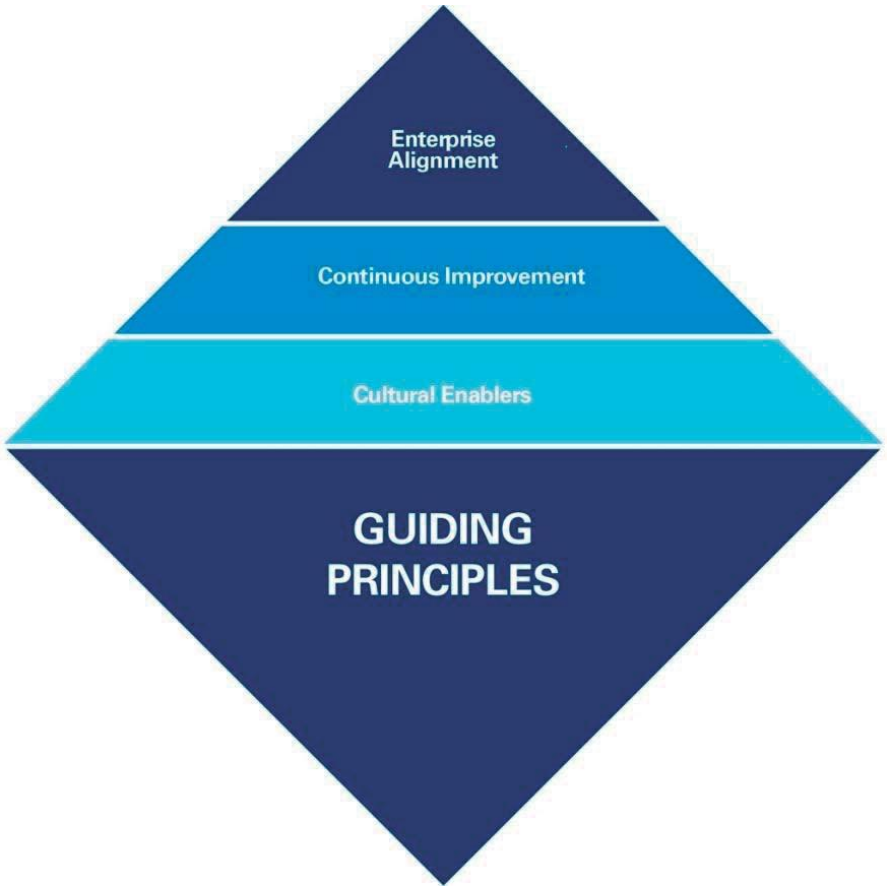


Figura 4 - Dimensões do Modelo de Shingo (Shingo Institute, 2023)

No diamante (*Figura 4*) os Princípios Orientadores, encontram-se divididos em três dimensões: Agentes Culturais, Melhoria Contínua e Alinhamento Empresarial. Na Tabela 2, é possível ver, de que forma os Princípios Orientadores se distribuem pelas 3 dimensões.

Tabela 2 - Distribuição dos Princípios Orientadores pelas três dimensões do Modelo de Shingo

Dimensões	**Princípios Orientadores**
Fatores Culturais	Respeito por cada indivíduo Liderar com humildade
Melhoria Contínua	Assegurar a qualidade na origem Melhorar o fluxo e o sistema puxado (pull) Busca pela perfeição Abraçar o pensamento científico
Alinhamento da Empresa	Foco no processo Criar valor para o cliente Criar constância de propósito Pensamento Sistemático

O Modelo de Shingo é um modelo que promove a melhoria contínua, com o objetivo de criar operações eficientes sem desperdícios, valorizando a qualidade e o envolvimento dos

trabalhadores, na busca da melhoria contínua. O modelo desempenha uma função muito importante na transformação das organizações, por forma a alcançarem a excelência operacional.

1.1.2.2 Modelo EFQM

Na década de 80 a Europa encontrava-se internamente num período de grande turbulência, devido à estagflação, altos níveis de desemprego e à necessidade de uma reestruturação industrial. A nível externo, existia uma crescente concorrência internacional, especialmente vinda de empresas japonesas que tinham adotado métodos de gestão avançadas no domínio da qualidade e melhoria contínua, como o TQM - *Total Quality Management* (Shiba et al., 1997).

No final da década de 80, mais precisamente em 1988, um conjunto de 14 empresas europeias que incluíam gigantes como a Bosch, BT, Ciba-Geigy, Dassault, Electrolux, KLM, Nestlé, Philips, Renault, Sulzer, Volkswagen entre outras, uniram-se e criaram a *European Foundation for Quality Management* (EFQM). A fundação da EFQM foi oficialmente apoiada pela Comissão Europeia, que viu na iniciativa das 14 empresas, excelente oportunidade para impulsionar a competitividade industrial europeia.

Apesar do modelo EFQM ter sido criado para superar os desafios que são colocados às organizações europeias, a verdade é que este modelo há muito ultrapassou as fronteiras europeias, e está a ser adotado por organizações espalhadas por diversos continentes, num total de 70 países. Já foram obtido um total de 6 597 reconhecimentos, ao Modelo EFQM. Na Tabela 3, é possível observar os países que fazem parte do Top 15 das organizações que obtiveram o seu reconhecimento pelo Modelo EFQM, por ordem decrescente, que representam 91,25% do total. No topo da lista encontram-se a Espanha seguida do Reino Unido, com 35,9% e 11,99% respetivamente do número total de reconhecimentos obtidos a nível mundial.

Tabela 3 - Os 15 países com mais reconhecimentos Modelo EFQM obtidos mundialmente

	PAÍSES	NÚMERO DE EMPRESAS
1	ESPANHA	2 368
2	REINO UNIDO	791
3	ALEMANHA	679
4	SUÍÇA	455
5	ÁUSTRIA	280
6	TURQUIA	275
7	REPÚBLICA CHECA	206
8	FRANÇA	170
9	EQUADOR	155
10	GRÉCIA	127
11	FEDERAÇÃO RUSSA	111
12	HUNGRIA	107
13	ITÁLIA	102
14	BÉLGICA	99
15	ÁRBIA SAUDITA	95

Na Figura 5 é possível constatar que o Modelo EFQM, se encontra perfeitamente disseminado por vários países a nível mundial.

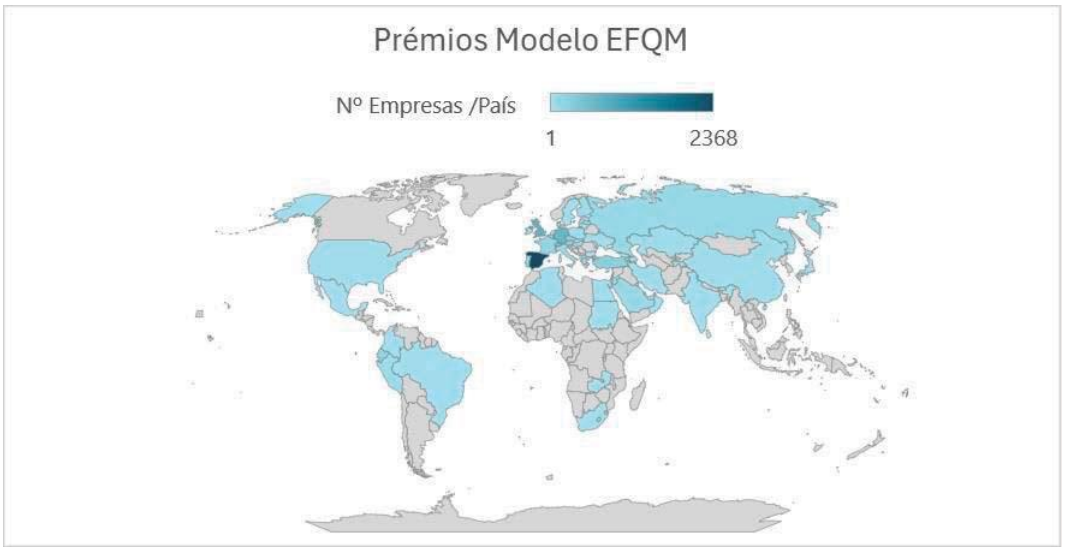


Figura 5 - Distribuição geográfica mundial do reconhecimento do Modelo EFQM

Atualmente, o Modelo EFQM assenta na resposta a três questões, através de sete critérios (EFQM, 2001).

Figura 6 - Modelo EFQM (EFQM, 2021)

Na Tabela *4*, encontram-se indicadas as três questões, assim como, de que forma os critérios estão alinhados com cada uma das questões.

Tabela 4 - As três perguntas e os sete critérios do Modelo EFQM

Perguntas	**Critérios**
"Porque" existe esta organização? Qual o seu Propósito? Porquê esta Estratégia em particular? "Como" pretende cumprir o seu Propósito e a sua Estratégia? (Execução)	Critério 1 - Propósito, Visão e Estratégia Critério 2 - Cultura Organizacional e Liderança Critério 3 - Envolvimento das Partes Interessadas Critério 4 - Criação de Valor Sustentável Critério 5 - Condução do Desempenho e da Transformação
"O que" verdadeiramente alcançou até hoje? "O que" pretende alcançar amanhã? (Resultados)	Critério 6 - Perceções das Partes Interessadas Critério 7 – Desempenho Estratégico e Operacional

Este modelo de gestão é de grande importância para as empresas que procuram a melhoria da sua gestão e do seu desempenho. O foco do Modelo EFQM, é na ligação que faz entre o Propósito e a Estratégia de uma empresa, e de como é utilizada na Criação de Valor Sustentável para as suas Partes Interessadas Chave, e de como alcançar excelentes resultados.

1.1.2.3 Toyota Way

Um outro modelo de excelência operacional que vale a pena referir, por ter sido a *Toyota* o grande farol da excelência com o seu *Toyota Production System* (TPS), é o modelo *Toyota Way* (Dinis- Carvalho & Macedo, 2021). O modelo *Toyota Way* aqui referido, que na verdade é a interpretação de Jeffrey Liker (ver Figura 7), é suportado por dois grandes eixos: Melhoria Contínua e o Respeito pelas Pessoas. No que se refere à Melhoria Contínua, ele envolve o "*Desafio*", o "*Kaizen*" e o "*Genchi Genbutsu*" enquanto o Respeito pelas Pessoas envolve "*Respeito*" e o "*Trabalho em Equipa*". Liker (2004) concebeu a sua interpretação do *Toyota Way* como um modelo piramidal, no qual inclui um conjunto de princípios ao nível de operacional e da gestão, divido em quatro áreas (Gao & Low, 2014). Na base do triângulo temos "*filosofia*", ou seja, o enquadramento de base para todos os outros princípios.

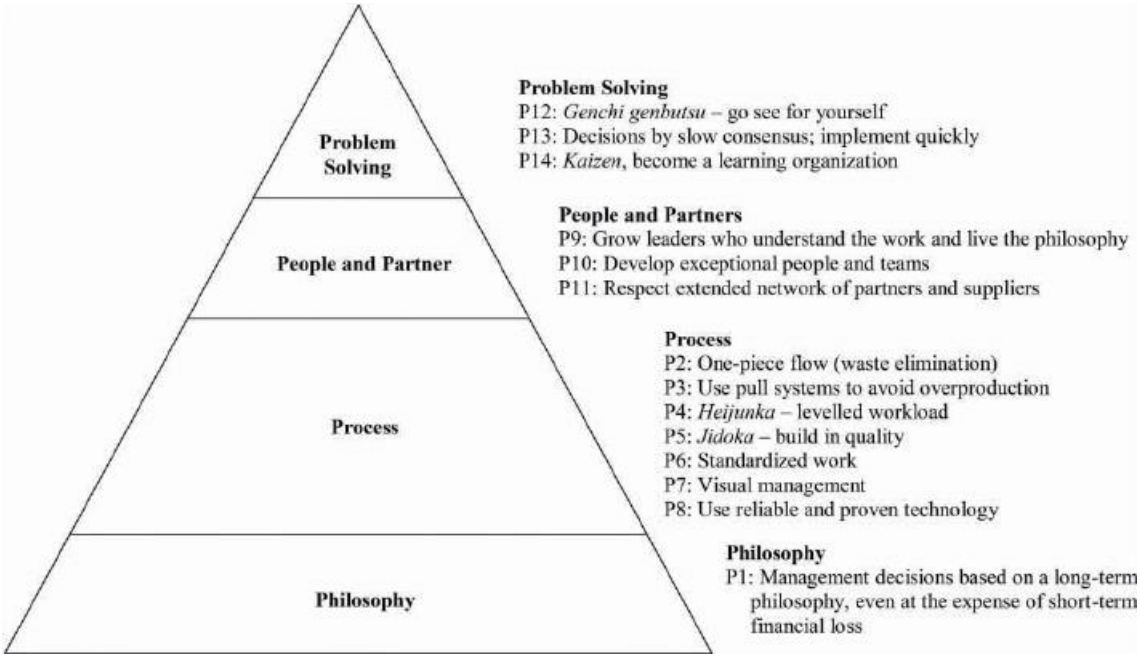


Figura 7 - Toyota Way (Liker, 2004)

Em seguida surgem os "*Processos*", com todas as ferramentas e metodologias que fazem com que este modelo tenha os resultados esperados, e só depois surgem as "*Pessoas e Parceiros*" que têm conhecimento dos "*Processos*" que foram anteriormente referidos. E só no fim, no topo do triângulo, é que surge a "*Resolução de Problemas*". Este modelo de gestão tem como principal objetivo a promoção da excelência operacional, eficiência, qualidade, sustentabilidade e na criação de uma cultura organizacional sólida. Pretende, acima de tudo, orientar a gestão para alcançar o sucesso a longo prazo.

1.1.2.4 Filosofia *Lean*

A filosofia *Lean* é também um modelo que faz sentido referir pela sua popularidade (Henderson et al., 2003). *Lean* é uma abordagem de gestão que tem como objetivo otimizar os processos, através da identificação dos desperdícios e sua eliminação/redução (Dinis-Carvalho, 2023). Esta ação leva a um aumento da eficiência das empresas, e um consequente aumento de rentabilidade (Wilson, 2010). Para isso é necessário identificar os 3M (*Muda, Mura e Muri*), que são essenciais serem identificados, dado que têm um papel fundamental na busca pela eficiência, eliminação de desperdícios e na melhoria contínua dos processos. Cada um dos "M's" representa um tipo de problema ou ineficiência que a filosofia *Lean* procura abordar: *Muda* (Desperdício), *Mura* (Irregularidade) e *Muri* (Sobrecarga). A importância dos 3M na filosofia *Lean* está em proporcionar uma estrutura sólida para identificar e abordar ineficiências nos processos, eliminar desperdícios e criar fluxos de processo contínuos. No que se refere especificamente à *Muda* (Desperdício), conhecidos também como os "Oito tipos de desperdícios" ou "Os oito Mudas", não são mais do

que uma divisão em tipos de ineficiências, ou atividades que não acrescentam valor. Identificar e eliminar esses desperdícios é um dos princípios fundamentais da filosofia *Lean*. No fundo, a identificação de cada desperdício, representa uma área em que a eficiência pode ser melhorada. Os "Oito desperdícios" (*muda*) são eles: "*transporte*", "*stock*", "*movimento*", "*espera*", "*sobreprodução*", "s*obreprocessamento*", "*produto não-conforme*" (Arumugam et al., 2012), e mais recentemente "*subaproveitamento do conhecimento*".

Relativamente à relação da filosofia Lean com a sustentabilidade (*Lean Sustainability*), Tran et al. (2023) consideram que a filosofia *Lean* tem um impacto positivo no *Triple Bottom Line*, dado que contribui de forma positiva para a sustentabilidade. Segundo Ciannella e Santos (2022), a filosofia *Lean* tem desempenhado um papel fundamental na promoção da sustentabilidade e da Responsabilidade Social Corporativa (*Corporate Social Responsibility - CSR*) nas empresas.

1.1.3 Segurança

Relativamente à questão da segurança, um tema muito importante nesta tese e que muitas organizações não lhe dão a atenção necessária, devido ao facto de não reconhecerem a sua importância e o seu real impacto na produtividade. Elas têm tendência a focarem-se apenas no seu volume de produção e produtividade, levando muitas vezes a perda de foco na segurança e consequente ocorrência de acidentes de trabalho. Os acidentes de trabalho decorrem do incumprimento das normas de segurança, os quais resultam em custos para a empresa (Bastos et al., 2014). Estes custos podem ser classificados em dois tipos: custos diretos e custos indiretos, sendo muitas vezes designados como custos invisíveis (Kwon & Park, 2002). A investigação conduzida sobre este tema por Heinrich, demonstrou uma proporção de 4 para 1 entre custos diretos e indiretos (Heinrich et al., 1980). Os custos diretos estão geralmente associados às indeminizações, custos dos atos médicos de reparação ao sinistrado, e por vezes alguma multa pela falta do cumprimento de requisitos legais. Estes custos são fáceis de identificar e quantificar, e geralmente não muito elevados, quando comparados com os custos indiretos. Estes custos de difícil quantificação são referentes a:

- Custo associado ao tempo de paragem de uma linha de produção ou o posto de trabalho.
- Custo associado dessa paragem, nas outras áreas a jusante e mesmo a montante.
- Custo (perda) associado à redução de produtividade entre a produtividade do trabalhador acidentado (trabalhador usual do posto de trabalho) e o operador que o irá substituir (curva da aprendizagem).
- Custos/impacto em outros postos de trabalho, pelo facto de ter ficado sem um trabalhador,

dado este ter ido substituir o trabalhador acidentado ou mesmo o custo de contratação de um novo colaborador.

- Custo do impacto da paragem, na produtividade da empresa.
- Custos relativos à indemnização ao cliente, ou mesmo do cancelamento da encomenda, devido ao atraso.
- Custos devido ao real impacto do acidente na imagem da empresa junto dos seus clientes (Clientes dispostos a terem associado ao seu nome, fornecedores que registam normalmente acidentes de trabalho?).

São vários os estudos que demostram o efeito positivos da adoção da filosofia *Lean*, na segurança dos trabalhadores, a qual se designa de "*Lean* Safety" (Cordeiro et al.,2020; L. Ateekh-ur-Rehman, 2012), o que demonstra uma clara relação positiva entre estas duas grandes áreas "*Lean*" e "segurança".

Como foi possível constatar anteriormente o Modelo de Shingo, Modelo EFQM, *Toyota Way* e a filosofia *Lean*, incorporam intrinsecamente a segurança dos trabalhadores, o bem-estar e a motivação dos trabalhadores, sendo a segurança um elemento essencial das suas abordagens de gestão e eficiência operacional. A segurança tem também um forte impacto na sustentabilidade, ao nível da dimensão social.

Como conclusão, pode-se referir que a sustentabilidade se tornou numa prática de gestão que as empresas terão de vir a adotar rapidamente, devido às preocupações sociais e imposições do mercado.

1.1.4 Relação Entre a Excelência Operacional (OpEx) e a Sustentabilidade

Os modelos de excelência, tais como o Modelo de Shingo, Modelo EFQM, *Toyota Way* e a filosofia *Lean*, bem como a segurança, demonstraram terem um forte impacto na sustentabilidade _das empresas. Em resumo, podemos concluir que:

- Na dimensão económica, o Modelo de Shingo, a filosofia *Lean* e o *Toyota Way* têm como objetivo a eliminação de desperdícios e a melhoria dos processos, permitindo desta forma a redução do consumo de recursos. Como consequência, haverá uma redução dos custos operacionais, contribuindo de forma positiva para a estabilidade e sustentabilidade económica da empresa. A segurança não se reflete apenas num compromisso com o bem-estar dos trabalhadores, mas também como uma contribuição na dimensão económica, ao evitar custos associados às lesões e ausências dos postos de trabalho.
- Na dimensão social, o Modelo EFQM valoriza fortemente a responsabilidade social e o

envolvimento das partes interessadas. Isso leva a que as organizações tenham de considerar não só os seus próprios interesses, nas suas tomadas de decisões, mas também os interesses da comunidade e da sociedade em geral. As preocupações com as questões éticas, o respeito pelos direitos humanos e o apoio às iniciativas sociais, são de grande relevância para o pilar social da sustentabilidade. Já no que se refere à filosofia *Lean* e ao *Toyota Way*, estes valorizam fortemente a participação dos trabalhadores na identificação de melhorias e nas tomadas de decisões, no seu dia-a-dia. Isto porque são os trabalhadores que têm o conhecimento das atividades que desenvolvem, e são o garante da implementação das melhorias, criando desta forma ambientes de trabalho mais inclusivos e participativos por todos. No que se refere à segurança, ela é um aspeto crítico da dimensão social, dado ter como foco a prevenção e a segurança dos trabalhadores, com o objetivo de prevenir a ocorrência de acidentes e lesões nos locais de trabalho, contribuindo desta forma para a sustentabilidade social.

- Na dimensão ambiental, existe uma maior visibilidade e urgência no que se refere à sustentabilidade global. O Modelo de Shingo tem o seu foco na eliminação de desperdícios, reduzindo desta forma o impacto ambiental. Isso inclui a redução de desperdícios, o uso eficiente de recursos naturais e a diminuição das emissões de carbono. Por sua vez, o *Toyota Way* e a filosofia *Lean* promovem práticas de produção *Lean* que reduzam o consumo de energia e materiais. Estes modelos de gestão, são essenciais para a sustentabilidade ambiental, ajudando a conservar os recursos naturais e a proteger ecossistemas frágeis.

Podemos então afirmar que o Modelo de Shingo, o Modelo EFQM, o *Toyota Way*, a filosofia *Lean* e a segurança, são fundamentais na promoção e garantia da sustentabilidade ao nível económico, social e ambiental. Eles oferecem às empresas um conjunto de ferramentas, princípios e práticas de gestão, que capacitam as mesmas a serem eficientes, socialmente responsáveis, ecologicamente conscientes e a manter ambientes de trabalho seguros, contribuindo desta forma para um futuro mais sustentável.

1.1.5 Publicações no Web of Science (WoS)

Consultando à base de dados "*Web of Science (WoS)*" é possível verificar que estes modelos de excelência são temas de investigação atuais por parte da comunidade académica e científica. Realizando uma pesquisa no WoS por forma a analisar as publicações referentes ao modelo de excelência *Toyota Way*, foram consideradas às seguintes palavras-chave da seguinte forma: "*Toyota Production System*" *or* "*Toyota Way*". O resultado da pesquisa (Figura 8), permitiu verificar a existência de 494 publicações, tendo a primeira publicação surgido no ano de 1977, com o título

"*Toyota production system and kanban system materialization of just-in-time and respect-for-human system*" (Sugimori et al, 1977). Em 2017 é atingido o número de publicações mais elevado, 41 publicações.

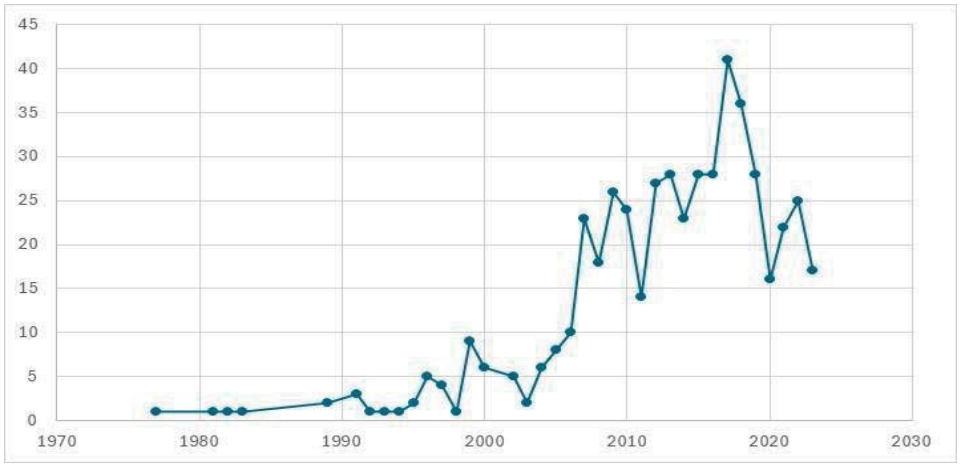


Figura 8 - Evolução das publicações no WoS referentes ao Toyota Production System

No que se refere ao modelo de excelência filosofia *Lean* foram utilizadas na consulta do WoS as seguintes palavras-chave, da seguinte forma: "*lean manufacturing*" or "*lean management*" or "*lean philosophy*" or "*lean thinking*" or "*lean production*" or "*lean 4.0*". O resultado da consulta (Figura 9) indica que existem 6 617 publicações, sendo que a primeira publicação surgiu em 1988, com o título "T*riumph of the lean production system*" (Krafcik, 1988). Em 2019 é atingido o número mais elevado, 590 publicações/ano. Apesar de nos últimos anos ter-se registado uma diminuição no número de publicações acerca deste tema, o número de publicações continua a ser elevado.

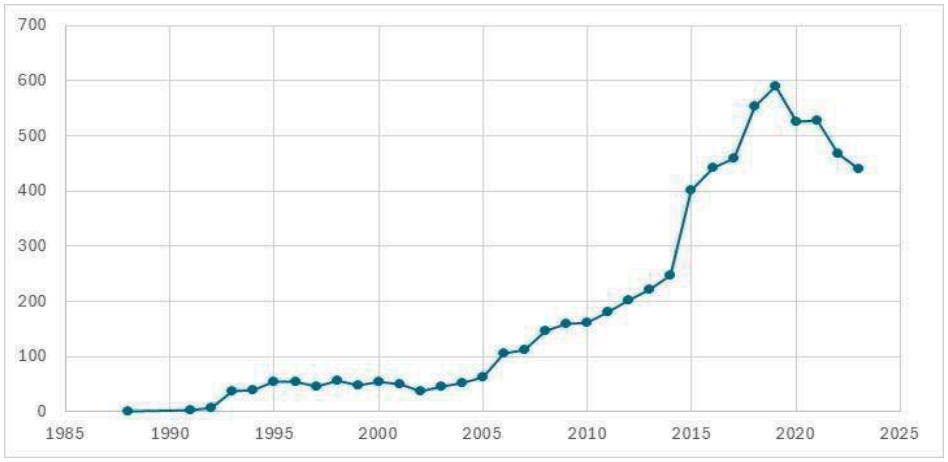


Figura 9 - Evolução das publicações no WoS referentes à filosofia Lean

Relativamente ao Modelo EFQM, foram consideradas as opções de os autores que pretenderam publicar acerca deste modelo, usarem nas suas publicações a designação do modelo de excelência

pelo seu nome completo "*European Foundation for Quality Management*" e pela abreviatura "EFQM". Nesse sentido foram estas as palavras-chave consideradas para a pesquisa, tendo sido realizada da seguinte forma: "*European Foundation for Quality Management*" or "EFQM". Os resultados obtidos abaixo (Figura 10) permitem verificar que a tendência deste modelo de excelência, segue a tendência dos modelos anteriores. O número de publicações é ligeiramente superior, existindo 749 publicações, sendo que a primeira publicação surge em 1992, com o título "Total Quality Management in Europe and EFQM" (Van Ham, 1992).

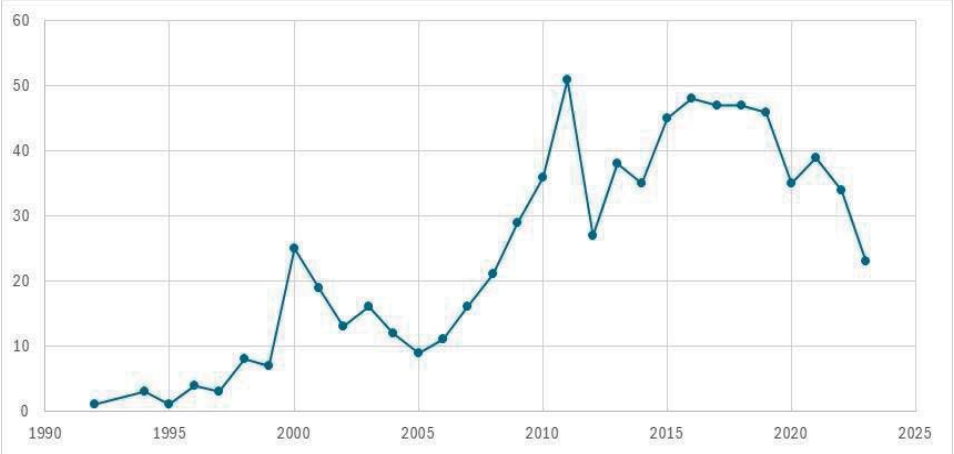


Figura 10 - Evolução das publicações no WoS referentes ao Modelo EFQM

No que se refere ao Modelo de Shingo, considerou-se que os autores que publicaram os seus artigos relacionados com este modelo, terão incluído nos seus artigos as palavras-chave "*Shingo Model*" e "*Shingo Prize*". O resultado da pesquisa na Figura 11, mostra um número muito reduzido de publicações quando comparado com os restantes modelos de excelência considerados nesta investigação, apenas 22 publicações. A primeira publicação encontrada no WoS, surge em 1997 com o título "*The power of combining research data and the wisdom of people*" (McIntoshFletcher et al, 1997).

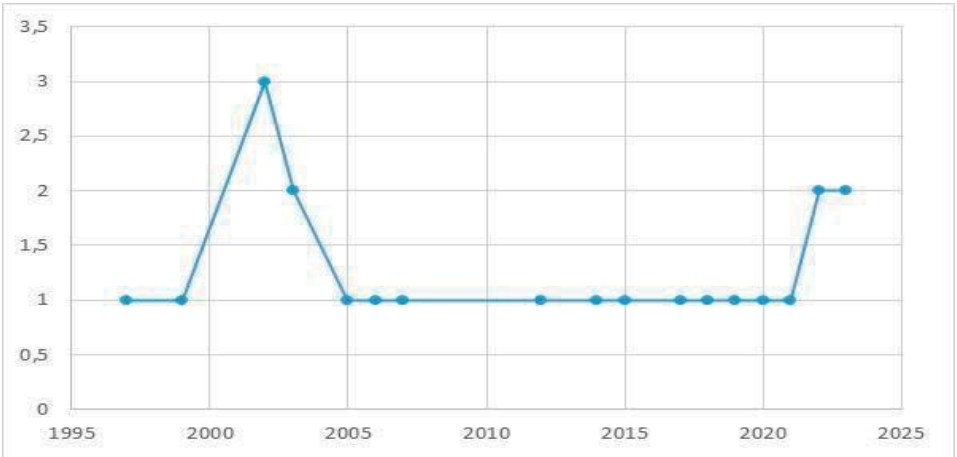


Figura 11 - Evolução das publicações no WoS referentes ao Modelo Shingo

Como conclusão, no que se refere ao número de publicações no domínio dos modelos de excelência selecionados para esta investigação, verifica-se uma clara predominância no que se refere ao número de publicações acerca da filosofia *Lean*, 6 617 publicações (*Tabela 5*), o que representa cerca de 84%, das publicações existentes na WoS, acerca dos quatro modelos de excelência considerados neste estudo. Em sentido oposto verifica-se que o Modelo de Shingo, não tem merecido grande atenção por parte da comunidade científica e académica, dado registar apenas 22 publicações, o que representa cerca de 0,3% do total das publicações (Figura 12).

Tabela 5 - Número de publicações por modelo de excelência

Modelos de Excelência	**Número de Publicações**
Toyota Production System / Toyota Way	494
Filosofia *Lean*	6 617
Modelo EFQM	749
Modelo Shingo	22

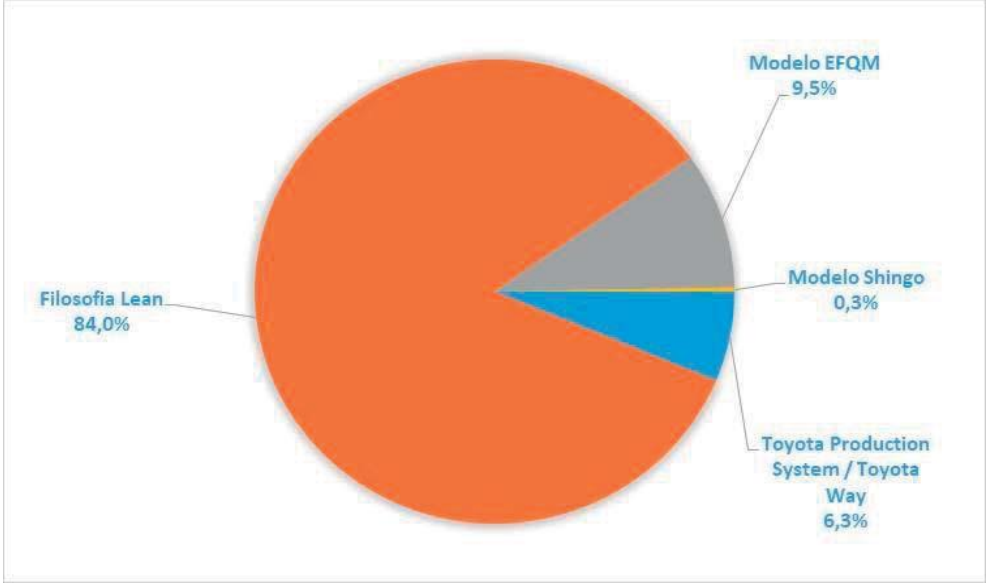


Figura 12 - % de publicações por modelo OpEx

1.2 Objetivos da Investigação

Atualmente existem diversos modelos de gestão que ajudam as empresas a melhorarem a sua eficiência, qualidade e desempenho em geral. A nível europeu os modelos de gestão de excelência operacional provavelmente mais conhecidos são: Modelo de Shingo, Modelo EFQM, *Toyota Way* e a filosofia *Lean*. Apesar de cada um dos modelos terem as suas próprias especificidades e

abordagens, todos eles partilham muitos objetivos comuns de melhoria do desempenho económico e humano, e sustentabilidade nas suas diferentes dimensões. Nos diversos requisitos que suportam cada um dos modelos, pode dizer-se que existe um denominador comum que sobressai, que se refere à preocupação com as relações humanas, o bem-estar dos trabalhadores e o desenvolvimento humano.

Sendo o tema da sustentabilidade um dos temas centrais desta tese, o desafio baseou-se em perceber de que forma os modelos de excelência operacional e outros modelos de gestão, podem contribuir para a melhoria da segurança e da sustentabilidade (Figura 13).

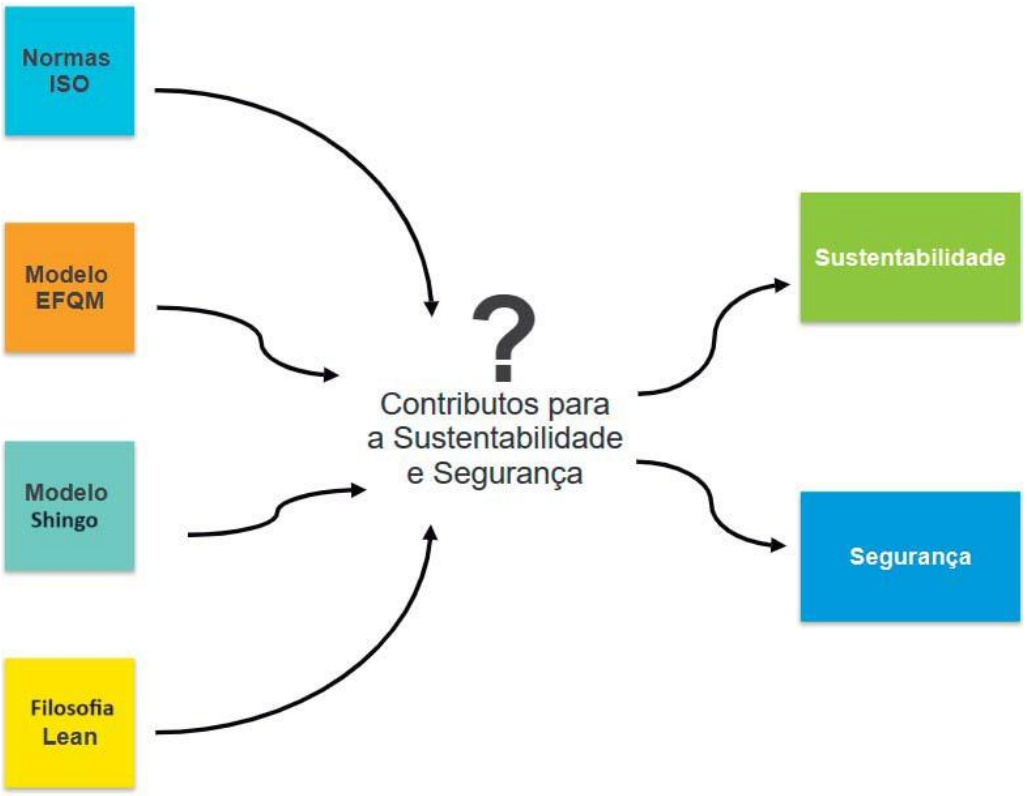


Figura 13 - Propósito da investigação

Por forma a ser feito esse estudo, considera-se importante definir as seguintes questões de investigação, às quais se pretende responder com o presente trabalho:

- *De que modo os diferentes modelos de excelência operacional podem contribuir para a melhoria da sustentabilidade das organizações?*
- *De que modo os diferentes modelos de excelência operacional podem contribuir para a melhoria da segurança?*

Sendo o propósito deste estudo, compreender de que forma os modelos de excelência podem contribuir para as organizações terem uma cultura de segurança e sustentabilidade, foi desenvolvido o modelo conceptual "*OpEx SafeSustain*" (Figura 14) representando as relações.

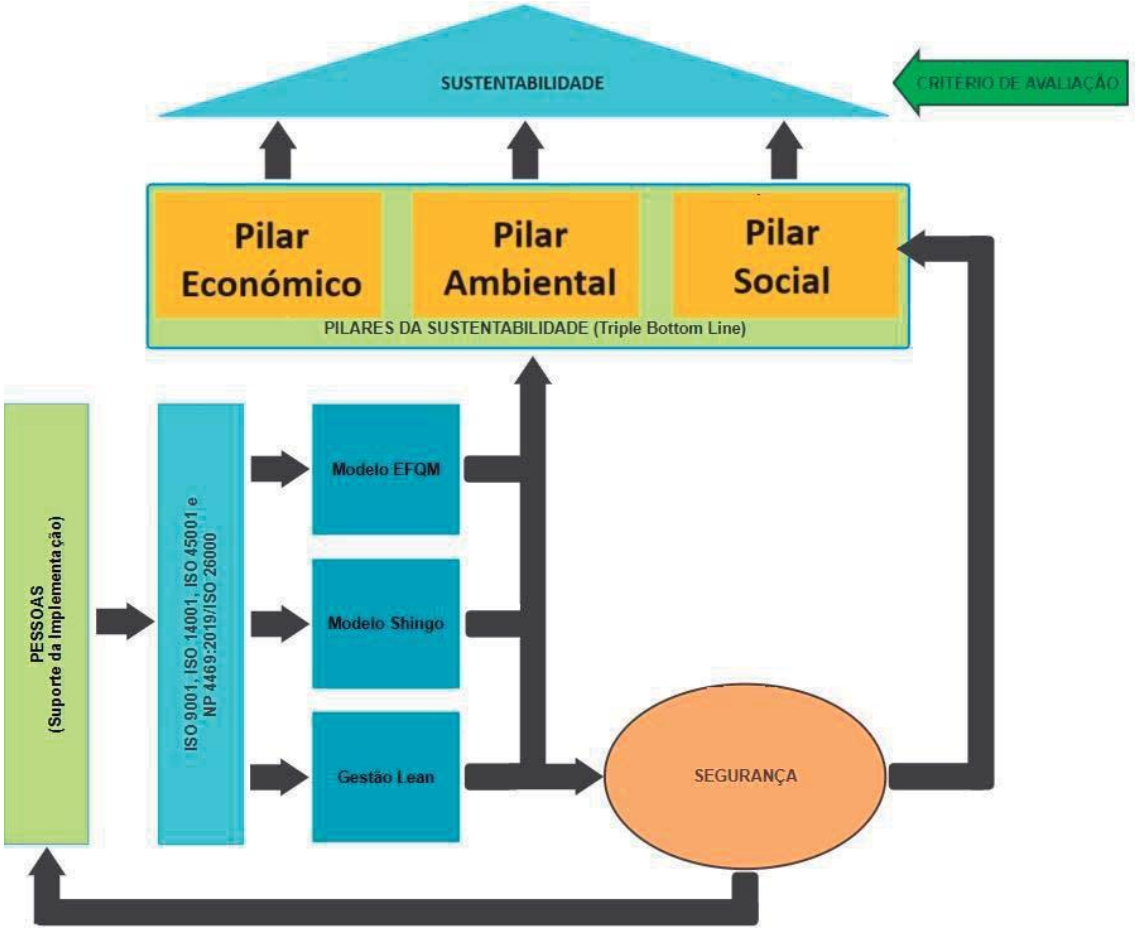


Figura 14 - Modelo conceptual ***OpEx SafeSustain***

Este modelo considera que as pessoas são a peça chave das organizações, e considera que muitas organizações têm já diversos referências normativos de gestão implementados. Sendo as pessoas responsáveis pela sua implementação, gestão e manutenção dos mesmos, ou seja, o seu suporte dos referências normativos. Neste sentido, tenta-se perceber se a adoção destes referências normativos, são uma mais-valia para as organizações que pretendem adotar modelos de excelência como o Modelo *Shingo*, Modelo EFQM e a filosofia *Lean*.

Tendo presente as questões de investigação, o modelo conceptual "*OpEx SafeSustain*", pretende avaliar se estes modelos de excelência contribuem para a sustentabilidade nos seus três pilares (*Triple Bottom Line*), e para a segurança dos colaboradores das organizações. O modelo concetual proposto, considera que o impacto que os modelos tiverem na segurança, irá ter impacto no desempenho dos trabalhadores, os quais são o suporte deste modelo concetual.

1.3 Metodologia

Por forma a ir de encontro aos objetivos propostos anteriormente, foram desenvolvidos trabalhos de investigação, os quais tiveram diferentes metodologias de investigação, tendo os resultados sido publicados em revistas indexadas na base de dados Scopus, e outros apresentados e publicados em congressos internacionais. Seguidamente são apresentadas as diversas opções metodológicas, utilizadas em cada um dos artigos publicados.

O artigo "*Sustainability - B Corporation Geo Distribution*" (Sá et al., 2024), teve como base metodológica um esquema para estudos académicos, onde o contexto social, a literatura, a base de dados e a discussão de artigos de investigação de pesquisa recentes foram o foco principal (Saunders & Thornhill, 2009). Os dados foram recolhidos através da base de dados do sistema de certificação *B Corporation* e foram aplicadas estatísticas descritivas e mapas interativos de georreferência para descrever a distribuição geográfica das empresas *B Corp*. Assim, garantindo que estes métodos são reproduzíveis por outros investigadores. Sendo este um modelo de avaliação da sustentabilidade das empresas, o objetivo era avaliar de que forma este modelo de avaliação se encontra disseminado pelos países.

No que se refere ao artigo "*Development of a conceptual model integrating management systems and the Shingo Model towards operational excellence*" (Carvalho et al., 2023), recorreu-se à metodologia de revisão sistemática de literatura. O objetivo consistiu em, a partir da revisão de literatura, desenvolver um modelo, que integre o Modelo de Shingo, com o Sistema Integrado de Gestão, Qualidade (ISO 9001), Ambiente (ISO 14001), Segurança (ISO 45001) e Responsabilidade Social (NP 4469). No modelo desenvolvido, foi criado um sistema de pontuação, o qual foi validado numa empresa do setor automóvel.

O artigo "*The Development of an Excellence Model Integrating the Shingo Model and Sustainability*" (Sá et al., 2022), seguiu uma metodologia de revisão de literatura sistemática que foi efetuada a partir da base de dados Web of Science (WoS), tendo sido suportada por uma análise Bibliométrica, apoiada pelo software VosViewer. O resultado da revisão de literatura, permitiu identificar quais são as ferramentas *Lean* que têm impacto na sustentabilidade, e qual o impacto em cada um dos três pilares da sustentabilidade, e propor um modelo concetual que suporte a excelência operacional, por forma a orientar as empresas.

O artigo "*A New Conceptual Model for Excellence in Business Towards Sustainable Development*" (Sá et al., 2023), teve como objetivo estudar o potencial contributo que o Modelo EFQM e o Modelo

Shingo poderão ter para a sustentabilidade das organizações (*Corporate Sustainability - CS*). Este estudo foi realizado a partir de uma revisão sistemática da literatura, seguindo a Metodologia Prisma, tendo sido considerados 102 artigos. Na realização da análise bibliométrica recorreu-se ao software VOSViewer. Este artigo contempla ainda, um modelo concetual de sustentabilidade, baseado na relação entre os modelos em estudo e a sua relação com a sustentabilidade.

O artigo "*Science Based Targets and the Factors Contributing to the Sustainable Development of an Organisation from a Literature Review to a Conceptual Model*" (Sá et al., 2023), recorreu-se à metodologia a Metodologia Prisma, tendo-se criado um mapa de correlação através do *VOSviewer*. A partir dos resultados obtidos da revisão de literatura, foi desenvolvido um modelo concetual, que permite integrar as práticas *Lean* com as práticas green, tendo sido definidos um conjunto KPI (*Key Performance Indicator*), no âmbito dos *Science Based Targets* (SBT), por forma a auxiliar as empresas no caminho a adotar para atingirem os objetivos climáticos de forma eficiente.

O artigo *"The Impact of Lean on Occupational Safety in Organisations"* (Sá et al, 2022), teve como metodologia o survey. Foi elaborado um questionário, com 13 questões, para ser aplicado a empresas que tivessem implementado ferramentas *Lean*, com o objetivo de avaliar o seu impacto na segurança. Obtiveram-se 59 respostas válidas, tendo-se observado a existência de melhorias ao nível da segurança.

Por fim o artigo "*Assessment of the Impact of Lean Tools on the Safety of the Shoemaking Industry*" (Sá et al., 2023), utilizou como metodologia a *Action Research* (Robertson, 2006), com o objetivo de estudar o impacto das ferramentas *Lean* na segurança. Para isso recorreu-se ao *Safety Value Stream Mapping* (SVSM), tendo sido feita uma adaptação do *Safety Efficiency Value Stream Mapping* (SEVSM) (Marques et al., 2021). Os resultados obtidos, permitiu verificar a existência de melhorias ao nível da segurança (*Lean Safety*).

1.4 Estrutura da Tese

Esta tese é elaborada através de artigos publicados em revistas indexadas, num total de 7 artigos publicados. Dos artigos que fazem parte desta tese, 5 artigos foram publicados em revistas indexados à Scopus, e 2 artigos foram apresentados e publicados em conferências internacionais. No que se refere à estrutura da tese, ela é composta por este capítulo de introdução (capítulo 1), e mais três capítulos. O capítulo 2 tem como título "Relação Entre Excelência e Sustentabilidade", e é composto por 6 subcapítulos. O primeiro subcapítulo (2.1) é de enquadramento referente ao

tema abordado no presente capítulo. Sendo os restantes 5 subcapítulos referentes aos artigos publicados neste âmbito de investigação. O capítulo 3 tem como título "Impacto de Práticas *Lean* na Segurança", sendo composto por 3 subcapítulos. O primeiro subcapítulo (3.1) é de enquadramento sobre a temática deste capítulo, e os restantes 2 subcapítulos são referentes aos artigos publicados neste domínio.

Por fim, o capítulo 4 encerra com a discussão, conclusões, contribuições e limitações do trabalho, além de recomendações de investigações futuras.

2 RELAÇÃO ENTRE EXCELÊNCIA E SUSTENTABILIDADE

2.1 Enquadramento

A excelência e a sustentabilidade, são um desafio para as empresas, uma vez que ambas contribuem para o sucesso e crescimento das empresas. No que se refere especificamente à excelência, este é um conceito abrangente que tem como objetivo tornar as empresas líderes no seu mercado. Para isso as empresas necessitam de adotar modelos de gestão alinhados com um ou com uma combinação de modelos de excelência existentes de modo que, com o contributo de todos os departamentos, consigam superar as expetativas dos seus clientes.

A obtenção de uma eficiência e produtividade elevadas, são objetivos que as organizações procuram atingir através da adoção de modelos de gestão de excelência, os quais contribuem diretamente para a sustentabilidade. Isto porque processos eficientes não reduzem apenas os custos, mas também reduzem o consumo de recursos e a emissão de resíduos, contribuindo desta forma para a sustentabilidade.

Dando enfase à preocupação do mercado com a sustentabilidade, foi criado em 2006 nos Estados Unidos, o Modelo de certificação *B Corporation*, que procura avaliar os interesses financeiros com um compromisso claro para com a responsabilidade social e ambiental (Paelman et al., 2020). As atividades, o fornecimento e receção de matérias, as doações de caridade, o modelo de negócios, os funcionários, a comunidade, o meio ambiente e os clientes são alguns dos principais índices medidos durante este processo de avaliação. Esta certificação comprova que as empresa reconhecidas como *B Corporation* regem-se pelos mais altos padrões de desempenho atribuindo-lhes uma espécie de selo de confiança para as partes interessadas (Moroz et al., 2018). Podemos mesmo estabelecer uma relação entre o "*B Corporation*" (B-Corp) e o *Triple Bottom Line* (TBL), dado que ambas as abordagens avaliam o desempenho da empresa, considerando não só os resultados financeiros, mas também os impactos sociais e ambientais. A "excelência operacional" e a "sustentabilidade" são áreas-chave nas quais o B-Corp contribui, alinhando-se totalmente com os princípios do *Triple Bottom Line*.

2.2 Sustainability - B Corporation Geo Distribution

O aparecimento do modelo de avaliação *B Corporation*, em 2006, por parte da B Lab, surge na defesa de um novo modelo económico, tendo por base o seu desempenho social e ambiental (Steingard & Gilbert, 2016). Este modelo de avaliação tem como objetivo avaliar o sucesso das organizações, não pelas mais-valias financeiras obtidas, mas sim pelos efeitos benéficos que estas proporcionam a nível social e ambiental (Stubbs, 2017). Sendo *B Corporation* um modelo de avaliação que assenta numa avaliação realizada em cinco dimensões: *Governação, Trabalhadores, Comunidade, Ambiente e Cliente*, e dado esta ser uma das possíveis certificações ou reconhecimentos internacionais que as organizações podem obter na área da sustentabilidade, foi adotado o *B Corporation*, como forma de avaliação do nível de sustentabilidade das organizações (Figura 15).

Figura 15 - Avaliação a sustentabilidade através do B Corporation

O artigo "*Sustainability - B Corporation Geo Distribution*" (Sá et al., 2023), tem como objetivo estudar de que forma a sustentabilidade está a ser uma preocupação a nível mundial por parte das organizações, assim como perceber de que forma está a ser a sua evolução ao longo dos anos.

Sustainability - B Corporation Geo Distribution

José Carlos Sá[1,2(B)], Vitor Silva[1], Luis Fonseca[1,2], Vanda Lima[3], and José Dinis-Carvalho[4]

[1] School of Engineering of Porto (ISEP), Polytechnic of Porto, Rua Dr. António Bernardino de Almeida 431, 4249-015 Porto, Portugal
cvs@isep.ipp.pt
[2] Associate Laboratory for Energy, Transports and Aerospace (LAETA-INEGI), Rua Dr. Roberto Frias 400, 4200-465 Porto, Portugal
[3] CIICESI, ESTG, Instituto Politécnico Do Porto, Rua Do Curral, Margaride (Santa Eulália), 4610-156 Felgueiras, Portugal
[4] Production and Systems Department, University of Minho, Campus de Azurém, 4804-533 Guimarães, Portugal

Abstract. Nowadays, for companies to assert themselves in the markets, the focus on sustainability and social responsibility is preponderant and supported by academic research. For this, certification is considered an essential means to achieve high levels of social responsibility and sustainable development. In this study, we investigate the Geo distribution of the B Corp certification, a certification aligned with the main assumptions of the triple bottom line. Given its novelty, the B Corp certification phenomenon diffusion/evolution, namely its degree of implementation in different countries, has yet to be researched in depth. Hence, this study, supported by data gathered through the B Corporation certification system database, descriptive statistics, and geo-reference interactive maps, maps B Corp certified organizations' geographical distribution and worldwide growth. The sample refers to a total of 2262 companies certified between the period 2017 and March 2021. The result showed a strong presence in the United States and appreciable growth in Europe, allowing for a better understanding of the B Corp diffusion patterns and supporting companies and certification bodies worldwide to emphasize social responsibility and sustainable development.

Keywords: B Corporation · Sustainability · Triple Bottom line (TBL) · Social Responsibility · Certification · Geo-distribution

1 Introduction

Even though sustainability is a straightforward general concept and widely accepted as a good idea in theory, many still need to fully understand the impact and critical necessity of such sustainable development and growth practices. In the last two decades, economic growth has mainly come at the expense of the environment, impacting today's climate change and depletion of natural resources. The relevance of sustainable development (SD) is emphasized by United Nations 2030 Agenda for Sustainable Development [1]

F. J. G. Silva et al. (Eds.): FAIM 2023, LNME, pp. 928–937, 2024.
https://doi.org/10.1007/978-3-031-38165-2_107

and the corresponding sustainable development goals (SDGs) that measure the progress towards SD. Companies are key actors in promoting SD, and emphasis on social responsibility has also increased lately, as socially responsible companies project more attractive images for consumers and shareholders, positively affecting their financial results. Nevertheless, the extent and speed of adopting sustainable practices are insufficient to achieve the Sustainable Development Goals as aspired [2]. Moreover, there is a need for sustainable business models that anchor sustainability at the core of the business and support business operations, preferably within a suitable framework and contribute to ensuring companies enduring success [3]. Due to the potential contribution of B Corp certification to the SDGs and sustainability among companies, the subject has received growing attention in the academic literature [4]. Moreover, there is increased evidence of the mutually beneficial and reinforced relationships between digital transformation and sustainability [5]. Since certification is an essential means for companies and organizations to achieve high levels of Sustainable Development and Social Responsibility [6–9], in this article, we contribute to the B Corporation certification model body of knowledge by studying its geo-distribution, in line with the main goals of the Sustainable Governance Indicators and Triple Bottom Line (TBL) framework. Hence, by highlighting the geographical distribution of B Corp certification worldwide, this study can provide valuable insights to companies that want to pursue sustainability and respond to present and future stakeholder needs.

2 State of the Art

The B Corporation certification model was created in 2006 in the United States and is not limited to the scope of products or services. Social responsibility (SR) emerged to deliver sustainable economic, environmental, and social value to the organization's extended stakeholders and society in general, and B Lab measures companies' entire social, economic, and environmental performance, which is the central pillar of the theory (TBL). The critical metrics measured during the BIA assessment process are the operations, the Supply and input of materials, charitable donations, business model, employees, community, environment, and customers. This certification proves that B Corporation companies are governed by the highest performance standards, giving them a seal of trust for interested parties [10]. Academic studies on the B Corporation reveal that it is a subject with great potential and emerging in the academic community [11], which supports the research question (What is B Corp Geo distribution?) for this investigation. This model is supported by transparency and accountability requirements where B Lab, a not-for-profit organization, administers B Corporation certification. Although little is known about the concept of B Enterprises, the commitment to the (TBL) philosophy catalyzes the sustainable development of the companies and organizations that adhere to it [12]. B Lab is already a well-known organization in the field of certification and is growing fast. Nevertheless, some companies are still reticent concerning the financial impact resulting from the implementation of this certification. However, as shown by a study carried out in the past on the subject, the positive effects on the growth of companies' turnover in the short term, resulting from the increase in transparency and the positive socio-environmental impact observed, outweigh the adverse

effects due to the rigorous procedure of audit [13]. The critical analysis of the potential of this certification, compared to the basic principles of the circular economy, allows an opportunity to portray multiple dynamic points of view concerning stakeholders [14]. Therefore, this research posits that adopting the B Corporation certification can activate circular economy paths due to the action of different stakeholders in an international context. The objective of B Lab is to improve the alignment of companies' missions and measure the impact of their business to meet the highest standards of society today [15]. The commitment to socio-environmental performance, sustainability, transparency, and legal responsibility is part of this pro-social movement and entrepreneurship strategy.

Some studies try to understand the reason and the most common reasons that lead companies and organizations to seek B Corporation certification. The main reasons for seeking this certification are that companies identify their mission with this model and attempt to enhance their values and identity in the markets [16]. Understanding the main reasons that lead interested parties to look for companies certified by the B Corporation is another perspective that deserves some attention. Regardless of whether this certification is a good tool for companies to identify more effective ways of integrating social values into markets, the adoption of green practices and the resulting environmentally friendly image, it can improve the quality of its services/products, which is a crucial success factor [17, 18]. In a survey carried out by academics, it was demonstrated that organizations and companies with strong brands in the markets often believe that they have already reached high ethical standards. However, they aspire for interested parties to know this [19]. According to the author, the B Corporation certification would give them that seal of legitimacy for foreign markets, investors, and customers.

The (TBL) alignment of B Corporation companies acts as driving and motivational forces on the overall assessment of the impact of benefits for the common good. In this context, the B Corporation movement competes alongside existing models as a new paradigm in sustainable development [20]. In the manufacturing scope, other tools, such as Lean, which contribute a lot to the sustainable development of companies [21], maybe an essential part of this sector's growth. The literature on the dissemination of certification (namely, ISO Management Systems certification) is extensive, and results found different geo-distribution patterns and approaches on a worldwide basis [22, 23]. However, given its novelty, the B Corp certification phenomenon diffusion/evolution, namely its degree of implementation in different countries, has yet to be researched in depth. Hence, by investigating the Geo distribution of the B Corp certification, this study provides valuable information for companies and certification bodies worldwide because it allows a better understanding of the B Corp diffusion patterns.

3 Method

The methodological basis of this paper followed a scheme for academic studies, where the social context, literature, database and discuss recent research articles are the principal focus [24]. Data was gathered through the B Corporation certification system database, and descriptive statistics and geo-reference interactive maps were applied to depict the B corporation Geo distribution. Therefore, ensuring these methods are reproducible by other researchers. The B Corp assessment method scores all impact areas

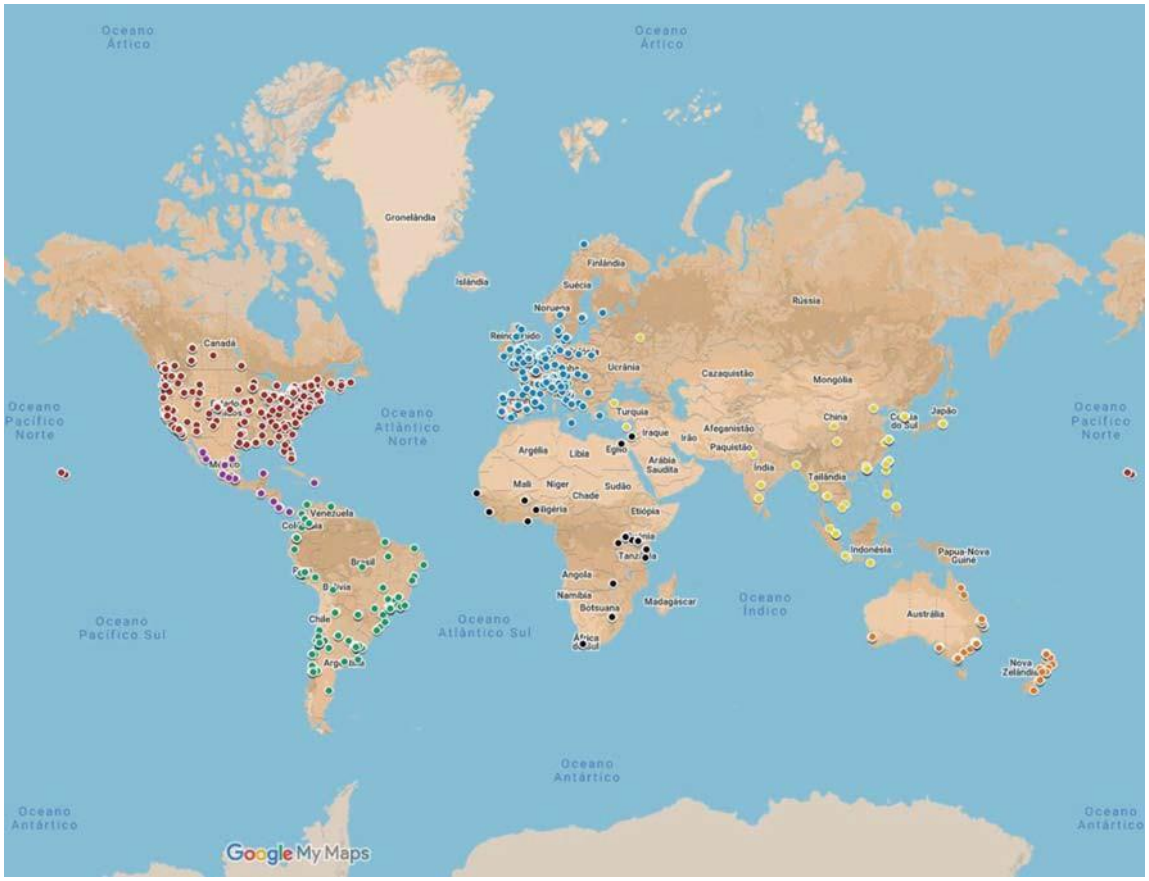


Fig. 1. Map of world distribution of B Corporation (2262 enterprises).

In Europe, the countries that stand out the most are the UK, with 303 certifications, followed by France and Italy, with the same number of B Corp companies, with 87 certifications in each country during the observable sample period. (see Fig. 2).

The most significant number of certified companies is concentrated in the main cities and capitals. However, the geographical distribution in Italy is more homogeneous and not only concentrated in the country's main areas. In addition, Italy was the first European country to introduce a legal framework for benefit companies [25]. This may have contributed significantly to the sedimentation of the B Corporation throughout the country.

The temporal analysis of certification makes it possible to understand in detail the direction of the certification system in recent years. Furthermore, through the data obtained, we could have a concrete perception of the growth of this certification model in all regions of the world.

As we will see below (Fig. 3), of the seven regions analyzed and illustrated in Fig. 1, Europe is the region with the highest growth when it comes to this certification B Corp. Contrary to expectations, the North American region showed, during the same observation period, a deceleration in the growth of the model (see Fig. 3).

The remaining regions with a less significant amount, such as South America, Oceania, and Africa, also showed a negative trend. On the other hand, Asia and Central America showed a slight growth trend with a negligible impact in terms of quantity.

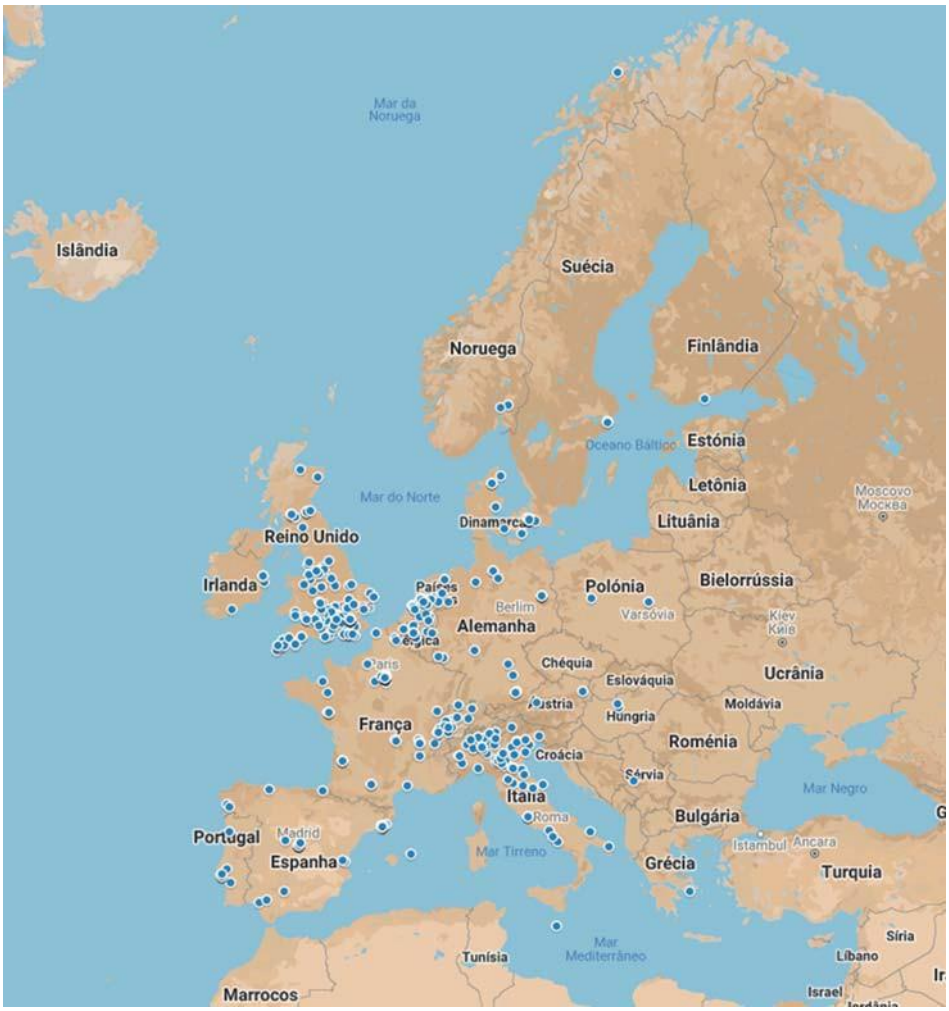


Fig. 2. Map of Europe distribution of B Corporation (Jan.2017 – Mar.2021).

The data analysis also allows for a comparative evaluation relating the two geographical areas with greater representation of the B Corporation and the sector of activity of the companies that obtained the certification. Regarding sectors, the data collected reflects five distinct areas: wholesale and retail, services with minor and significant environmental footprint, manufacturing, and agriculture.

As can be seen from the graphs in Fig. 4, both in the North American region and Europe, the predominant sector of the B Corporation is undoubtedly the service sector with a low ecological footprint.

In proportional terms, we can conclude from this analysis that both regions follow similar sectoral patterns.

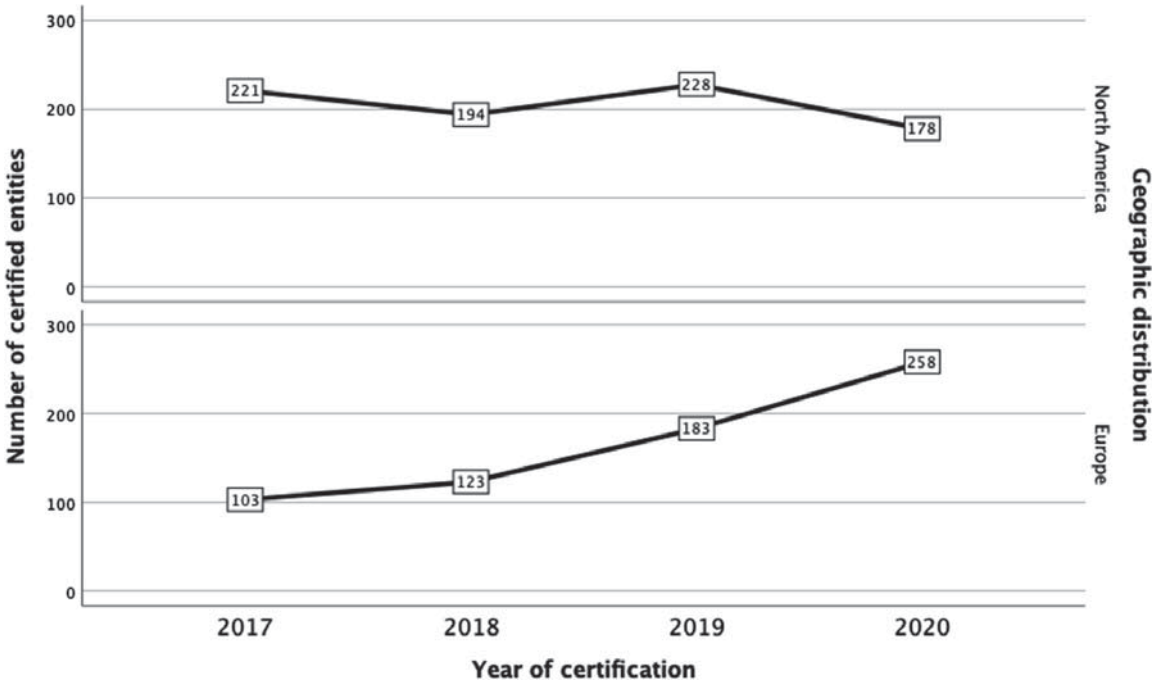


Fig. 3. Growth of the B Corporation in North America and Europe (Jan.2017 – Dec.2021),

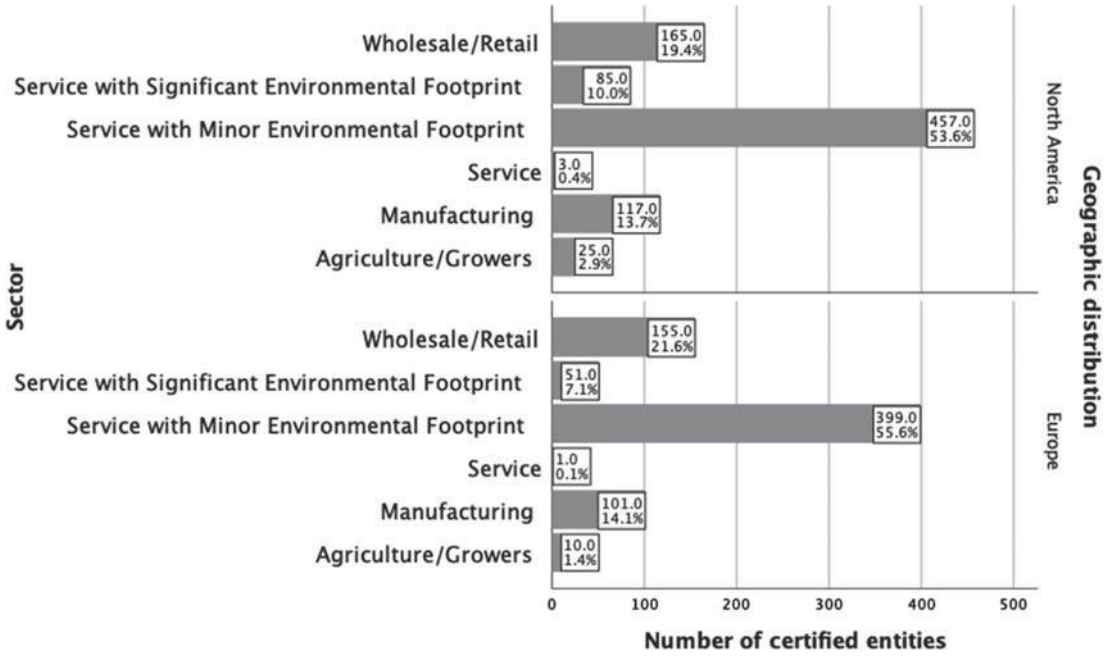


Fig. 4. B Corp certifications by activity sector in North America and Europe (Jan.2017 – Mar.2021).

5 Conclusion

The B Corporation certification model is a subject under development, and there are still many questions surrounding it. However, public articles on this topic have increased exponentially. Some authors, managers, and other stakeholders challenge academics to focus on understanding this certification system, exploring all the perspectives that

involve it to respond to fundamental questions about its evolution and importance in the prosocial context [15].

As we expected in our research, the results show a strong presence of this certification model in the United States, 30.1% of the total sample referring to 2262 companies that have obtained the B Corp seal. However, the countries most adhering to this certification model in the European region are the United Kingdom, ranking second with 13.4%, and France and Italy with 3.8% each. As it is possible to interpret through the graph in Fig. 3, Europe presents a growth trend, even higher than the region where this certification originated. Hence, although B Corp certification does not show the same worldwide spread as ISO Management System Certifications (such as ISO 9001 or ISO 14001), it is consistently growing in other geographic areas outside the United States and Canada, hinting that the B Corp worldwide dispersion is increasing.

Regarding the sectors of economic activity in North America and Europe, the sectoral distribution of the B Corporation is similar in proportional terms, clearly standing out in both the services sector with a low ecological footprint.

Authors [26–29] (e.g., Berrone et al., 2007; Fonseca et al., 2016; Margolis & Walsh, 2003; Mattingly, 2017), have argued that companies that implement social responsibility policies and satisfy the expectations of their stakeholders have higher economic benefits than competitors and achieve positive differentiation. Hence the firm investment policy in sustainability and social responsibility projects or the attempt to open new markets can be the main reasons that may drive European companies and organizations to join this certification. The potential contribution of B Corp certification to the SDGs and sustainability among companies can enhance its market competitiveness and business performance. Moreover, there is increased evidence of the mutually beneficial and reinforced relationships between digital transformation and sustainability [4].

This study gives a clear geographical idea of the demand for sustainable development methodologies. Furthermore, it highlights the differences between countries and world regions and that the manufacturing sector still needs to catch up compared to services. Therefore, additional research could focus on the reasons and conditions for implementing and certifying with B Corp in different world regions. Moreover, another proposed line of future research would be to investigate the role of B Corp within digital transformation and sustainability. Namely, how can B Corp support digital transformation and sustainability, and how does it evolve to ensure synergies with the new paradigms. The main limitation of this research is that the results obtained can be conditioned (i) by the accuracy of the data provided by B Corp and (ii) by the geo-reference interactive maps methodology.

Funding. The authors acknowledge Fundação para a Ciência e a Tecnologia (FCT) for its financial support - UIDB/50022/2020 (LAETA Base Funding).

References

1. UN. Transforming our world: the 2020 Agenda for Sustainable Development A/RES/70/1. United Nations Sustainable Development Goals Knowledge Platform 2015 21 October 2015. https://sustainabledevelopment.un.org/post2015/transformingourworld/publication. Accessed 23 Mar 2020

2. United Nations. (2019). Decade of action: Ten years to transform our world. https://www.un.org/sustainabledevelopment/decade-of-action/. Accessed 23 May 2021
3. Stubbs, W.: Strategies, practices, and tensions in managing business model innovation for sus-tainability: The case of an Australian BCorp. Corp. Soc. Responsib. Environ. Manag. **26**(5), 1063–1072 (2019)
4. Tabares, S.: Do hybrid organizations contribute to sustainable development goals? evidence from B Corps in Colombia. J. Clean. Prod. **280**, 124615 (2020)
5. Birkel, H., Müller, J.M.: Potentials of industry 4.0 for supply chain management within the triple bottom line of sustainability – a systematic literature review. J. Clean. Prod. **289**, 125612 (2021)
6. Fonseca, L.M.C.M.: ISO 14001:2015: an improved tool for sustainability. J. Ind. Eng. Manage. **8**(1), 35–50 (2015)
7. Santos Ferreira, C., Poltronieri, C. F., Gerolamo, M. C.: ISO 14001:2015 and ISO 9001:2015: Analyse the relationship between these management systems standards and corporate sustainability. Gestão & Produção 26(4) (2019).
8. Zimon, D., Madzik, P., Sroufe, R.: The influence of ISO 9001 & ISO 14001 on sustainable supply chain management in the textile industry. Sustainability **12**(10), 1–19 (2020)
9. Fonseca, L., Silva, V., Sá, J.C., Lima, V., Santos, G., Silva, R.: B corp versus ISO 9001 and 14001 certifications: aligned, or alternative paths, towards sustainable development? Corp. Soc. Responsib. Environ. Manag. **29**(3), 496–508 (2022)
10. B Corporation. Certified B Corporation (2021). https://bcorporation.net/. Accessed 30 Jan 2021
11. Diez-Busto, E., Sanchez-Ruiz, L., Fernandez-Laviada, A.: The B corp movement: a systematic literature review. Sustainability **13**(5), 1–17 (2021)
12. Mann, M., Byun, S.E., Ginder, W.: B corps' social media communications during the COVID-19 pandemic: through the lens of the triple bottom line. Sustainability **13**(17), 9634 (2021)
13. Paelman, V., Van Cauwenberge, P., Vander Bauwhede, H.: Effect of B corp certification on short-term growth: european evidence. Sustainability **12**(20), 1–18 (2020)
14. Poponi, S., Colantoni, A., Cividino, S.R.S., Mosconi, E.M.: The stakeholders' perspective within the B corp certification for a circular approach. Sustainability **11**(6), 1–15 (2019)
15. Moroz, P.W., Branzei, O., Parker, S.C., Gamble, E.N.: Imprinting with purpose: prosocial opportunities and B corp certification. J. Bus. Ventur. **33**(2), 117–129 (2018)
16. Gehman, J., Grimes, M.: Hidden badge of honor: how contextual distinctiveness affects category promotion among certified B corporations. Acad. Manag. J. **60**(6), 2294–2320 (2017)
17. Teixeira, P., et al.: Combining lean and green practices to achieve a superior performance: the contribution for a sustainable development and competitiveness-an empirical study on the Portuguese context. Corp. Soc. Responsib. Environ. Manag. **29**(4), 887–903 (2022)
18. Teixeira, P., Sá, J.C., Silva, F.J.G., Ferreira, L.P., Santos, G., Fontoura, P.: Connecting lean and green with sustainability towards a conceptual model. J. Clean. Prod. **322**, 129047 (2021)
19. Villela, M., Bulgacov, S., Morgan, G.: B corp certification and its impact on organizations over time. J. Bus. Ethics **170**(2), 343–357 (2019)
20. Nigri, G., Del Baldo, M.: Sustainability reporting and performance measurement systems: how do small- and medium- sized benefit corporations manage integration? Sustainability **10**(12), 4499 (2018)
21. Silva, S., Sá, J.C., Silva, F.J.G., Ferreira, L.P., Santos, G.: Lean green-the importance of integrating environment into lean philosophy-a Case Study. Lecture Notes in Netw. Syst. **122**, 211–219 (2020)
22. Fonseca, L.M.C.M., Domingues, J.P., Machado, P.B., Harder, D.: ISO 9001:2015 adoption: a multi-country empirical research. J. Ind. Eng. Manage. (JIEM) **12**(1), 27–50 (2019)

23. Fonseca, L., Domingues, P., Nóvoa, H., Simpson, P., dos Guimarães Sá, J.: ISO 9001:2015: the view from the conformity assessment community. Total Qual. Manag. Bus. Excell. **34**, 558–579 (2022)
24. Saunders, M.: Research methods for business students. Pearson India. 5th edition
25. Mion, G., Adaui, C. R. L.: Understanding the purpose of benefit corporations?: an empirical study on the Italian case. International Journal of Corporate Social Responsibility 5(4) (2020).
26. Berrone, P., Surroca, J., Tribo, J.A.: Corporate ethical identity as a determinant of firm performance: a test of the mediating role of stakeholder satisfaction. J. Bus. Ethics **76**(1), 35–53 (2007)
27. Fonseca, L.M.: Strategic drivers for implementing sustainability programs in Portuguese organizations–let's listen to aristotle: from triple to quadruple bottom line. Sustain. J. Rec. **8**(3), 136–142 (2015)
28. Margolis, J.D., Walsh, J.P.: Misery loves companies: rethinking social initiatives by business. Adm. Sci. Q. **48**(2), 268–305 (2003)
29. Mattingly, J.E.: Corporate social performance a review of empirical research examining the corporation-society relationship using kinder, Lydenberg, domini social ratings data. Bus. Soc. **56**(6), 796–839 (2017)
30. Saunders, M., Lewis, P., Thornhill, A.: Research Methods for Business Students. 7th edn. Pearson, Harlow (2016)

2.3 Development of a Conceptual Model Integrating Management Systems and the Shingo Model Towards Operational Excellence

São cada mais as organizações que procuram melhorar o seu desempenho ao nível da sustentabilidade, através da adoção de referências normativos ISO (Ferreira et al., 2019). Ronalter e Romaní (2023) referem mesmo num estudo que desenvolveram com um número alargado de empresas, que a adoção de referências normativos nas áreas da gestão da qualidade (ISO 9001) e gestão ambiental (ISO 14001) têm impacto positivo nos três pilares da sustentabilidade (TBL).

Por forma a consolidar o modelo conceptual ***OpEx SafeSustain***, o modelo inclui para além dos referenciais normativos ISO 9001 e ISO 14001, os referenciais normativos NP 4460 (ISO 26000) e ISO 45001, por forma consolidar a avaliação do impacto dos referenciais normativos no pilar social (Figura 16).

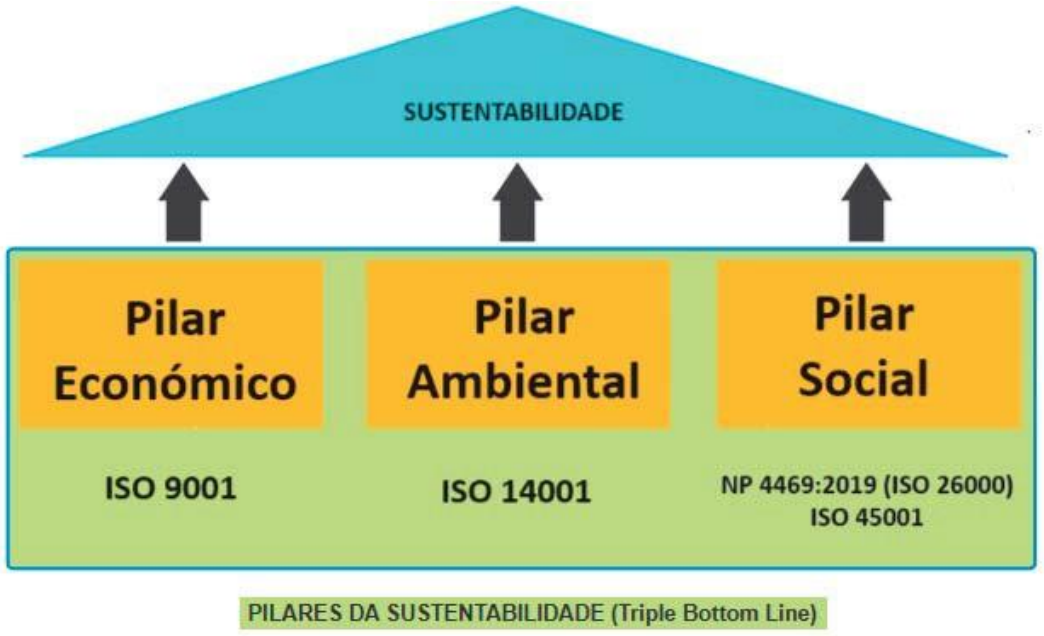


Figura 16 - Impacto dos referenciais normativos ISO na Sustentabilidade

O artigo "*Development of a Conceptual Model Integrating Management Systems and the Shingo Model Towards Operational Excellence*" (Carvalho et al., 2023) tem como objetivo avaliar de que forma a adoção dos referenciais normativos ISO 9001, ISO 14001, NP 4460 (ISO 26000) e ISO 45001 por parte das organizações, pode contribuir para as organizações adotarem o Modelo de Shingo (Figura 17), e desta forma contribuírem de forma positiva para a sustentabilidade das organizações.

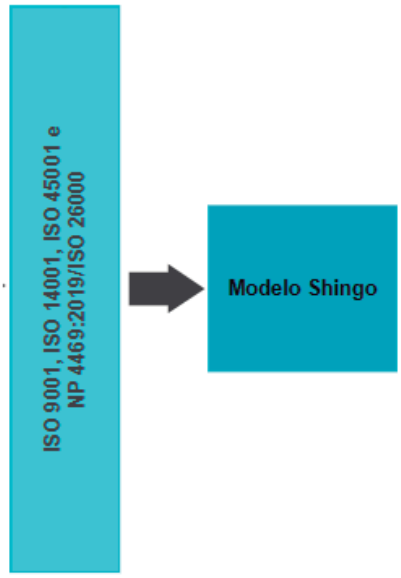


Figura 17 - Impacto de normas ISO no Modelo Shingo

Routledge
Taylor & Francis Group

Total Quality Management & Business Excellence

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/ctqm20

Development of a conceptual model integrating management systems and the Shingo Model towards operational excellence

Mariana Carvalho, José Carlos Sá, Pedro Alexandre Marques, Gilberto Santos & António Mário Pereira

To cite this article: Mariana Carvalho, José Carlos Sá, Pedro Alexandre Marques, Gilberto Santos & António Mário Pereira (2023) Development of a conceptual model integrating management systems and the Shingo Model towards operational excellence, Total Quality Management & Business Excellence, 34:3-4, 397-420, DOI: 10.1080/14783363.2022.2060810

To link to this article: https://doi.org/10.1080/14783363.2022.2060810

Total Quality Management, 2023
Vol. 34, No. 4, 397–420, https://doi.org/10.1080/14783363.2022.2060810

Development of a conceptual model integrating management systems and the Shingo Model towards operational excellence

Mariana Carvalho [a], José Carlos Sá [a,e], Pedro Alexandre Marques [b], Gilberto Santos [c*] and António Mário Pereira [d]

[a]*School of Engineering, Polytechnic of Porto, Rua Dr. António Bernardino de Almeida, 431, 4200–072 Porto, Portugal;* [b]*EIGeS–Research Centre in Industrial Engineering, Management and Sustainability–Lusófona University, Campo Grande, 376, 1749–024 Lisbon, Portugal;* [c]*School of Design–Polytechnic Institute Cávado Ave–Campus do IPCA, 4750–810 Barcelos, Portugal;* [d]*ESTG/CDRsp–Polytechnic Institute of Leiria, Portugal–Campus 2, Morro do Lena–Alto do Vieiro, 2411–901 Leiria, Portugal;* [e]*INEGI – Institute of Science and Innovation in Mechanical and Industrial Engineering, Rua Dr. Roberto Frias, 400, 4200–465 Porto, Portugal*

To remain competitive in the marketplace, organizations are seeking the adoption of management models and tools that will allow them to find better and more effective practices to reinvent themselves, and continuously improve their business processes and product's quality in a sustainable way, hence pursuing the ultimate goal of reaching enterprise excellence. The purpose of this paper is to present a conceptual model that relates the requirements of the ISO Management System Standards with the dimensions and guiding principles of the Shingo Model for Operational Excellence. The proposed approach allows an organization with and existing management system based on one or more ISO Management System Standards to adopt and perform an assessment tool to evaluate its level of maturity regarding the adoption of the best practices and behaviours prescribed by the Shingo Model, which is a novelty contribution of this research. The validation of the proposed assessment tool took place in a Portuguese organization from the automotive sector, having comprised two moments: in the first one, an external assessor performed a set of behavioural observations that acted as a base to assign a score, while in the second moment such score was internally obtained through a survey that was filled by the organization's employees. The results reveal that these two methods converge to similar conclusions, hence confirming that the proposed model has the potential to enable an organization to assess the maturity level of its management system regarding the adoption of the guiding principles of the Shingo Model for Operational Excellence. A limitation of this research is that the model was only validated in a single company.

Keywords: Integrated management systems; Shingo Model; operational excellence; ISO 9001; continuous improvement; corporate social responsibility

Introduction

Having a certified management system is an important factor for the development of organizations and for the sustainability of their results and performance (Bernardo et al., 2015; Bravi et al., 2020; Teixeira et al., 2021). Among all the available Management System Standards (MSS), ISO 9001 for Quality Management Systems (QMS) is the widest-spread reference. Research from Chatzoglou et al. (2015) and Aba et al. (2015) provide strong evidence that the implementation of ISO 9000 is highly associated with improvements in the overall financial performance of a company. Zayas-Mateo and Martínez-

*Corresponding author. Email: gsantos@ipca.pt

Lorente (2021) concluded that certified industrial companies tend to achieve better outcomes than their non-certified counterparts, while Psomas et al. (2013) demonstrated that certified service companies tend to present greater product/service quality and operational performance compared with non-certified ones (Barbosa et al., 2018; Costa et al., 2019; Jiménez-Delgado et al., 2020).

In addition to the fact that the majority of the published literature does suggest that the benefits of ISO 9001 certification can last over long periods of time (Araújo et al., 2019; Sá et al., 2019). Cândido et al. (2016) found that even after decertification, organizations tend to exhibit sustainability in the performance of their business processes.

After years of strong and consecutive growth in the number of ISO 9001 certificates issued worldwide, data from the latest available ISO Survey (ISO, 2020) show a slight downward trend since 2014, especially in European countries. Ferreira and Cândido (2021), Mastrogiacomo et al. (2021) and Kafel and Simon (2017) are amongst the researchers that explored the reasons behind ISO 9001 decertification. Certification sets the path for the achievement of Operational Excellence (Oakland, 2014) is related to the values and culture of an organization and is particularly relevant for those who aspire to grow and prevail in the face of competition (Correia et al., 2021; Doiro et al., 2019; Santos et al., 2021; Santos, Sá, et al., 2019; Zgodavova et al., 2020).

Many organizations have decided to develop and implement more than one management system in place. In addition to ISO 9001, there has been a proliferation of other MSS with different but complementary scopes (Bernardo et al., 2015; Samani et al., 2019), including ISO 14001 for Environmental Management Systems (EMS) and ISO 45001/OHSAS 18001 for Health and Safety Management Systems (H&SMS). Because opting for individual implementation of MSS will lead to a sub-optimization of each management system and to an excessive focus on the fulfilment of specific requirements (Carvalho et al., 2020; Rebelo et al., 2016), many organizations realized that it is a more effective and efficient approach to integrate the requirements of multiple MSS. The benefits, as well as the challenges of developing, implementing and maintaining an integrated management system (IMS), have been described by many authors, including Zeng et al. (2011), Simon et al. (2012), Santos et al. (2011) and Moumen and El Aoufir (2018).

According to Bernardo et al. (2015) and Barbosa et al. (2020), organizations that have their management systems fully integrated into a single and often certified management system can usually sustain their results and performance. Corporate sustainability is a dynamic concept that is impacted by specific environmental, economic and social aspects and priorities, which will continually change (Asif et al., 2011). An IMS usually comprises the economic (ISO 9001), environmental (ISO 14001) and social (ISO 45001 / OHSAS 18001 in terms of health & safety and/or ISO 26000 / SA 8000 for social accountability) pillars of sustainability (Borella & Borella, 2016). As underlined by Jørgensen et al. (2006), the continuous improvement of an IMS strongly depends on the development of a Lean infrastructure to meet the stakeholders' needs. However, many companies make mistakes in implementing Lean because they tend to focus on specific tools and techniques that are not well adapted to their organizational setting (Oakland, 2014; Plenert, 2019). The difference between successful and unsuccessful efforts actually relies on their ability to ingrain into its culture timeless and universal operational excellence principles rather than rely on the superficial implementation of tools and programs (Patel, 2016).

The Shingo Model is the most well-known and globally accepted framework used to guide the implementation of an operational excellence system (Carvalho et al., 2019).

This approach includes a well-established focus on the customer and Lean tools, but has extended this to include a set of guiding and supporting principles, corporate culture and wider enterprise systems, such as strategy planning and deployment, people lifecycle management, among others. Despite its international diffusion, very few studies or research are available in linking the Shingo Model with international MSS. This paper contributes to fill this gap.

Therefore, the aim of this paper is to present a model that integrates the requirements of the ISO MSS with the dimensions of the Shingo Model. In particular, a new tool that allows organizations to assess and quantify the maturity level of their management systems in adopting the best practices from an operational excellence point of view. The manuscript is organized around five sections: after an extensive review of the literature, the methodology adopted during the case study is described, being followed by the presentation and discussion of the obtained results. Finally, the conclusions of the paper are summarized.

Literature review

Integrated management systems

An IMS combines different but related components of a business into a single system for easier management. The most common IMSs comprise three management subsystems: Quality (QMS/ISO 9001), Environmental (EMS/ISO 14001) and Occupational Health & Safety (OHSMS/ISO 45001 and OHSAS 18001). IMS involving these three types of MSS have been generally used to enhance operational performance in manufacturing systems (Abisourour et al., 2020; Matias & Coelho, 2002; Rebelo et al., 2014a), to promote the value created by organizations (Deif & ElMaraghy, 2017; Gonçalves et al., 2019; Santos, Gomes, et al., 2019), and to support the role of the knowledge management process within the organizations (Gunasekaran & Ngai, 2007; Yang & Lu, 2015).

With the expansion of the global markets in recent decades, nations have become part of a process of globalization, which has increased industry competition (Alves & Alves, 2015). Due to competitive and societal pressures, many organizations have begun to develop strategies for addressing the 'triple bottom line' of their overall economic, environmental and social performance (Edgeman & Eskildsen, 2014; Rocha et al., 2007). This reality fostered the adoption of IMS, such as the ones dedicated to Quality (ISO 9001), Environment (ISO 14001) and Occupational Health & Safety (OHSAS 18001 and ISO 45001), which is a strategic decision of relevant importance for the competitiveness of an organization and to the sustainability of its results (Moumen & El Aoufir, 2018; Murmura et al., 2021; Rebelo et al., 2015).

The proliferation of national and international certifiable MSS that took place from the beginning of the century imposed a set of challenges for companies to effectively integrate them (Beckmerhagen et al., 2003; Bernardo et al., 2010; Santos et al., 2014). For this reason, in 2001 the International Organization for Standardization published the ISO Guide 72, a document to be used by the Technical Committees members when developing or reviewing all new international MSS (Karapetrovic, 2003). ISO Guide 72 defined a set of common elements for all MSS issued by ISO, thus providing a rational order for IMSs, based on the PDCA cycle (Basaran, 2017). In addition, some national standards organizations, including BSI from Great Britain and AFNOR from France published the PAS 99 and AC X 50-200, respectively, which are two specifications that provide guidelines and a common structure to facilitate the integration of different MSS. In 2012, ISO launched Annex SL with the intent to help organizations to achieve the benefits from integrating

the requirements of all international MSS into a common and single structure (Marques et al., 2016; Nunhes et al., 2019).

As various authors have pointed out, companies can benefit from specific advantages provided by a fully IMS, including a greater potential for innovation (Bernardo et al., 2018), an enhanced ability to control business and operational risks (Hernandez-Vivanco et al., 2018; Moumen & El Aoufir, 2018), less bureaucracy, costs and duplication of tasks (Rebelo et al., 2014b; Ribeiro et al., 2017; Santos et al., 2011; Zeng et al., 2007) and a better capacity to meet customer needs (Nunhes et al., 2019; Simon et al., 2012). Authors like Talapatra et al. (2019), Santos et al. (2014) and Zeng et al. (2011) provide an extensive literature review about the advantages as well as the constraints in integrating different MSS.

Some researchers studied IMS from various viewpoints, including the impact of certification on the performance of organizations. Hernandez-Vivanco et al. (2019) analysed the impact of adopting multiple certifications on firm performance, in particular all possible combinations encompassing the ISO 9001, ISO 14001 and OHSAS 18001/ISO 45001 standards, having concluded that ISO 9001 is the common factor in all combinations of certifications that leverage firm's performance. According to Bernardo et al. (2018) and Rebelo et al. (2016), the process of integrating multiple MSS can be divided into the following four domains: (a) integration strategy, (b) integration methodology, (c) integration level and (d) systems' auditing integration. The first domain corresponds to the scope and implementation sequence, having been addressed by authors like Karapetrovic (2003) and Rocha et al. (2007). The integration methodology refers to the methodology or tools used in the integration process, where frameworks such as those proposed by Asif et al. (2011) and Rebelo et al. (2014b) have been developed. The integration level is a domain that corresponds to the level of integration, and has been subject of research by Jørgensen et al. (2006), Santos et al. (2011) and Rebelo et al. (2016). The last domain, which was addressed by authors like Simon et al. (2011) and Rebelo et al. (2016), concerns the integration of both the internal and external audits that may result in certain benefits.

Lean

To achieve the outlined objectives and to sustain business growth, an organization needs to adopt a mindset that contemplates the maintenance of its activities and processes whilst continually improving them (Félix et al., 2019; Santos et al., 2020), where some risks may appear (Ferreira et al., 2019). One of the ways to aid this achievement is through Lean (Jiménez et al., 2019; Rodrigues et al., 2020) with the help of computer tools (Marinho et al., 2020; Santos, Mandado, et al., 2019).

The concept of Lean Management can be traced to the Toyota Production System (TPS), a manufacturing approach pioneered by the Japanese engineers Taiichi Ohno and Shigeo Shingo (Arnheiter & Maleyeff, 2005). The term 'Lean' was coined by John Krafcik (1988) and began to attract greater attention due to the influence of Womack et al. (1990), in the United States of America, through the publication of the book 'The Machine That Changed the World', which quickly became quite popular because it highlighted the discrepancy in success between other car manufacturers and Toyota, unveiling why it was so efficient. As such, the foundations of the Lean philosophy can be traced to one of the most popular production models developed by the Japanese – the Toyota Production System (TPS). This model supports the entire way of working and the results obtained by Toyota, so much so that in their publication Womack et al. (1990), define Lean through the following quote: '(…) *Compared to mass production it uses less of*

everything – half the human effort in the factory, half the manufacturing space, half the investment in tools, half the engineering hours to develop a new product in half the time.'

The overall objectives of Lean are to improve production methods, increase the efficiency, quality and speed of processes, eliminate waste and reduce costs (Rodrigues et al., 2019). The prevailing assertion within a substantial amount of the literature describes Lean as an approach in which the main objective of Lean is to systematically identify and eliminate waste in the organizational processes (Bhasin, 2015). One of the key points to achieve these goals is the concept of 'Value' from the customer viewpoint, since it concerns all activities that justify the attention, time and effort dedicated to them, helping to identify where waste exists and, at the same time, where the opportunities for improvement reside. The Lean toolbox is used to eliminate anything that does not add value to a process (Bhuiyan & Baghe, 2005). According to Womack and Jones (2003), 'Value' can be defined as the '*product's or service's capability provided to a customer at the right time at an appropriate price, as defined in each case by the customer*'.

The success of the implementation and operation of Lean in an organization is dependent on the adhesion and involvement of employees as well as on the correct application of the tools at their disposal (Borris, 2006). Liker (2004) identified 14 principles for the success of any Lean program. They were clustered around four groups and the following two pillars: continuous improvement (kaizen) and respect for people. Kaizen, the first pillar, is defined as a culture of sustained improvement targeting the elimination of waste in all systems and processes of an organization (Bhuiyan & Baghe, 2005). The second pillar, respect for people, relies on respecting every single individual (Miller, 2018).

Many Lean tools can be applied depending on the panorama and the specific needs of the organization. When Lean philosophy is put into practice and tools employed in a structured way, organizations can achieve significant benefits with impact on their business results, as can be derived from the countless positive testimonies found in the literature. Through the research carried out for this paper, some successful case studies described in the available literature were selected for clarification and further analysis, regarding the business sectors where they were conducted. The following references were considered:

- Ribeiro et al. (2019): A reduction of 70% in the time spent on non-value-added tasks of an automotive production line, such as transportation during painting, waiting and unnecessary over-processing, was achieved. Tools like 5S's, visual management and SMED (Azevedo et al., 2019; McIntosh et al., 2000) were utilized. Altogether, these improvements allowed the organization to save 10.9% of the total investment planned, but also improvements on the employees' morale.
- Rodrigues et al. (2019) explored the advantages of implementing Lean to get quick-wins in terms of results. The authors describe the case of a small-medium enterprise (SME) from the metallurgical sector that obtained notorious results just 3 months after the implementation of a Lean program. The company was able to obtain a decrease of 27.9% in the costs of non-quality per hour, an increase of 5% in the machine occupancy rate, reduction of 10% in the hourly costs resulting from defective products. These advantages were also reflected in the motivation of the employees.

The search for published case studies illustrating successful implementations of Lean allowed us to ascertain that several gains can be obtained and translated into quantifiable benefits (e.g. cost avoidance, reduction of travel distances, a decrease of inventory levels, among others). Other types of benefits, including the improvement in the well-being, safety

and motivation of the employees, are sometimes also mentioned in the literature. Both types of gains are extremely relevant and important for organizations since they are likely to impact can affect their performance, although in different ways.

Nevertheless, it is also important to note that, in practice, not all attempts to implement Lean are so successful. This is due to the fact that some organizations exhibit a restrictive approach in eliminating waste by excessively focusing on the usage of tools, without considering the importance of systems and corporate culture to sustain results in the long run (Hines et al., 2020).

Management systems and lean

Lean was conceived as a total management system, not just for the manufacturing floor, so it needs to be a part of the company's QMS. Authors such as Sá et al. (2022), Salah and Rahim (2019), Marques et al. (2019), Marques et al. (2016) and Micklewright (2010) developed frameworks to take advantage of synergies between a QMS based on the ISO 9001 standard and a Lean management system.

Sá et al. (2022) developed a complete ISO 9001 interface model, where a set of Lean and Six Sigma tools are allocated to each of the 10 clauses of requirements of ISO 9001:2015. The authors also studied the degree of adoption of different tools by a set of surveyed companies. Marques et al. (2016) came up with a model that adopts the high-level structure provided by ISO Annex SL to take advantage of the existing linkages between the clauses of requirements of ISO 9001:2015 with the activities that usually take place in a Lean Six Sigma program. This model was further developed by Marques et al. (2019) that allocate a wide set of Lean and Six Sigma tools to each clause of requirements of the ISO 9001:2015 standard. Salah and Rahim (2019) presented a set of approaches to make use of Lean and Six Sigma tools to systematically improve and standardize organizational processes. According to Micklewright (2010), Management Systems (more specifically QMS based on ISO 9001) are complementary with the Lean tools, as long as developed knowledgeably and carefully, to result in gains for the organization. More than that, considering the current dynamics and challenges of the global markets, that are demanding and constantly changing, organizations must develop agile Management Systems capable of meeting the stipulated objectives. To achieve this, the operationalization of a Management System benefits from having Lean-based tools and methodologies aligned with the requirements of the standards (Sá et al., 2022).

In the Portuguese reality, studies such as those of Nogueira et al. (2018) and Sá et al. (2022) allow the understanding that although there may be some barriers within the organizations surpassing them is possible. One of the key success factors is the incorporation of Lean tools and methodologies in the overall Management System. Besides, it shows that to achieve a better and sustained performance, the application of tools, needs to have a purpose within the overall system.

The Shingo Model

Toyota Production System (TPS) was more than a simple production system, since it was developed as a company-wide management system (Miller, 2018; Sugimori et al., 1977). Whereas Taiichi Ohno's career remained with Toyota, Shigeo Shingo introduced these concepts to many other industries, not only in Japan, but also in the US and in Europe (Oakland, 2014; Rüttimann & Stöckli, 2016; Shingo, 2019).

Enterprise culture, which is the base for all involvement activities, is both a result and an enabler for sustainable and successful Lean operations (Bhamu & Sangwan, 2014). Culture is a collection of values, beliefs and behaviours held by an organization and the individuals within the organization (Plenert, 2019).

The Shingo Institute, an organization affiliated with the Utah State University, created the Shingo Model for enterprise excellence in 1993. The latest version of this model was updated at the beginning of 2020. It provides a set of guiding principles that supports the purpose and evidence of a culture (Plenert, 2019). The model emphasizes the behavioural and cultural part of organizations without forgetting the importance of integrating Lean philosophy, so that transformation and development can occur with the desired results (Shingo Institute, 2020). The related parameters correspond to:

- Guiding Principles – These refer to basic rules that ensure the understanding of the consequences of behaviour, allowing the decision making to be made in a more informed way. There are 10 guiding principles in the Shingo Model and they are organized around three dimensions, as depicted in Figure 1.
- Systems – These correspond to sets of processes, people or procedures that interact with each other, through the selection of tools that allow the implementation of the Guiding Principles;
- Tools – These refer to all the instruments that enable and assist the systems, allowing the intended results to be achieved;
- Results – The results obtained should mirror the Guiding Principles. As such, the ideal results will be all of those that classify as sustainable in the long term and that demonstrate constant improvements over time, originating from ideal behaviours.

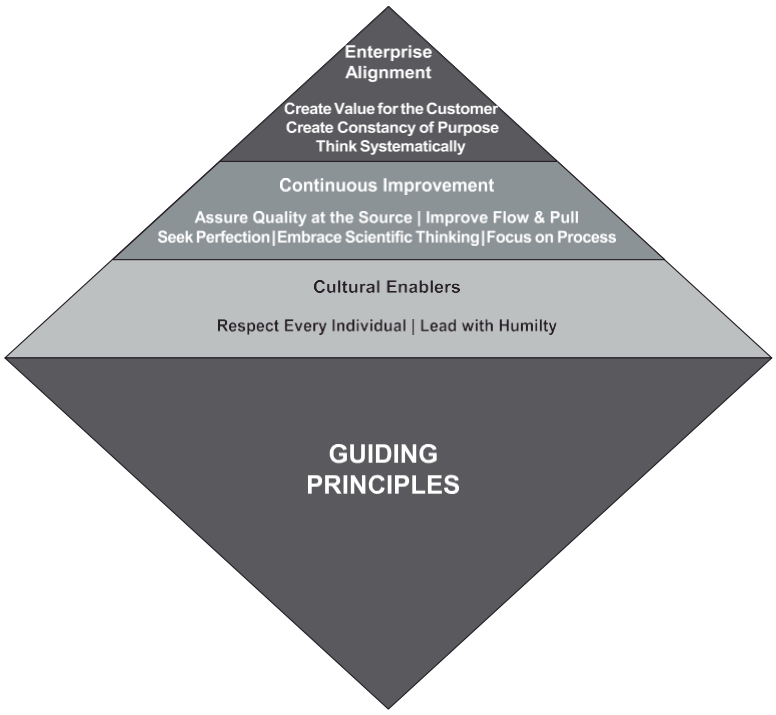


Figure 1. The guiding principles of the Shingo Model.
(Source: Shingo Institute, 2020).

In Shingo's view, Excellence – the achievement of ideal results – is only valid when it is not temporary and when it is achieved through the combination of know-how and know why (Matos, 2015).

An award which assesses the level of transformation of organizations and recognizes their operational excellence, called The Shingo Prize, was created in 1988 (Edgeman, 2018). This assessment is carried out through a scoring system developed and perfected throughout the years by the Shingo Institute. Every component of each dimension is evaluated according to a scale, which considers the best description of the organization's current practices and their corresponding level of maturity. There are three levels. Level 1 means that the organization is mainly guided by tools, using some methods to solve sporadic problems. In Level 2, the organization is at an intermediate transformational phase where it already uses the tools in a structured and integrated way. Finally, the most advanced level of transformation corresponds to Level 3, in which the organization is guided by the Guiding Principles, incorporating them in their culture and in the way they work. These levels of maturity apply to each dimension or layer of the model depicted in Figure 1. It is important to emphasize that each layer can have different levels of maturity.

In general, the Shingo Model is perceived as a tool that can help organizations in the search for better results in all of its dimensions, as long as it is properly implemented (Edgeman, 2018). However, there are few research available in the literature and validated in real organizations, that describe the gains and the limitations associated with the implementation of the Shingo Model.

Research studies such as those described by Bravo-Sanchez et al. (2018) focus on the integration of Lean practices with the principles outlined by the Shingo Model. According to the authors, the advantages of the Shingo-Lean alliance lie in the fact that it fosters a much stronger collective alignment within the organization around the need of designing, developing, implementing and maintaining systems capable of driving an effective cultural transformation. The practical component of their research work took place in a healthcare company where the authors conceived and tested an Interprofessional Lean Facilitator Assessment Scale (ILFAS), a tool that helps to measure both technical and 'soft' skills levels of Lean facilitators, attributes that have a significant impact on the results of the improvement initiatives they coordinate, regarding indicators of quality, safety and reliability. Kelly and Hines (2019) provide a clear view of the direct effects resulting from the implementation of the Shingo Model in the long term. The case presented by the authors concerns a pharmaceutical company where the consolidated results were measured over a period of six years. The reported benefits include cost savings of more than 22 million Euros. Also, a reduction of the non-compliance rate by 77%, as well as the lead-time which decreased by 38%, and a decrease of 69% in the damaged inventory. The positive impact of the Shingo Model was also observed in the morale and attitude of employees, due to the focus on training and education that led to the internal promotion of 419 employees.

3. Methodology

The research methodology was divided into two stages. The first one comprised the idealization and development of the model focusing on the integration of the Shingo Model with MSS. To achieve this, a literature review was conducted to understand the state of the art on the subject, thus enabling the identification of gaps in the existing available research. Then, the specific MSS under the scope of this research were defined. The following

international MSS were considered for the model: ISO 9001:2015 (Quality Management System), ISO 14001:2015 (Environmental Management Systems) and ISO 45001:2018 (Occupational Health and Safety Management Systems). Due to the specific context of the country, a national Portuguese MSS was also included: NP 4469:2019 (Social Accountability Management Systems).

The second stage allowed us to develop the model itself, particularly in establishing a connection between the requirements contained in the mentioned MSS with the framework provided by the Shingo Model. A matrix format scoring system, derived from this integration model, was also proposed. The matrix can be used as an assessment tool, was designed to incorporate the following three parameters:

- MSS, namely the four international standards previously mentioned: ISO 9001:2015, ISO 14001:2015, ISO 45001:2018 and NP 4469:2019;
- Lean tools, methods and concepts;
- The Shingo Model with its framework and guiding principles. One of the tools provided by this model is The Shingo Prize assessment that was used as a benchmark for the design, development and application of the matrix assessment tool herein proposed.

The proposed model is based on the assumption that all these parameters interact with each other, which means that it is not recommended to disassociate them and, as such, the effects of one parameter will have direct or indirect consequences on the others. Thereafter, the mentioned three areas ought to be regarded as part of an integrated and dynamic system, so one of the most important contributions of this research consisted of the analysis of the interaction between these different parameters. Regarding the first parameter, the four MSS referred above were analysed individually to determine which of their requirements are common and which of them are exclusive to any of the standards. From this analysis, it was concluded that regarding the specific scope of each standard, all the requirements could be related to each other. This analysis proved to be important in the sense that it allowed the confirmation that all MSS relate in a similar way with the Shingo Model, hence meaning that the weight considered for each Management System was the same.

The conceptual model was then tested in an organization from the automotive sector to be validated. The following three complementary assessment tools were incorporated into the model being tested in the host organization:

- A holistic preliminary qualitative assessment was carried out by an evaluator. This assessment approach contemplates behavioural observation of teams from different departments on their day-to-day activities.
- A quantitative assessment that consisted of a scoring system spreadsheet, filled out by an evaluator, who quantitatively ranks the observations gathered.
- A quantitative assessment approach uses a survey that is filled out by the employees.

The internship in the company where the model and its tools were tested took place at the Quality, Environment, Safety and Kaizen Department of a Portuguese corporation from the automotive sector. This company was chosen because its leaders expressed the desire to implement the Shingo Model in the future. At the beginning, it was struggling to assess its level of preparation to incorporate the Shingo Model principles and guidelines, given

the focus of the company is almost exclusively on the MSS that comprise the company's implemented IMSs.

The operational work of the research was performed by a master's student enrolling on a master thesis in this internship. She was a student of Graduation's Degree in Bio Resources. The work of the internship revolved around this study. Two evaluators with many years of experience in implementing management systems in companies as consultants were chosen. Both are also professors at the university. One of them is an external assessor and a Visiting Guest Lecturer (Executive MBA in Management) who also conducts research at the Research Centre in Industrial Engineering, Management and Sustainability. The other evaluator is a professor on the university staff, but with extensive experience in the implementation of management systems in a wide number of companies.

The first assessment is characterized for being highly subjective and dependent on the evaluator's point of view; nevertheless, it is a fundamental initial step to be able to perform the subsequent ones, since the whole model relies on behavioural judgments from the part of the evaluator.

Regarding the second assessment, the spreadsheet depicted in Table 1 was developed considering the associations between the clauses of requirements described in the ISO 9001:2015, ISO 14001:2015, ISO 45001:2018 standards and the principles contained in the dimensions or levels of the Shingo Model. This allowed us to match the clauses of requirements of the MSS with the correspondent dimensions of the Shingo Model. Although the requirements of these standards were not always designated in the same way (regulatory requirements described on Table 1), they are all related to each other, safeguarding the specific scope of each one.

The scores for each dimension are assigned by an evaluator and recorded in the spreadsheet. If the organization shows clear evidence in complying well with the evaluated dimension, the assigned score for that dimension is 17.24 points; on the other hand, if there are none or even few evidences regarding such compliance, than the assigned score is zero points. The maximum total score for the overall grid was 1000 points, allowing an easy comparison to already the existing Excellence models.

The third assessment conducted during the internship consisted of a survey comprising 15 closed questions, as depicted in Table 2 and Figure 2. With the intent of covering all departments of the company, a Google Forms survey was sent by e-mail to all the 165 employees of the company, hence comprising its whole set of areas. From the overall responses received, only 80 of them were considered valid, which represents a rate of 48.48%. This is considered the sample for our research.

Results and analysis

Through behavioural observations, the 'results' dimension (also referred to as dimension 4) was highlighted as a strength aspect, since the organization showed evidence of keeping track of business, management and operational performance indicators, considering the opinion of the employees. Similarly, the 'cultural enablers' dimension (also known as dimension 1) was also pinpointed as a strong point due to the clear sense of corporate values and culture that was shared throughout the organization by the employees, in every sort of activity.

On the other hand, the two other dimensions seemed to require further attention. Regarding dimension 2 – 'continuous improvement' – it showed signs of a dichotomy regarding team profiles from different departments. Some of them seemed comfortable

Table 1. Spreadsheet and corresponding scores.

Regulatory requirements	Dimensions				Maximum score
	Dimension 1	Dimension 2	Dimension 3	Dimension 4	
Understanding the organization and its context	x		x		34.48
Understanding the needs and expectations of the stakeholders	x	x		x	51.72
Determine the scope of the management system	x				17.24
Management system	x	x	x		51.72
Leadership and commitment	x	x	x	x	68.96
Policy	x		x		34.48
Organizational roles, responsibilities and authorities	x		x		34.48
Actions to address risks and opportunities	x	x	x		51.72
Objectives of the management system and planning to achieve them	x	x	x		51.72
Resources	x	x			34.48
Skills	x			x	34.48
Awareness	x	x	x		51.72
Communication	x	x	x		51.72
Documented information	x	x	x	x	68.96
Operational planning and control		x		x	34.48
Emergency preparedness and response	x	x	x	x	68.96
Monitoring, measurement, analysis and evaluation		x		x	34.48
Internal audit	x	x		x	51.72
Management review	x	x	x	x	68.96
Non-compliance and corrective actions		x		x	34.48
Continuous improvement	x	x	x	x	68.96
				Total	1000

and knowledgeable when using Lean tools, while and others showed signs of not understanding the – how or the why of employing such tools. The evaluation of the 'enterprise alignment' dimension (dimension 3) also showed a lack of a unified and coherent approach with some redundancy associated, especially when it comes to documented information.

Based on the described observations, the spreadsheet was filled out and the corresponding scores were assigned that are available in Table 3.

The overall obtained score was 732.26 points (out of 1000). The scoring results for the four assessed dimensions showed greater maturity levels on the 'cultural enablers' and 'results' dimensions. The mean value associated with each dimension was calculated, allowing the construction of a radar chart on Figure 3.

Table 2. Survey questions.

1	1.1	The organization invests in initiatives that promote training and awareness regarding environmental questions.
	1.2	The set of values that guide the organization's actions are communicated and comprehended on all levels of the enterprise.
	1.3	I have access to tools and systems that help and instruct me on how to maintain my workspace clean, ergonomic and safe.
2	2.1	There is committed attitude on delivery but also flexibility to eventual alterations, when it comes to the relationship with the costumer.
	2.2	The organization invests in the exploration of its current activity but also in the development of new markets of interest.
	2.3	There is a clear relationship between the organization and its suppliers, with the main goal of establishing methods and practices capable of creating value.
	2.4	The administrative departments are well aligned and integrated, providing support for the value stream of the organization.
	2.5	I regularly use tools like SMED, 5Ss, Poka Yoke, A3 Thinking, Quick Change-Over, Visual Management and Value Stream Mapping.
	2.6	When possible, the solutions are presented in a visual form in order to ease the understanding.
3	3.1	The elimination of activities that do not add value, as well as the existence of a continuous workflow, are common characteristics to every level of activity within the organization.
	3.2	I utilize scientific thinking daily, which helps me to find counter measures instead of definitive solutions.
4	4.1	The client's satisfaction and the product/service quality are regularly checked and monitored.
	4.2	The time that a product/service takes between the supplier and costumer is a regularly checked parameter.
	4.3	As a worker, I do not feel as if the cost reductions impact the stability, standardization and quality of the work.
	4.4	The client's satisfaction is used as a competitive advantage by the organization.

Figure 3 provides a good understanding that the tendency associated with the four dimensions is not balanced. On the contrary of dimensions 1 and 4, dimensions 2 and 3 are less developed by the organization, especially dimension 2 being the one to present a smaller inclination.

After the spreadsheet assessment, the results of the validated surveys were analysed. Cronbach's alpha is most commonly used to assess the internal consistency of a questionnaire that is made up of multiple Likert-type scales and items. Hence, taking into consideration the obtained scores, the mean value for each question, dimension and whole questionnaire was calculated, together with the standard deviation for each question to ascertain the uniformity of the results. In addition, a Cronbach's alpha test was determined (using the IBM SPSS software) to evaluate the internal consistency and reliability of the survey.

Since the questions already had staggered answers using the Likert's scale, the analysis was carried out and their results are represented on Table 4.

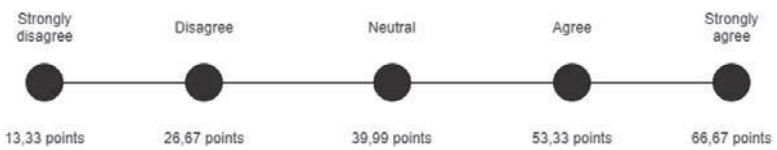


Figure 2. Closed answers for each question and their respective score.

Table 3. Spreadsheet with the performed assessment.

Regulatory requirements	Dimension 1	Dimension 2	Dimension 3	Dimension 4	Maximum score
Understanding the organization and its context	17.24		17.24		34.48
Understanding the needs and expectations of the stakeholders	17.24	17.24		17.24	51.72
Determine the scope of the management system	17.24				17.24
Management system	17.24	0	17.24		34.48
Leadership and commitment	17.24	17.24	0	17.24	51.72
Policy	17.24		0		17.24
Organizational roles, responsibilities and authorities	17.24		17.24		34.48
Actions to address risks and opportunities	17.24	0	0		17.24
Objectives of the management system and planning to achieve them	17.24	0	0		17.24
Resources	17.24	0			17.24
Skills	0			17.24	17.24
Awareness	17.24	0	0		17.24
Communication	17.24	0	17.24		34.48
Documented information	17.24	17.24	17.24	17.24	68.96
Operational planning and control		17.24		17.24	34.48
Emergency preparedness and response	17.24	0	0	0	17.24
Monitoring, measurement, analysis and evaluation		17.24		17.24	34.48
Internal audit	17.24	17.24		17.24	51.72
Management review	17.24	17.24	17.24	17.24	68.96
Non-compliance and corrective actions		17.24		17.24	34.48
Continuous improvement	17.24	0	17.24	17.24	51.72
				Total	724.08

The obtained value for Cronbach's alpha is 0.988. Despite the fact that a strong correlation between all the items is sometimes, not an advantage, it is possible to state, according to George and Mallery (2003), that the internal consistency of the survey is good. The correlations between questions were analysed (Table 5).

Table 4. Cronbach's alpha value was obtained through the IBM SPSS software.

Cronbach's alpha	Number of items
0.988	15

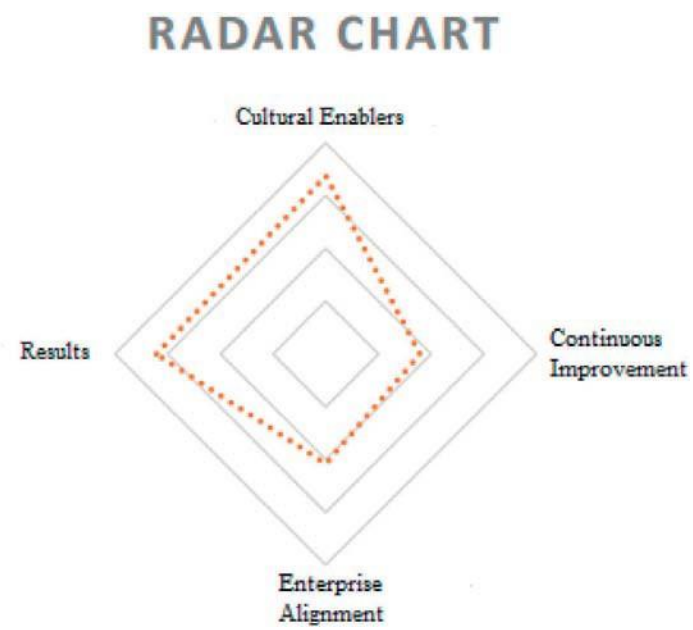


Figure 3. Radar chart with the organization's inclination, accordingly to the assessment results.

The Cronbach's alpha mean value for the correlation between questions is 0.869, which corroborates the high internal consistency of the survey, together with its reliability.

The results for the mean value and standard deviation of the questions included in section 1 – associated to the 'cultural enablers' dimension – are presented in Table 6. Since the maximum score for this section is 200 points and the obtained score is 160.32, this means that a rate of 80% of the employees has a positive perception of the organization in the scope of these questions.

By its turn, the results for Section 2 of the survey, concerning Continuous Improvement and Lean Tools are available in Table 7. In this particular case, the resulting score was 301.64 points out of 400, which translates into a rate of compatibility of 75%. Although it is not a bad score, it is however lower than the previous one, thus indicating that the perception of the employees in issues related to this scope is not so well aligned. It is also important to highlight that the question with the lowest score was question 2.5 ('*I regularly use tools like SMED, 5Ss, Poka Yoke, A3 Thinking, Quick Change-Over, Visual Management and Value Stream Mapping*') with 38.83 points, hence with only 36.5% of the employees showing any level of concordance with the sentence.

The results for the 'Enterprise Alignment' dimension are displayed in Table 8. The total score of 99.49 points, once again reveals a 75% rate of compatibility, with a maximum score of 133 points. It is interesting to notice that the answers received for question 3.1, which focuses on a generalized analytical guidance, are considerably lower when compared to the ones obtained received for question 3.2 that appeals to wider criteria for self-assessment.

Lastly, the score for dimension or Section 4 was 206.83 points, which translates into a 77% rate of compatibility when compared to the 267 possible points. This was the section with the highest score on a question (4.4 – The client's satisfaction is used as a competitive advantage by the organization) but it also had lower scores on the remaining questions if compared to other sections (Table 9).

After analysing the specific results regarding each section of the survey, we took a close look at the overall results. Attending to the values obtained of the standard deviation,

Table 5. Correlation matrix between questions, obtained through the Cronbach's alpha test.

	α 1.1	α 1.2	α 1.3	α 2.1	α 2.2	α 2.3	α 2.4	α 2.5	α 2.6	α 3.1	α 3.2	α 4.1	α 4.2	α 4.3	α 4.4
Q 1.1	1.000	0.968	0.889	0.932	0.890	0.941	0.895	0.756	0.886	0.845	0.850	0.863	0.825	0.805	0.831
Q 1.2	0.968	1.000	0.916	0.942	0.915	0.969	0.912	0.770	0.877	0.841	0.878	0.889	0.848	0.815	0.848
Q 1.3	0.889	0.916	1.000	0.908	0.926	0.883	0.881	0.864	0.860	0.852	0.898	0.956	0.841	0.861	0.889
Q 2.1	0.932	0.942	0.908	1.000	0.916	0.946	0.899	0.824	0.875	0.835	0.895	0.884	0.833	0.865	0.802
Q 2.2	0.890	0.915	0.926	0.916	1.000	0.939	0.853	0.848	0.853	0.829	0.927	0.906	0.819	0.853	0.822
Q 2.3	0.941	0.969	0.883	0.946	0.939	1.000	0.871	0.804	0.867	0.826	0.892	0.865	0.824	0.840	0.797
Q 2.4	0.895	0.912	0.881	0.899	0.853	0.871	1.000	0.820	0.934	0.852	0.891	0.899	0.891	0.867	0.815
Q 2.5	0.756	0.770	0.864	0.824	0.848	0.804	0.820	1.000	0.882	0.868	0.872	0.888	0.849	0.908	0.773
Q 2.6	0.886	0.877	0.860	0.875	0.853	0.867	0.934	0.882	1.000	0.892	0.876	0.871	0.912	0.907	0.810
Q 3.1	0.845	0.841	0.852	0.835	0.829	0.826	0.852	0.868	0.892	1.000	0.838	0.856	0.915	0.913	0.851
Q 3.2	0.850	0.878	0.898	0.895	0.927	0.892	0.891	0.872	0.876	0.838	1.000	0.921	0.843	0.860	0.839
Q 4.1	0.863	0.889	0.956	0.884	0.906	0.865	0.899	0.888	0.871	0.856	0.921	1.000	0.853	0.850	0.892
Q 4.2	0.825	0.848	0.841	0.833	0.819	0.824	0.891	0.849	0.912	0.915	0.843	0.853	1.000	0.924	0.838
Q 4.3	0.805	0.815	0.861	0.865	0.853	0.840	0.867	0.908	0.907	0.913	0.860	0.850	0.924	1.000	0.786
Q 4.4	0.831	0.848	0.889	0.802	0.822	0,797	0.815	0.773	0.810	0.851	0.839	0.892	0.838	0.786	1.000

Table 6. Obtained score for Section 1 of the survey – cultural enablers.

	Cultural enablers		
Question	Question 1.1	Question 1.2	Question 1.3
Mean value	52.83	53.16	54.33
Standard deviation	11.82	11.45	11.89
Total points		160.32	

Table 7. Obtained score for Section 2 of the survey – continuous improvement.

	Continuous improvement					
Question	Question 2.1	Question 2.2	Question 2.3	Question 2.4	Question 2.5	Question 2.6
Mean value	53.33	54.66	54.16	51.16	38.83	49.5
Standard deviation	9.89	9.57	9.03	11.25	16.36	12.33
Total points			301.64			

Table 8. Obtained score for Section 3 of the survey – enterprise alignment.

	Enterprise alignment	
Question	Question 3.1	Question 3.2
Mean value	46.33	53.16
Standard deviation	12.11	11.06
Total points	99.49	

Table 9. Obtained score for Section 4 of the survey – results.

	Results			
Question	Question 4.1	Question 4.2	Question 4.3	Question 4.4
Mean value	54.00	48.10	47.16	57.17
Standard deviation	12.46	11.60	12.99	10.37
Total points		206.83		

the answers reveal that the highest variability occurred on questions 2.5. On the other hand, the answers for questions 2.2 and 2.3 show the greatest signs of homogeneity. All of the information gathered shows that, from the employees' point of view, the organization is not yet at a high level of maturity in terms of Excellence, but the assessment results clearly show that many of the practices from the Lean philosophy are already well rooted into the actions and mindset of the people, hence demonstrating some structure on the continuous improvement approach which is reflected on solid development on key areas.

Together with the survey results, a radar chart was built to exhibit the tendency of the organization regarding each dimension. In Figure 4, it is possible to confirm that both

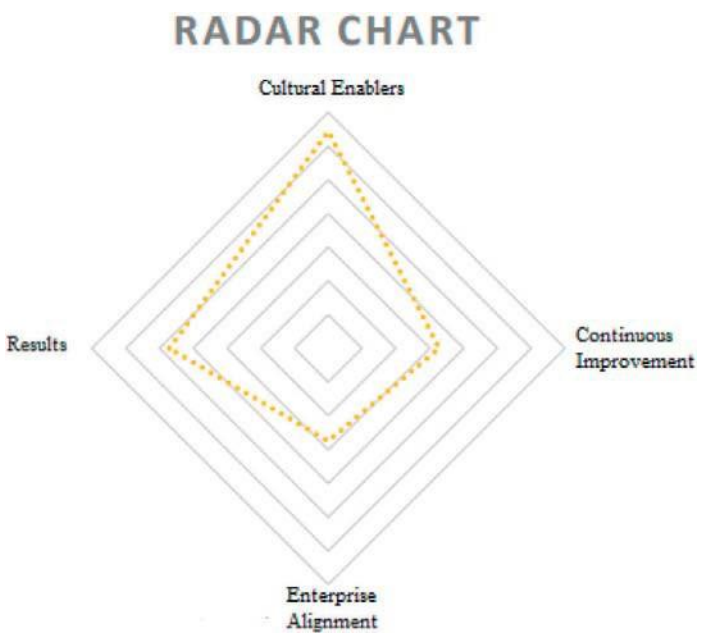


Figure 4. Radar chart with the organization's inclination, accordingly to the survey results.

'cultural enablers' and 'results' dimensions are perceived as being stronger and positive when compared to the 'continuous improvement' and 'enterprise alignment' sections.

The overall score of the survey was 768.28 points out of 1000, corresponding to a 77% success rate on the journey to Excellence. When compared to the score that was determined by the external analysis, in the form of behavioural observations followed by the assignment of punctuation recorded on a spreadsheet, we see that the percentual difference is just 3.6%, which is not significant. It means that the external perception of the evaluator goes hand in hand with the internal perception from the employees.

Figure 5 presents a conceptual model for integrating MSS, including ISO 9001 for Quality Management Systems, ISO 14001 for Environmental Management Systems, ISO 45001 for Occupational Health and Safety Management Systems and ISO 26000 for Social Accountability Systems according to ISO 26000, with the Shingo Model for Operational Excellence. Other ISO MSS can be added to this model.

A model was developed and the study shows that it is possible to use it. It is useful in the sense that it provides tools for assessing behaviours (i.e. corporate culture) and whether they are aligned with the principles and best practices on an IMS. As a consequence, it has the

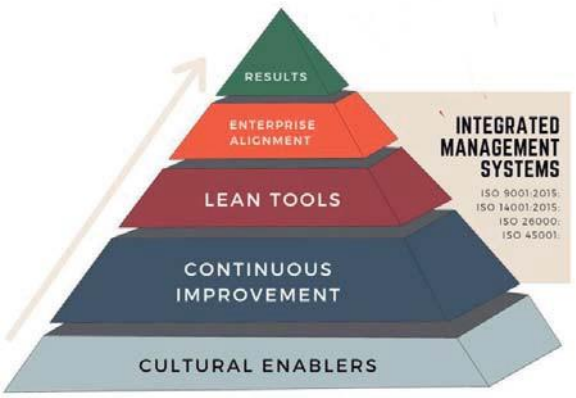


Figure 5. A conceptual model integrating management systems and the Shingo Model towards operational excellence.

potential to lead better organization at various levels of the company. It aligns continuous improvement and Lean tools contained in the Shingo model, with the main standards usually adopted in the context of IMSs, which is a contribution to enhance the ability of designed organizational systems to seek the achievement of the best results for the organization.

Discussion

The results from the application of the development of this conceptual model and its assessment tools proposed in this paper, together with its further validation, show that creating a framework that integrates aspects from MSS with the guidelines from the Shingo Model can be useful for organizations to evolve in their level of maturity regarding the adoption of behaviours and practices in accordance with best principles of Operational Excellence.

It also fills a gap in the current literature because it identifies and explores synergies between subjects that have not been yet the scope of any other research in a systematic way. By creating this model and its assessment tools, this paper contributes to providing solutions to organizations that allow them to improve their Management Systems towards recognized best practices that are encouraged by Excellence models, including the Shingo Model. Furthermore, it accommodates well qualitative and subjective issues, like behaviours, by translating them into quantifiable parameters.

Complementing an external analysis conducted by an external and independent evaluator with an internal assessment using a survey answered by the employees, allows managers to have a holistic and clearer vision about the company's baseline, hence minimizing the risk of misjudging due to partiality.

As it rests upon behavioural foundations as well as in the clauses of requirements from MSS, it can be applied to any sort of organization, regardless its business or size, thus providing a complete framework that can be used by enterprises seeking to adopt organizational models that help them to achieve competitive advantages in the global markets, whilst providing guidelines for their continuous improvement efforts.

Conclusions

The main contribution of this work was the creation of a model and a set of assessment tools that organizations can use to quantitatively evaluate their maturity in effectively incorporating the best Lean and Operational Excellence practices in their IMSs.

The results obtained through the assessment methods demonstrated that the external perception from an evaluator, based on the observation and analysis of behaviours met the internal perception of the employees, mirrored by their survey responses. Although both scores obtained (732.26 points for the external evaluation system and 768.28 points for the survey) place the organization on a favourable level of maturity, hence demonstrating that there is already evidence of good Lean practices and that the company's culture and values are thematic targets, it suggests that there is still room for improvement, to reach the maximum level of organizational excellence. Likewise, it was found that in both assessment methods, the areas associated with the systematic adoption of Lean tools and with the adoption of effective systems capable to ensure an effective deployment of the corporate strategy, were identified as those dimensions that need more attention and development in the future.

Even though the validation took place in a single company from the automotive industry, since the proposed model was designed as a universal framework, it is expected that it

will enable its applicability in organizations from other sectors in a similar effective manner.

Nevertheless, its application must be accompanied by specialized personnel who understand the objectives and the reasoning behind the model itself, being also able to evaluate and properly follow-up the results and conclusions obtained.

Future research could benefit through the achievement of a more in-depth study that considers the impact of the model and of its results and how the communication of these results can impact the perception and attitude of the employees. It is also proposed that the analysis can be carried out in several sites of the organizations, so that the results can be compared with each other. Such option will possibly encourage the sharing of knowledge and good practices within the organization itself, fostering the conjoint spirit of continuous improvement.

In addition, it is concluded that the objectives outlined were successfully met. The ideas described in this work may serve as guidelines not only for the practical implementation of the model in organizations but also for the development of other methodologies that use Lean tools, management systems and Excellence Models.

Disclosure statement

No potential conflict of interest was reported by the author(s).

ORCID

Mariana Carvalho http://orcid.org/0000-0001-8393-8069
José Carlos Sá http://orcid.org/0000-0002-2228-5348
Pedro Alexandre Marques http://orcid.org/0000-0002-8429-0249
Gilberto Santos http://orcid.org/0000-0001-9268-3272
António Mário Pereira http://orcid.org/0000-0003-1219-0596

References

Aba, E. K., Badar, M. A., & Hayden, M. A. (2015). Impact of ISO 9001 certification on firms financial operating performance. *International Journal of Quality & Reliability Management*, *33* (1), 78–89. https://doi.org/10.1108/IJQRM-02-2014-0021

Abisourour, J., Hachkar, M., Mounir, B., & Farchi, A. (2020). Methodology for integrated management system improvement: Combining costs deployment and value stream mapping. *International Journal of Production Research*, *58*(12), 3667–3685. https://doi.org/10.1080/00207543.2019.1633482

Alves, J. R. X., & Alves, J. M. (2015). Production management model integrating the principles of lean manufacturing and sustainability supported by the cultural transformation of a company. *International Journal of Production Research*, *53*(17), 5320–5333. https://doi.org/10.1080/00207543.2015.1033032

Araújo, R., Santos, G., Costa, J. B., & Sá, J. C. (2019). The quality management system as a driver of organizational culture: An empirical study in the Portuguese textile industry. *Quality Innovation Prosperity*, *23*(1), 1–23. https://doi.org/10.12776/qip.v23i1.1132

Arnheiter, E. D., & Maleyeff, J. (2005). The integration of lean management and Six Sigma. *The TQM Magazine*, *17*(1), 5–18. https://doi.org/10.1108/09544780510573020

Asif, M., Searcy, C., Zutshi, A., & Ahmad, N. (2011). An integrated management systems approach to corporate sustainability. *European Business Review*, *23*(4), 353–367. https://doi.org/10.1108/09555341111145744

Azevedo, J., Sá, J. C., Ferreira, L., Santos, G., Cruz, F., Jimenez, G., & Silva, F. (2019). Improvement of production line in the automotive industry through Lean Philosophy. *Procedia Manufacturing*, *41*, 1023–1030. https://doi.org/10.1016/j.promfg.2019.10.029

Barbosa, L. C. F. M., de Oliveira, O. J., & Santos, G. (2018). Proposition for the alignment of the integrated management system (quality, environmental and safety) with the business strategy. *International Journal for Quality Research*, *12*(4), 925–940. https://doi.org/10.18421/IJQR12.04-09

Barbosa, L. C. F. M., Mathias, M. A. S., Santos, G., & de Oliveira, O. J. (2020). How the knowledge of the major researchers is forging the business strategy paths: Trends and forecasts from the state of the art. *Quality Innovation Prosperity*, *24*(3), 1–20. https://doi.org/10.12776/qip.v24i3.1404

Basaran, B. (2017). Integrated management systems and sustainable development. In L. D. Kounis (Ed.), *Quality management systems: A selective presentation of case studies showcasing its evolution* (pp. 1–20). IntechOpen. https://doi.org/10.5772/intechopen.71468

Beckmerhagen, I. A., Berg, H. P., Karapetrovic, S. V., & Willborn, W. O. (2003). Integration of management systems: Focus on safety in the nuclear industry. *International Journal of Quality & Reliability Management*, *20*(2), 210–228. https://doi.org/10.1108/02656710310456626

Bernardo, M., Casadesus, M., Karapetrovic, S., & Heras, I. (2010). An empirical study on the integration of management system audits. *Journal of Cleaner Production*, *18*(5), 486–495. https://doi.org/10.1016/j.jclepro.2009.12.001

Bernardo, M., Gotzamani, K., Vouzas, F., & Casadesus, M. (2018). A qualitative study on integrated management systems in a non-leading country in certifications. *Total Quality Management & Business Excellence*, *29*(4), 453–480. https://doi.org/10.1080/14783363.2016.1212652

Bernardo, M., Simon, A., Tatí, J. J., & Molina-Azorín, J. F. (2015). Benefits of management systems integration: A literature review. *Journal of Cleaner Production*, *94*(1), 260–267. https://doi.org/10.1016/j.jclepro.2015.01.075

Bhamu, J., & Sangwan, K. S. (2014). Lean manufacturing: Literature review and research issues. *International Journal of Operations & Production Management*, *34*(7), 876–940. https://doi.org/10.1108/IJOPM-08-2012-0315

Bhasin, S. (2015). *Lean management beyond manufacturing: A holistic approach*. Springer.

Bhuiyan, N., & Baghe, A. (2005). An overview of continuous improvement: From the past to the present. *Management Decision*, *43*(5), 761–771. https://doi.org/10.1108/00251740510597761

Borella, I. L., & Borella, M. R. C. (2016). Environmental impact and sustainable development: An analysis in the context of standards ISO 9001, ISO 14001, and OHSAS 18001. *Environmental Quality Management*, *25*(3), 67–83. https://doi.org/10.1002/tqem.21460

Borris, S. (2006). *Total productive maintenance: Proven strategies and techniques to keep equipment running at maximum efficiency*. McGraw-Hill Education.

Bravi, L., Santos, G., Pagano, A., & Murmura, F. (2020). Environmental management system according to ISO 14001:2015 as a driver to sustainable development. *Corporate Social Responsibility and Environmental Management*, *27*(6), 2599–2614. https://doi.org/10.1002/csr.1985

Bravo-Sanchez, C., Dorazio, V., Denmark, R., Heuer, A. J., & Parrott, S. (2018). Development of an interprofessional lean facilitator assessment scale. *Journal of Interprofessional Care*, *32*(3), 370–373. https://doi.org/10.1080/13561820.2017.1407300

Cândido, C. J. F., Coelho, L. M. S., & Peixinho, R. M. T. (2016). The financial impact of a withdrawn ISO 9001 certificate. *International Journal of Operations & Production Management*, *36*(1), 23–41. https://doi.org/10.1108/IJOPM-11-2014-0540

Carvalho, A. M., Sampaio, P., Rebentisch, E., Carvalho, J. A., & Saraiva, P. (2019). Operational excellence, organisational culture and agility: The missing link? *Total Quality Management & Business Excellence*, *30*(13-14), 1495–1514. https://doi.org/10.1080/14783363.2017.1374833

Carvalho, F., Santos, G., & Gonçalves, J. (2020). Critical analysis of information about integrated management systems and environmental policy on the Portuguese firms' website, towards sustainable development. *Corporate Social Responsibility and Environmental Management*, *27*(2), 1069–1088. https://doi.org/10.1002/csr.1866

Chatzoglou, P., Chatzoudes, D., & Kipraios, N. (2015). The impact of ISO 9000 certification on firms' financial performance. *International Journal of Operations & Production Management*, *35*(1), 145–174. https://doi.org/10.1108/IJOPM-07-2012-0387

Correia, F., Carvalho, A. M., & Sampaio, P. (2021). A new approach to organisational excellence for small and medium enterprises: The QOE-SME model. *Total Quality Management & Business Excellence*, *32*(11-12), 1359–1383. https://doi.org/10.1080/14783363.2020.1718490

Costa, A. R., Barbosa, C., Santos, G., & Alves, M. R. (2019). Six Sigma: Main metrics and R based software for training purposes and practical industrial quality control. *Quality Innovation Prosperity*, *23*(2), 83–100. https://doi.org/10.12776/qip.v23i2.1278

Deif, A. M., & ElMaraghy, H. A. (2017). Variety and volume dynamic management for value creation in changeable manufacturing systems. *International Journal of Production Research*, *55* (5), 1516–1529. https://doi.org/10.1080/00207543.2016.1222088

Doiro, M., Fernández, F. J., Félix, M. J., & Santos, G. (2019). Machining operations for components in kitchen furniture: A comparison between two management systems. *Procedia Manufacturing*, *41*, 10–17. https://doi.org/10.1016/j.promfg.2019.07.023

Edgeman, R. (2018). Excellence models as complex management systems: An examination of the Shingo operational excellence model. *Business Process Management Journal*, *24*(6), 1321–1338. https://doi.org/10.1108/BPMJ-02-2018-0049

Edgeman, R., & Eskildsen, J. (2014). Modeling and assessing sustainable enterprise excellence. *Business Strategy and the Environment*, *23*(3), 173–187. https://doi.org/10.1002/bse.1779

Félix, M. J., Silva, S., Santos, G., Doiro, M., & Sá, J. C. (2019). Integrated product and processes development in design: A case study. *Procedia Manufacturing*, *41*, 296–303. https://doi.org/10.1016/j.promfg.2019.09.012

Ferreira, L. M. F. R., & Cândido, C. J. F. (2021). Factors influencing firm propensity for ISO 9001 withdrawal: Evidence on decertification tendency and antecedents. *International Journal of Production Economics*, *233*, Article 108024. https://doi.org/10.1016/j.ijpe.2020.108024

Ferreira, N., Santos, G., & Silva, R. (2019). Risk level reduction in construction sites: Towards a computer aided methodology – A case study. *Applied Computing and Informatics*, *15*(2), 136–143. https://doi.org/10.1016/j.aci.2018.01.003

George, D., & Mallery, P. (2003). *SPSS for windows step by step: A simples guide and reference* (4th ed). Allyn and Bacon.

Gonçalves, I., Sá, J. C., Santos, G., & Gonçalves, M. A. (2019). Safety stream mapping—A new tool applied to the textile company as a case study. In *Occupational and environmental safety and health* (pp. 71–79). Springer Nature. https://doi.org/10.1007/978-3-030-14730-3_8

Gunasekaran, A., & Ngai, E. W. T. (2007). Knowledge management in 21st century manufacturing. *International Journal of Production Research*, *45*(11), 2391–2418. https://doi.org/10.1080/00207540601020429

Hernandez-Vivanco, A., Cruz-Cázares, C., & Bernardo, M. (2018). Openness and management systems integration: Pursuing innovation benefits. *Journal of Engineering and Technology Management*, *49*, 76–90. https://doi.org/10.1016/j.jengtecman.2018.07.001

Hernandez-Vivanco, A., Domingues, P., Sampaio, P., Bernardo, M., & Cruz-Cázeres, P. M. (2019). Do multiple certifications leverage firm performance? A dynamic approach. *International Journal of Production Economics*, *218*(7), 386–399. https://doi.org/10.1108/IJQRM-03-2015-0032

Hines, P., Taylor, D., & Walsh, A. (2020). The lean journey: Have we got it wrong? *Total Quality Management & Business Excellence*, *31*(3-4), 389–406. https://doi.org/10.1080/14783363.2018.1429258

International Organization for Standardization. (2020). The ISO Survey 2019. Retrieved October 24, 2020, from https://isotc.iso.org/livelink/livelink?func=ll&objId=18808772&objAction=browse&viewType=1

Jiménez, G., Santos, G., Sá, J. C., Ricardo, S., Pulido, J., Pizarro, A., & Hernández, H. (2019). Improvement of productivity and quality in the value chain through lean manufacturing - A case study. *Procedia Manufacturing*, *41*, 882–889. https://doi.org/10.1016/j.promfg.2019.10.011

Jiménez-Delgado, G., Santos, G., Félix, M. J., Teixeira, P., & Sá, J. C. (2020). A combined AHP-topsis approach for evaluating the process of innovation and integration of management systems in the logistic sector. In C. Stephanidis, G. Salvendy, J. Wei, S. Yamamoto, H. Mori, G. Meiselwitz, F. Fui-Hoon Nah, & K. Siau (Eds.), *HCI International 2020 – Late breaking papers: Interaction, knowledge and social media* (Vol. 12427 Lecture Notes in Computer Science, pp. 535–559). Springer. https://doi.org/10.1007/978-3-030-60152-2_40

Jørgensen, T. H., Remmen, A., & Mellado, M. D. (2006). Integrated management systems – three different levels of integration. *Journal of Cleaner Production*, *14*(8), 713–722. https://doi.org/10.1016/j.jclepro.2005.04.005

Kafel, P., & Simon, A. (2017). The reasons for decertification of ISO 9001: Financial aspects. *Quality Innovation Prosperity*, *21*(3), 173–184. https://doi.org/10.12776/QIP.V21I3.1024

Karapetrovic, S. (2003). Musings on integrated management systems. *Measuring Business Excellence*, *7*(1), 4–13. https://doi.org/10.1108/13683040310466681

Kelly, S., & Hines, P. (2019). Discreetly embedding the Shingo principles of enterprise excellence at Abbott diagnostics manufacturing facility in Longford Ireland. *Total Quality Management & Business Excellence*, *30*(11-12), 1235–1256. https://doi.org/10.1080/14783363.2017.1363645

Krafcik, J. F. (1988). Triumph of the lean production system. *Sloan Management Review*, *30*, 41–52.

Liker, J. K. (2004). *The Toyota Way: 14 management principles from the world's greatest manufacturer*. McGraw-Hill.

Marinho, A., Silva, R. G., & Santos, G. (2020). Why most university-industry partnerships fail to endure and how to create value and gain competitive advantage through collaboration – a systematic review. *Quality Innovation Prosperity*, *24*(2), 34–50. https://doi.org/10.12776/qip.v24i2.1389

Marques, P. A., Meyrelles, P., Saraiva, P., & Frazão-Guerreiro, F. (2016, December 4–7). *Integrating Lean Six Sigma with ISO 9001:2015*. IEEE International Conference on Industrial Engineering and Engineering Management, Bali, Indonesia (pp. 894–898). https://doi.org/10.1109/IEEM.2016.7798006

Marques, P. A., Saraiva, P. M., & Frazão-Guerreiro, F. J. (2019). Lean Six Sigma methods and tools in ISO 9001:2015 management systems. *Journal of Engineering and Science Research*, *3*(5), 28–35. https://doi.org/10.26666/rmp.jesr.2019.5.5

Mastrogiacomo, L., Carrozza, A., Maisano, D. A., & Franceschini, F. (2021). Is 'post-decline' the next phase of the diffusion of ISO 9001 certifications? New empirical evidence from European countries. *Total Quality Management & Business Excellence*, *32*(11-12), 1384–1403. https://doi.org/10.1080/14783363.2020.1724508

Matias, J. C. O., & Coelho, D. A. (2002). The integration of the standards systems of quality management, environmental management and occupational health and safety management. *International Journal of Production Research*, *40*(15), 3857–3866. https://doi.org/10.1080/00207540210155828

Matos, D. P. (2015). *Application of the Shingo Model at Fernando Namora Secondary School.* Master thesis, ISCTE Business School, Marketing, Operações e Gestão Geral.

McIntosh, R. I., Culley, S. J., Mileham, A. R., & Owen, G. W. (2000). A critical evaluation of Shingo's 'SMED' (single minute exchange of die) methodology. *International Journal of Production Research*, *38*(11), 2377–2395. https://doi.org/10.1080/00207540050031823

Micklewright, M. (2010). *Lean ISO 9001: Adding spark to your ISO 9001 QMS and sustainability to your Lean efforts.* ASQ Quality Press.

Miller, R. D. (2018). *Hearing the voice of the Shingo principles: Creating sustainable cultures of enterprise excellence.* Routledge.

Moumen, M., & El Aoufir, H. (2018). An integrated management system: From various aspects of the literature to a maturity model based on the process approach. *International Journal of Productivity and Quality Management*, *23*(2), 218–246. https://doi.org/10.1504/IJPQM.2018.089157

Murmura, F., Bravi, L., & Santos, G. (2021). Sustainable process and product innovation in the eyewear sector: The role of industry 4.0 enabling technologies. *Sustainability*, *13*(1), 365–17. https://doi.org/10.3390/su13010365

Nogueira, D. M. C., Sousa, P. S. A., & Moreira, M. R. A. (2018). The relationship between leadership style and the success of Lean management implementation. *Leadership & Organization Development Journal*, *39*(6), 807–824. https://doi.org/10.1108/LODJ-05-2018-0192

Nunhes, T., Bernardo, M., & Oliveira, O. J. (2019). Guiding principles of integrated management systems: Towards unifying a starting point for researchers and practitioners. *Journal of Cleaner Production*, *210*, 977–993. https://doi.org/10.1016/j.jclepro.2018.11.066

Oakland, J. S. (2014). *Total Quality Management and operational excellence: Text with cases* (4th ed). Routledge.

Patel, S. (2016). *Lean transformation: Cultural enablers and enterprise alignment.* CRC Press.

Plenert, G. (2019). *Discover excellence: An overview of the Shingo Model and its guiding principles.* CRC Press.

Psomas, E. L., Pantouvakis, A., & Kafetzopoulos, D. P. (2013). The impact of ISO 9001 effectiveness on the performance of service companies. *Managing Service Quality: An International Journal*, *23*(2), 149–164. https://doi.org/10.1108/09604521311303426

Rebelo, M., Santos, G., & Silva, R. (2015). Integration of standardized management systems: A dilemma? *Systems*, *3*(2), 45–59. https://doi.org/10.3390/systems3020045

Rebelo, M. F., Santos, G., & Silva, R. (2014a). Conception of a flexible integrator and lean model for integrated management systems. *Total Quality Management & Business Excellence*, *25*(5-6), 683–701. https://doi.org/10.1080/14783363.2013.835616

Rebelo, M. F., Santos, G., & Silva, R. (2014b). A generic model for integration of quality, environment and safety management s*ystems*. *The TQM Journal*, *26*(2), 143–159. https://doi.org/10.1108/TQM-08-2012-0055

Rebelo, M. F., Santos, G., & Silva, R. (2016). Integration of management systems: Towards a sustained success and development of organizations. *Journal of Cleaner Production*, *127*(4), 96–111. https://doi.org/10.1016/j.jclepro.2016.04.011

Ribeiro, F., Santos, G., Rebelo, M. F., & Silva, R. (2017). Integrated management systems: Trends for Portugal in the 2025 horizon. *Procedia Manufacturing*, *13*, 1191–1198. https://doi.org/10.1016/j.promfg.2017.09.194

Ribeiro, P., Sá, J. C., Ferreira, L., Silva, F., Pereira, M. T., & Santos, G. (2019). The impact of the application of Lean tools for improvement of process in a plastic company: A case study. *Procedia Manufacturing*, *38*, 765–775. https://doi.org/10.1016/j.promfg.2020.01.104

Rocha, M., Searcy, C., & Karapetrovic, S. (2007). Integrating sustainable development into existing management systems. *Total Quality Management & Business Excellence*, *18*(1-2), 83–92. https://doi.org/10.1080/14783360601051594

Rodrigues, J., Sá, J. C., Ferreira, L. P., Silva, F. J., & Santos, G. (2019). Lean management "Quick wins": Results of implementation - A case study. *Quality Innovation Prosperity*, *23*(3). https://doi.org/10.12776/QIP.V23I3.1291

Rodrigues, J., Sá, J. C., Silva, F. J. G., Ferreira, L. P., Jimenez, G., & Santos, G. (2020). A rapid improvement process through "quick-win" lean tools: A case study. *Systems*, *8*(4), Article 55. https://doi.org/10.3390/systems8040055

Rüttimann, B. G., & Stöckli, M. T. (2016). Going beyond triviality: The Toyota production system—Lean manufacturing beyond Muda and *Kaizen*. *Journal of Service Science and Management*, *9*(2), 140–149. https://doi.org/10.4236/jssm.2016.92018

Sá, J., Vaz, S., Carvalho, O., Lima, V., Fonseca, L., Morgado, L., & Santos, G. (2022). A model of integration ISO 9001 with Lean Six Sigma and main benefits achieved. *Total Quality Management & Business Excellence*, *33*(1-2), 218–242. https://doi.org/10.1080/14783363.2020.1829969

Sá, J. C., Amaral, A., Barreto, L., Carvalho, F., & Santos, G. (2019). Perception of the importance to implement ISO 9001 in organizations related to people linked to quality - An empirical study. *International Journal for Quality Research*, *13*(4), 1055–1070. https://doi.org/10.24874/IJQR13.04-20

Salah, S., & Rahim, A. (2019). *An integrated company-wide management system: Combining Lean Six Sigma with process improvement.* Springer.

Samani, M. A., Ismail, N., Leman, Z., & Zulkifli, N. (2019). Development of a conceptual model for risk-based quality management system. *Total Quality Management & Business Excellence*, *30*(5-6), 483–498. https://doi.org/10.1080/14783363.2017.1310617

Santos, G., Doiro, M., Félix, M. J., Mandado, E., Sá, J. C., Gonçalves, J., & Teixeira, P. (2020). On the concept of an integrated and lean model of product development proposed for intellectual property creation and competitive economies. *International Journal of Intellectual Property Management*, *10*(4), 409–435. https://doi.org/10.1504/IJIPM.2020.112412

Santos, G., Gomes, S., Braga, V., Braga, A., Lima, V., Teixeira, P., & Sá, J. C. (2019). Value creation through quality and innovation – a case study on Portugal. *TQM Journal*, *31*(6), 928–947. https://doi.org/10.1108/TQM-12-2018-0223

Santos, G., Mandado, E., Silva, R., & Doiro, M. (2019). Engineering learning objectives and computer assisted tools. *European Journal of Engineering Education*, *44*(4), 616–628. https://doi.org/10.1080/03043797.2018.1563585

Santos, G., Mendes, F., & Barbosa, J. (2011). Certification and integration of management systems: The experience of Portuguese small and medium enterprises. *Journal of Cleaner Production*, *19*(17-18), 1965–1974. https://doi.org/10.1016/j.jclepro.2011.06.017

Santos, G., Rebelo, M., Barros, S., Silva, R., Pereira, M., Ramos, G., & Lopes, N. (2014). Developments regarding the integration of the occupational safety and health with quality and environment management systems. In I. Kavouras & M.-C. G. Chalbot (Eds.),

Occupational safety and health – Public health in the 21st century (Chap. 6, pp. 113–146). The Nova Science Publishers. https://www.amazon.com/Occupational-Safety-Health- Public-Century/dp/1631176951

Santos, G., Sá, J. C., Félix, M. J., Barreto, L., Carvalho, F., Doiro, M., Zgodavová, K., & Stefanović, M. (2021). New needed quality management skills for quality managers 4.0. *Sustainability, 13* (13), Article 6149. https://doi.org/10.3390/su13116149

Santos, G., Sá, J. C., Oliveira, J., Ramos, D., & Ferreira, C. (2019). Quality and safety continuous improvement through Lean tools. In F. Silva, & L. Ferreira (Eds.), *Chapter 8 of the book Lean manufacturing – implementation, opportunities and challenges* (pp. 165–188). Nova Science Publishers.

Shingo, S. (2019). *A revolution in manufacturing: The SMED system*. Routledge.

Shingo Institute. (2020). *The Shingo Model*. Obtido em 27 de maio de 2020, de Shingo Institute: https://shingo.org/shingo-model/

Simon, A., Bernardo, M., Karapetrovic, S., & Casadesús, M. (2011). Integration of standardized environmental and quality management systems audits. *Journal of Cleaner Production, 19* (5), 2057–2065. https://doi.org/10.1016/j.jclepro.2011.06.028

Simon, A., Karapetrovic, S., & Casadesús, M. (2012). Difficulties and benefits of integrated management systems. *Industrial Management & Data Systems*, *112*(5), 828–846. https://doi.org/10.1108/02635571211232406

Sugimori, Y., Kusunoki, F., Cho, F., & Uchikawa, S. (1977). Toyota production system and Kanban system materialization of just-in-time and respect-for-human system. *International Journal of Production Research*, *15*(6), 553–564. https://doi.org/10.1080/00207547708943149

Talapatra, S., Santos, G., Uddin, K., & Carvalho, F. (2019). Main benefits of integrated management systems through literature review. *International Journal for Quality Research*, *13*(4), 1037–1054. https://doi.org/10.24874/IJQR13.04-19

Teixeira, P., Sá, J. C., Silva, F. J. G., Santos, G., Ferreira, L. P., & Fontoura, P. (2021). Connecting lean and green with sustainability towards a conceptual model. *Journal of Cleaner Production*, *322*, Article 129047. https://doi.org/10.1016/j.jclepro.2021.129047

Womack, J., Jones, D., & Roos, D. (1990). *The machine that changed the world*. Simon & Schuster.

Womack, J. P., & Jones, D. T. (2003). *Lean thinking: Banish waste and create wealth in your corporation.* Free Press.

Yang, T., & Lu, J.-C. (2015). Implementing lean standard work to solve a low work-in-process buffer problem in a highly automated manufacturing environment. *International Journal of Production Research*, *53*(8), 2285–2305. https://doi.org/10.1080/00207543.2014.937009

Zayas-Mateo, R. A., & Martínez-Lorente, ÁR. (2021). ISO 9001: A vaccine for time of crisis. *Measuring Business Excellence*, *25*(3), 287–299. https://doi.org/10.1108/MBE-07-2020-0100

Zeng, S. X., Shi, J. J., & Lou, G. X. (2007). A synergetic model for implementing an integrated management system: An empirical study in China. *Journal of Cleaner Production*, *15*(18), 1760–1767. https://doi.org/10.1016/j.jclepro.2006.03.007

Zeng, S. X., Xie, X. M., Tam, C. M., & Shen, L. Y. (2011). An empirical examination of benefits fromimplementing integrated management systems (IMS). *Total Quality Management & Business Excellence*, *22*(2), 173–186. https://doi.org/10.1080/14783363.2010.530797

Zgodavova, K., Bober, P., Majstorovic, V., Monkova, K., Santos, G., & Juhaszova, D. (2020). Innovative methods for small mixed batches production system improvement: The case of a bakery machine manufacturer. *Sustainability (Switzerland)*, *12*(15), 6266. https://doi.org/10.3390/su12156266

2.4 The Development of an Excellence Model Integrating the Shingo Model and Sustainability

A filosofia *Lean* atualmente é um dos modelos de excelência operacional mais adotado a nível mundial pelas organizações, apesar de não existirem registos, ao contrário do que acontece com os modelos OpEx o Modelo EFQM e o Modelo Shingo, onde é possível ter acesso ao número de empresas que estão a adotar estes modelos.

A nível académico através da consulta WoS, é possível verificar que as publicações existentes relacionadas com a filosofia *Lean*, representam 84%, do total de publicações existentes relacionadas com os modelos OpEX: Modelos Shingo, Modelo EFQM, Toyota Way e filosofia *Lean* (*Figura 12*).

Investigar se a filosofia *Lean* tem impacto na sustentabilidade (*Lean Sustainability*), tem vindo a ser tema de investigação ao longo dos últimos anos para a comunidade científica e académica (Figura 19). Esta situação resulta do facto do tema da sustentabilidade ser cada vez mais um tema atual, e a comunidade científica e académica, pretender estudar se a adoção de práticas *Lean*, têm algum impacto na sustentabilidade das organizações. Uma pesquisa ao WoS, recorrendo a palavra-chave "*Lean Sustainability*", permite constatar essa mesma situação (Figura 18).

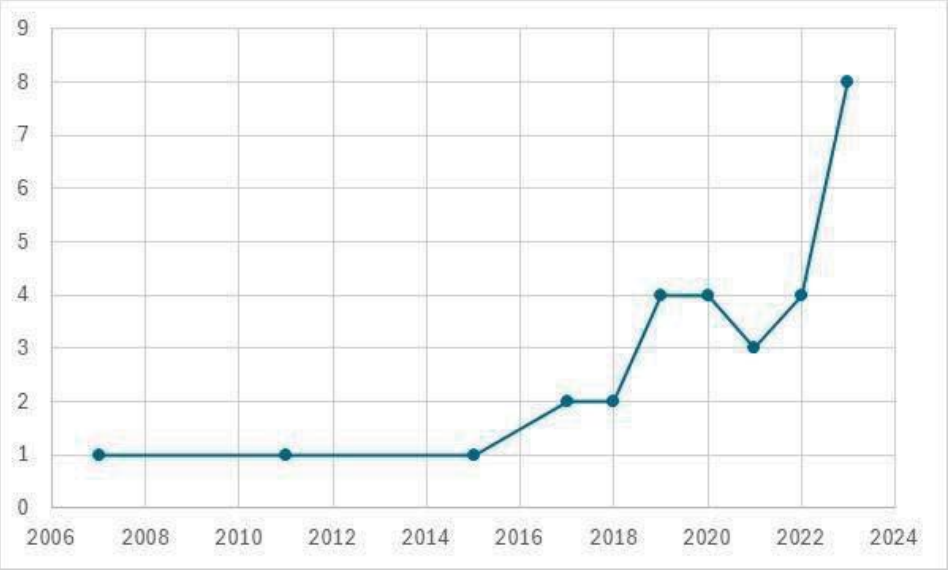


Figura 18 - Evolução das publicações no WoS referentes ao "*Lean* Sustainability"

As publicações têm sugerido que existem contributos positivos (Teixeira at al., 2022), e isto tem estimulado a comunidade científica e académica a aprofundar este estudo

O artigo "*The Development of an Excellence Model Integrating the Shingo Model and Sustainability*" (Sá et al., 2022), pretende contribuir para a consolidação modelo conceptual ***OpEx SafeSustain***, pretendo estudar se as práticas *Lean* (*Lean Tools*) têm impacto na sustentabilidade, e especificamente em quais dos três pilares (TBL) que suportam a sustentabilidade (Figura 19).

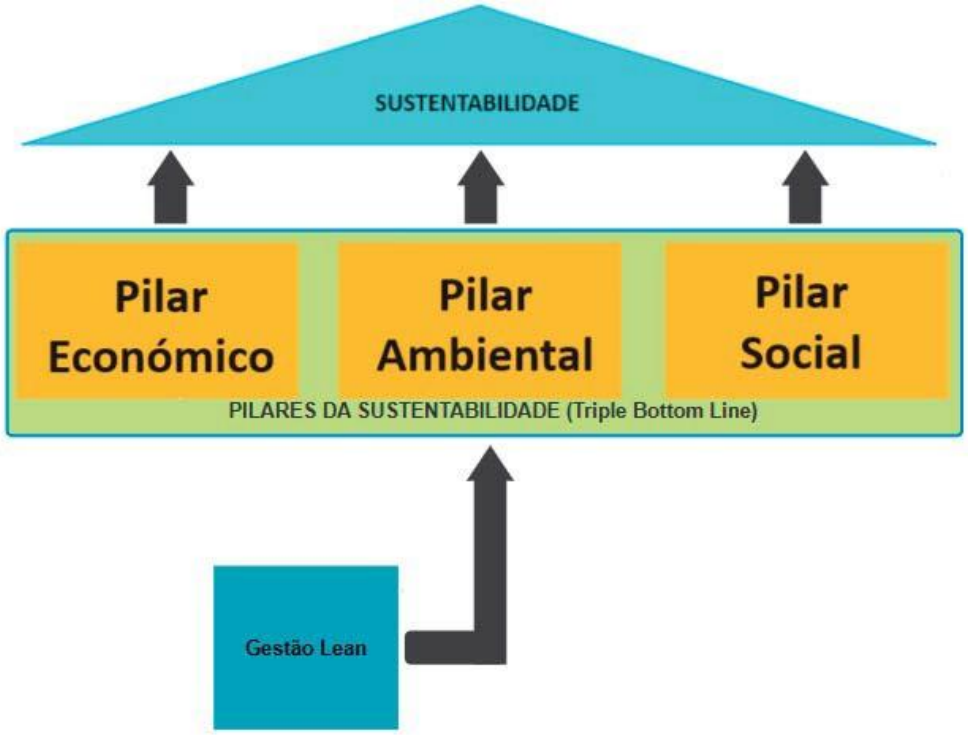


Figura 19 - Impacto do Lean na Sustentabilidade

s nability

MDPI

Article

The Development of an Excellence Model Integrating the Shingo Model and Sustainability

José Carlos Sá [1,2,*], Manuel Reis [1], José Dinis-Carvalho [3], Francisco J. G. Silva [1,2], Gilberto Santos [4], Luis P. Ferreira [1,2] and Vanda Lima [5,6]

1 School of Engineering, Polytechnic of Porto (ISEP), 4200-072 Porto, Portugal; 1171526@isep.ipp.pt (M.R.); fgs@isep.ipp.pt (F.J.G.S.); lpf@isep.ipp.pt (L.P.F.)
2 Institute of Science and Innovation in Mechanical and Industrial Engineering (INEGI), 4200-465 Porto, Portugal
3 Production and Systems Department, University of Minho, 4800-058 Guimarães, Portugal; dinis@dps.uminho.pt
4 Design School, Polytechnic Institute Cavado and Ave, 4750-810 Barcelos, Portugal; gsantos@ipca.pt
5 Polytechnic Institute of Porto, 4200-465 Porto, Portugal; vlima@estg.ipp.pt
6 CIICESI, Escola Superior de Tecnologia e Gestão, Politécnico do Porto, 4610-156 Felgueiras, Portugal
* Correspondence: cvs@isep.ipp.pt

Abstract: Companies are continuously looking to improve their production systems using excellence models, with lean thinking, the Shingo model, six sigma and lean six sigma being the most comprehensive and applied. It is expected that the initial focus for the survival of companies is their economic profitability, but when economic needs are met, the next step is to achieve operational excellence. For this, in addition to economic objectives, it is necessary to include social and environmental objectives, i.e., the other two pillars of sustainability. This study aims to propose a conceptual model identifying the tools that can help achieve the desired results in the three pillars of sustainability aligned with operational excellence. The design of the conceptual model was based on a bibliometric analysis of the literature that relates the concepts of lean thinking, six sigma, lean six sigma and the Shingo model. The Web of Science was the platform selected for the collection of data, and the timeframe considered was 2010 to 2021. A total of 125 articles were analyzed using the VosViewer software, through which it was possible to analyze different topics of study related to the literature. The bibliometric analysis allowed for the identification of the temporal distribution of publications, the categorization of topics, different areas of application and the importance of the tools used in different practical cases. This study points out that companies have at their disposal several tools to achieve economic objectives. On the other hand, there is a set of more restricted tools that are used to meet the objectives of the social and environmental pillars. Future research should focus on identifying tools that meet social and environmental goals in order to strengthen these pillars that are essential for operational excellence and for the sustainability of companies.

Keywords: sustainability; Shingo model; lean six sigma; lean thinking; six sigma; DMAIC

Citation: Sá, J.C.; Reis, M.; Dinis-Carvalho, J.; Silva, F.J.G.; Santos, G.; Ferreira, L.P.; Lima, V. The Development of an Excellence Model Integrating the Shingo Model and Sustainability. *Sustainability* **2022**, *14*, 9472. https://doi.org/10.3390/su14159472

Academic Editor: Jose Arturo Garza-Reyes

Received: 15 June 2022
Accepted: 25 July 2022
Published: 2 August 2022

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

1. Introduction

Existing global competition has led to significant changes in the market, with a considerable increase in the variety of increasingly complex products with ever shorter and uncertain life cycles [1]. The current problem for manufacturers is how to deliver their products or materials quickly at a low cost and with good quality [2].

In recent years, continuous improvement and operational excellence programs have played an important role in the success and sustainability of organizations, allowing companies to achieve high grades of competitiveness [3]. Lean thinking, the Shingo model, the Toyota way, six sigma and lean six sigma are some examples of applied models. These models guide companies to maintain consistent practices with sustainable development

strategies, and, as such, they control waste, reduce production variability and implement practices that are environmentally and socially responsible [4,5].

Organizations have been pressured by stakeholders to adopt not only economic but also social and environmental objectives [6,7]. The growth of ecological consumerism, climate change and the latest government legislation are some of the reasons why companies have improved their performance in all components of sustainable development [8–10]. This growing trend of companies in responding to the challenge of sustainability has resulted in the emergence of the concept of corporate social responsibility, which focuses on creating value that promotes harmony between economic development, social progress, equity and respect for the environment [11].

Lean six sigma (LSS) is one of the excellence models that helps companies improve operational efficiency, reduce costs and increase effectiveness, especially when they need to operate in a highly competitive globalized market [12]. It allows companies to increase the speed of waste elimination, reducing the processes variation as well by integrating the best methodologies and tools associated with lean thinking and six sigma [2,5].

LSS, like other excellence models, has undergone evolutions towards sustainability. First, there was integration between LSS and Green Technology, resulting in GLS (green lean six sigma) methodology that incorporates two dimensions of sustainability (economic and environmental). Recently, sustainable green lean six sigma has emerged, which incorporates all the dimensions of sustainability (economic, environmental and social) and an inclusive approach that makes industries more resilient and promotes a healthier society, meeting Corporate Social Responsibility [13].

The lean six sigma philosophy promotes process and product innovation and has the potential to influence radical innovation in the industry worldwide. To achieve long-term success, organizations need to focus on continuous improvement and problem-solving approaches by changing the organizational culture. Thus, it is possible to adopt these new philosophies, including sustainability, Industry 4.0 and the Circular Economy [14,15].

An important component of this work is to research and categorize the different operational excellence tools used on DMAIC methodology applications, allowing for readers to easily understand the best ones to act in each pillar of the conceptual model under development. In fact, their suitability to act economically, environmentally and socially are different and promotes different effects in achieving operational excellence. The model developed allows for easy perception about what tools can be used to improve each pillar. This categorization of the tools regarding each pillar toward operational excellence is the main novelty presented by this paper, representing an important contribution to the sustainability of companies regarding different pillars. Indeed, if companies improve their performance considering the DMAIC methodology and excellence tools, their sustainability also increases, leading to a better economic, environmental and social performance.

The investigation was based on a literature review in the areas of lean thinking, six sigma, lean six sigma and the Shingo model, through which a bibliometric analysis was performed. The main contribution of this research is the development of a conceptual model that relates excellence tools with the different pillars of sustainable development, in which the DMAIC plays the role of structured methodology, allowing for a strategic direction for improvement. This article is divided into the following sections. First, a theoretical review of the lean thinking literature, six sigma, lean six sigma and the Shingo model is presented. Second, the methodology and research criteria that enabled the treatment of information are presented. Third, the results of the bibliometric analysis are presented. Fourth, the information of the analyzed publications is discussed. Finally, the main findings of the research are revealed.

2. Literature Review

2.1. Lean Philosophy

Production systems have undergone several evolutions throughout history. First, production was essentially handmade, and then it was replaced by mass production with

assembly lines. From the middle of the 20th century, the lean approach has increasingly replaced mass production until today [16]. Lean philosophy, or lean thinking, inspired by the Toyota Production System, can be considered as a philosophy that helps in the identification and elimination of waste. In practice, lean philosophy helps maximize product value by minimizing waste [17–20].

Taiichi Ohno, the pioneer of the Toyota Production System (TPS), described the following: "All we are doing is looking at the timeline from the moment a customer gives us an order, to the point when we receive the money. In addition, we are reducing the timeline by reducing waste activities that do not add value" [18].

The objectives of the lean philosophy are: to reduce waste in human efforts, stock, the time of marketing and production space to become agile-looking for the customer while producing quality products more efficiently and economically [21]. This production approach consists of determining the value of each activity and distinguishing the activities that add value from activities that do not add value. The latter has been worked on in order to reduce or even eliminate them [22,23]. Lean philosophy is "a way to do more with less and less human effort, less equipment, less time and less space as it comes closer to providing customers with what they want" [24].

Lean thinking is a critical concept in which value creation and waste reduction are interrelated with each other. Value creation is defined as meeting customer requirements by understanding requirements, mapping the process, promoting value flow to and from stakeholders, extracting customer value and driving toward perfection [25]. In order to reduce or even eliminate waste in the production system, organizations need to follow five key principles, as follows: Define "Value" from the customer's point of view, Identify the "Value Stream", Create a "Continuous Flow", Create "Pull Flow" and "Seek Perfection" [26]. The lean philosophy suggests that, in order to create capacity in the workplace, it is better to identify areas where there is waste and to work in these areas in order to eliminate them from processes [27].

Lean thinking practitioners traditionally focus on what they refer to as the seven forms of waste: Overproduction, Waiting Time, Transportation, Improper Processing, Inventory, Defects and Movements [4,15,28]. Recently, the authors have suggested two more types of waste that should be considered: the Underutilization of People's Creativity and Environmental Waste [29]. The departure of individuals from companies with a certain set of skills and the non-use of talent results in losses of competitiveness and productivity for companies [15].

2.2. Six Sigma

The six sigma philosophy embarks on organized and systematic methodologies that do not have, as their sole purpose, the improvement of a strategic process, but it also allows for the design of new products and services. It achieves significant reductions in defect rates and frequently uses statistical and scientific methods [30]. Essentially, an approach that improves productivity, quality and reduces operating costs is traditionally used to measure and reduce process variability [31]. It is a philosophy of continuous improvement aimed at increasing efficiency and customer satisfaction and reducing operating costs [29]. In general, it is a business improvement strategy, focused on processes to improve the profit yield by eliminating waste, reducing the cost of non-quality and improving the effectiveness and efficiency of the entire system in order to achieve or even exceed the stakeholders' needs and expectations [32].

The six sigma philosophy has two methodological branches: DMAIC (Define, Measure, Analyze, Improve, and Control) and DMADV (Define, Measure, Analyze, Design, Verify). The first focuses on existing products and processes. The second focuses on new products and processes [33,34]. The main differences between the DMAIC and DMADV methodologies are in the objectives and results of the project. DMADV has a more tangible result; however, both methods have better quality, efficiency, more production, profits and greater customer satisfaction as their common goals [35].

The DMAIC methodology provides organizations with a rigorous and disciplined structure [36]. It is used for process improvement and, more recently, for project management. It enables the finding of solutions and opportunities based on decisions supported by data and management standards, and it also provides formal procedures for the implementation of solutions [37,38].

The path of the different DMAIC phases is then described succinctly [39–41]:

- Define: The identification of the problem, the determination of objectives and the appropriation of the relevance of the objectives.
- Measure: The translation of the problem in a measurable way through the observation and research of knowledge.
- Analysis: Making a diagnosis by identifying the factors and causes of influence that determine certain behaviors, and using the aggregated data in the Measurement phase.
- Improve: Implementation of measures that have been designed to improve performance and achieve the desirable state.
- Control: Adjustments to process management and system control; therefore, the results are sustainable.

2.3. Lean Six Sigma

The lean six sigma (LSS) philosophy emerged in the early 2000s and is a hybrid philosophy built from the combination of lean methods and principles with DMAIC [1,42]. Being considered a differentiating philosophy of management and improvement, its acceptance in the generality of the industry has grown rapidly, causing significant improvements in the performance of organizations [43]. These improvements are based on reducing costs, reducing lead time and increasing quality through the elimination of waste and process variation, thus enabling organizations to achieve competitive prices and thereby ensuring customer satisfaction [44–46]. The consistent practice of methodologies such as LSS allows companies to embark on a sustainable development strategy and to be socially and environmentally responsible for their practices, achieving a desirable control that enables them to gain a competitive advantage [47].

The combination of lean thinking and six sigma allows companies to capitalize on the best of both worlds in order to achieve operational excellence [5]. The LSS philosophy "uses tools from both toolboxes to get the best of both philosophies, increasing speed while increasing accuracy" [48]. Lean philosophy, as mentioned above, increases productivity by eliminating waste, such as activities that do not add value, with the goal of achieving the continuous flow of production smoothly and uninterruptedly, producing only what the customer requires. The six sigma philosophy increases productivity by reducing product variations and increases the quality of production processes [49,50]. In addition to that, it also provides methodologies for solving problems in a structured way, which allows a strategic direction for improvement [48].

2.4. The Shingo Model

The Models of Operational Excellence began to emerge around the late 1980s and early 1990s, with the aim of supporting organizations to overcome challenges, to improve the level of performance and to achieve results that are sustainable in the long term [51]. The Models of Operational Excellence, today, are also identified as a potential support for corporate sustainability through the integration of sustainable development criteria in traditional business models. Corporate sustainability is a concept that incorporates areas such as long-term focus, stakeholder needs and the foundations of sustainable development (social responsibility, environmental responsibility and economic responsibility) [52].

In order to achieve operational excellence, there is a panoply of methodologies that can be applied, as is the case of the Shingo model. It was conceived by Japanese industrial engineer Shigeo Shingo, who highlighted the importance of organizational and behavioral culture along with the integration of lean culture; therefore, transformation and development can occur with the desired results [53].

The Shingo model allows for the symbiosis of the multiple strands of a lean management system in a strand of operational excellence, i.e., it is not only focused on the customer (results) and tools but also covers systems, culture and guiding [54]. Organizations design systems with the intention of achieving specific results and select tools to support these systems. However, the tools do not run a business. The behaviors of people in an organization can influence the sustainability of results, and therefore, this model argues that the search for improvement can not only be limited to the application of a new tool or method but should also focus on organizational culture [53]. Organizational culture is the system of principles that members of the organization share, including ways of working, traditions, histories and methods capable of achieving goals [55]. The cultural perspective is important in models of excellence, since it influences the actions and behaviors of people. From the perspective of business excellence, it helps organizations find a motivating context for change and achieve higher performance levels. It is through culture that organizations are able to build systems and processes that are strong and stable to meet the market's needs [56].

The Shingo model presents guiding principles and connects them with systems, tools, results and culture, integrating these five elements around the relationships illustrated in Figure 1.

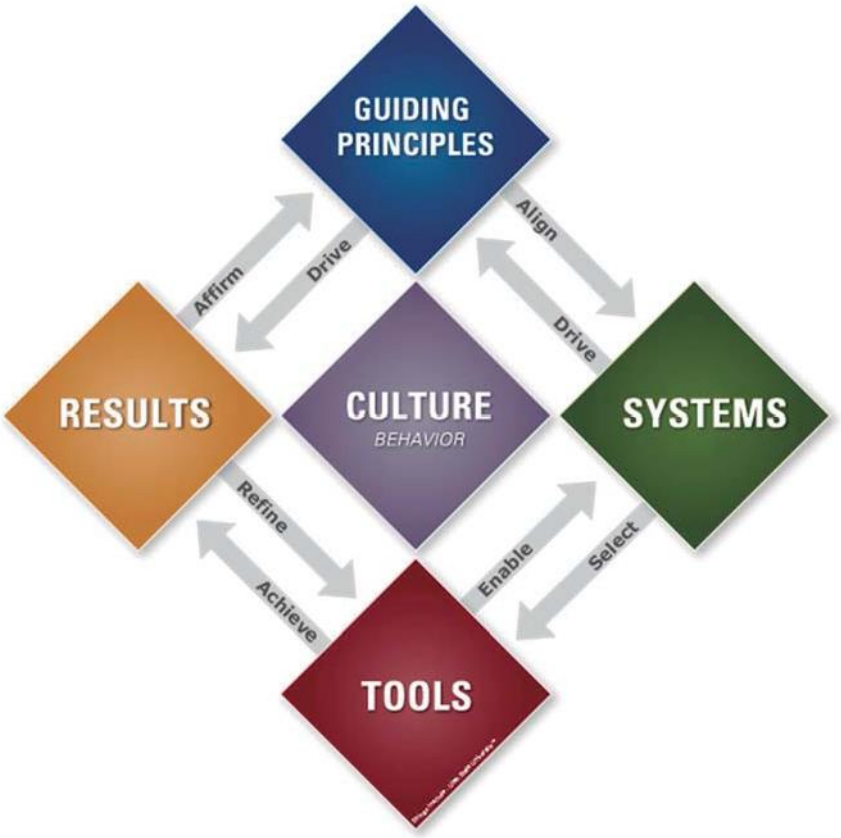


Figure 1. Shingo model parameters (Shingo Institute, 2022).

The parameters present in Figure 1 correspond to [53]:

- Guiding Principles: Shingo's guiding principles are the basis for a sustainable organizational culture of excellence. They indicate rules that enable the understanding of the consequences of behaviors and, therefore, enable decision making to be conscious and to meet the ideal results;
- Tools: Tools that allow operational execution to be carried out in order to achieve the purpose of the system. Therefore, they must be carefully selected in order for the tools to be aligned with the system;

- Systems: These are sets of processes, persons or procedures that are interconnected and allow the realization of guiding principles;
- Results: The consequence of leadership capacity, behaviors and routines. Ideal results are all those that are sustainable in the long term and that require leadership capacity to create cultures in which behaviors and routines are practiced;
- Culture: The center of the Shingo model, which represents the manifestation of the behaviors and actions of the organization's elements;

The Shingo model presents ten guiding principles that are organized in three dimensions: cultural enablers, continuous improvement and enterprise alignment (Figure 2).

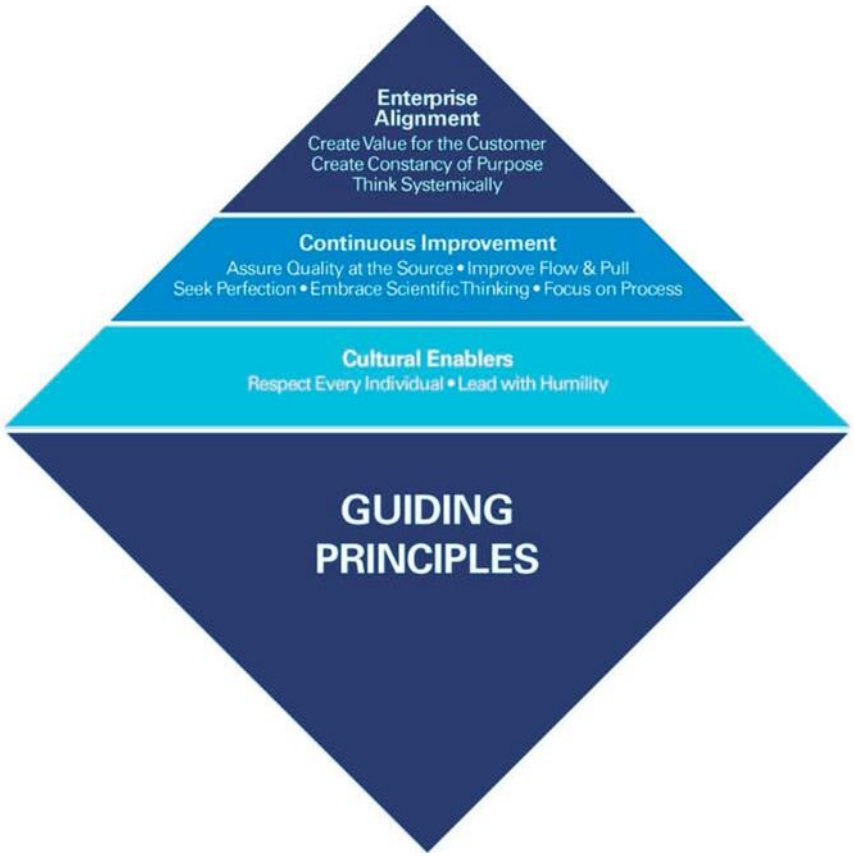


Figure 2. Dimensions of the Shingo model (Shingo Institute, 2022).

Guiding principles are used to align behaviors and actions, a process that is improved by selecting specific tools used to achieve results, where the results then affirm the guiding principles. In the opposite direction, the Shingo model indicates that the guiding principles can generate results in the form of performance indicators and impacts from which the company can obtain interpretations and predictions that can help in the refinement of the tools used to improve the systems that, in turn, direct principles that are anchored in the core values of the company [57].

The principles of the Shingo model are universal and timeless, and therefore, they do not vary in different cultures and eras, although they may manifest themselves differently [57]. Table 1 shows the principles corresponding to the Shingo model's dimensions.

As already referenced, it is known that the Shingo model can help organizations search for optimal results in various dimensions, as long as it is implemented appropriately [57]. Briefly, the model argues that the involvement of all elements of the organization is essential for significant and sustainable improvement and that it is only possible when people's behaviors are aligned with ideal behaviors based on principles.

Table 1. Shingo's model guiding principles [55].

Dimensions	Guiding Principles
Cultural Enablers	Respect each individual
	Lead with humility
Continuous Improvement	Seek perfection
	Adopt scientific thinking
	Focus on processes
	Ensuring quality at the source
	Improve flow and pull
Enterprise Alignment	Thinking systematically
	Create continuity of purpose
	Create value for the customer

3. Methodology

This research was conducted from the Web of Science (WoS) database, and since its scientific quality is internationally recognized, it covers a wide range of publications, a robust citation index as well as other features such as interesting and effective analytical tools. The bibliometric analysis of the referenced articles aims at evaluating the scientific activity of a field of study and performing a meta-analytical evaluation of the literature.

3.1. Database Selection

The Web of Science (WoS) database includes the most important journals in this field of knowledge, such as: Production Planning and Control, Materials Today: Proceedings, the International Journal of Production Research, the International Journal of Productivity and Performance Management, the Journal of Cleaner Production, the International Journal of Advanced Manufacturing Technology, Total Quality Management and Business Excellence, the International Journal of Lean Six Sigma, Clean Technologies and Environmental Policy, the International Journal of Sustainable Engineering, and Sustainability, among others. Moreover, due to restricted access to other databases, this has been the main source of information used by many research groups, being one of the most reputed databases as well because it is linked to Clarivate.

3.2. Publication Search Criteria

The criteria selected with the research are ordered chronologically in Figure 3. First, after the selection of the database (Web of Science), documents written in English and peer reviewed were exclusively considered. Second, the restricted time space between 2010 and 2021 was considered; therefore, the matters that are regarded are current and valid. Data collection was finalized in May 2022. Third, four distinct combinations of keywords ("lean methodology" or "lean manufacturing" or "lean tools", "six sigma" or "DMAIC", "lean six sigma", "sustainability" or "Shingo's model" or "excellence models") were used. This research covered the theme, which included the title, summary and keywords of each post. After these first three steps, articles from the database were randomly selected for each combination of keywords. Finally, a manual selection of publications was carried out on the publications that were selected randomly, and they were fully read. This procedure resulted in the selection of 67 publications based on the theme "Lean", 40 publications based on the theme "Lean Six Sigma", 12 publications based on the theme "Six Sigma" and 6 articles based on the theme "Shingo's Model". A total of 125 publications were consulted, for which a quantitative and qualitative analysis was carried out.

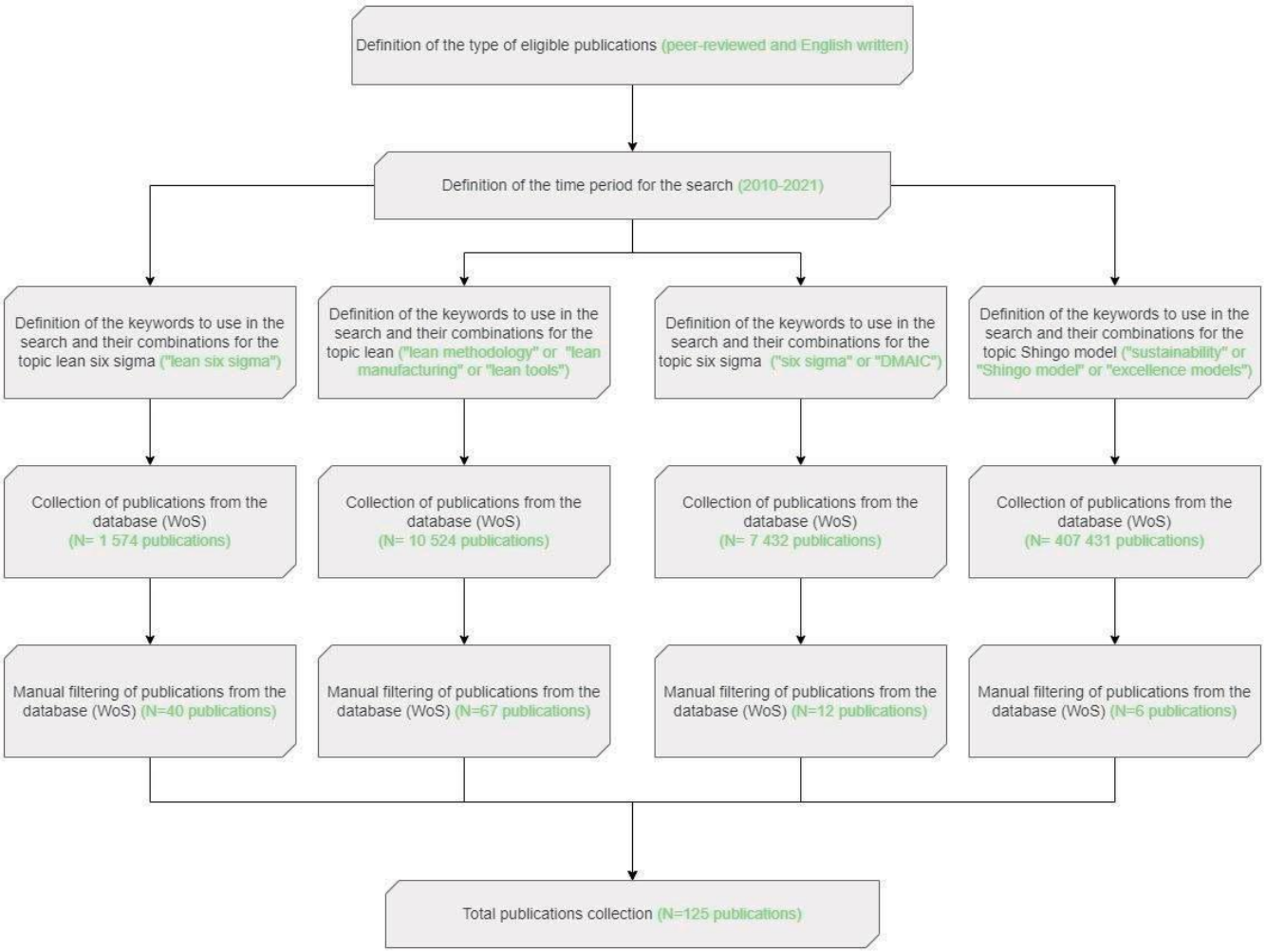


Figure 3. Research strategy steps.

In order to design the respective publication analyses, a database was constructed in an MS Excel® data sheet based on data obtained from the Web of Science, such as the title of the publication, the average number of citations per year and the journal name. Additionally, after reading and analyzing each document, the MS Excel® data sheet was complemented with the area of the application, research objectives, main contributions and suggestions for future research mentioned by the authors of the publications. Finally, these documents were classified into four groups based on research themes, as follows: "Lean", "Six Sigma", "Lean Six Sigma" and "Shingo's Model".

3.3. Bibliometric Analysis

The design of the bibliometric analysis was supported by VosViewer software (version 1.6.17) (Universiteit Leiden, Leiden, The Netherlands) through which it was possible to obtain a network visualization map with key concepts of greater relevance of the various publications.

4. Results of the Bibliometric Analysis

4.1. Distribution of Publications

With the support of WoS, the publications referenced for several years (Figure 4) were made. It was found that the oldest publications were from the year 2011, with 7 (5.6%) publications, whereas the most recent publications were from 2021, with 14 (11.2%) publications. The years 2017 and 2019 had the most publications, with each having 16 (12.8%)

and 19 (15.2%) publications, respectively. It was noted that there is a growing trend of publications analyzed from more distant years to the most recent.

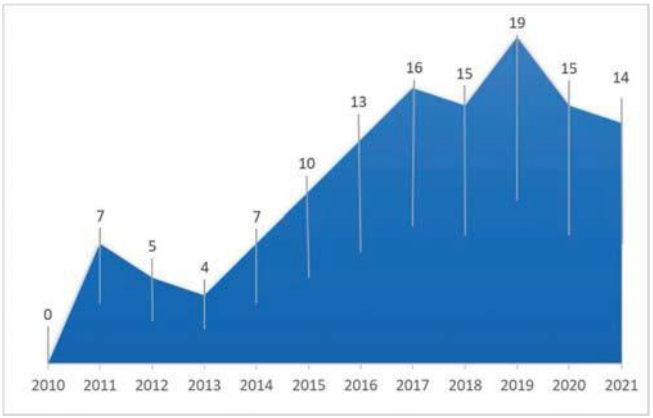


Figure 4. Distribution of publications found under this scope by year of publication.

Regarding the average number of citations per year (Figure 5), there is also an increasing trend. In addition to the upward trend in the number of publications, there is also an upward trend in the number of citations. This shows the increasing interest of the scientific community in studying the concepts lean, six sigma, lean six sigma and the Shingo model in recent years. The publications of the years 2020 and 2021 were the most cited, with each surpassing the barrier of 500 citations.

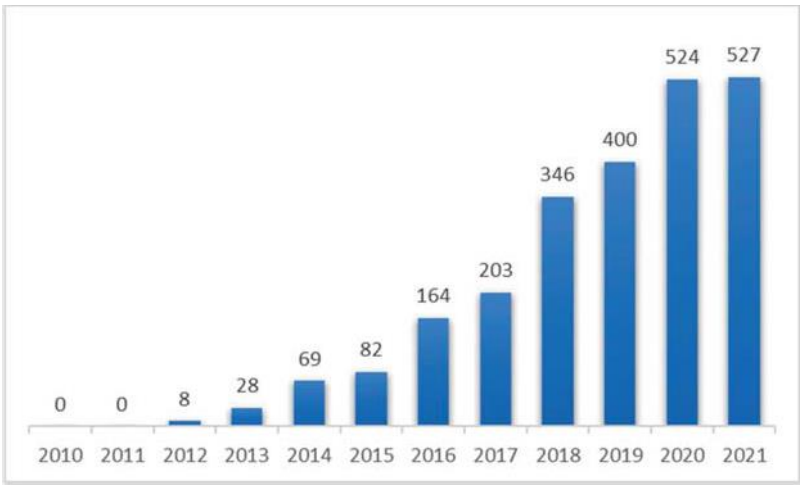


Figure 5. Distribution of citations by year of publication.

In relation to the journals used as sources of information (Figure 6), it was verified that Production Planning and Control and Materials Today: Proceedings were the most common, with a total of 9 and 7 publications, respectively. The following was Total Quality Management and Business Excellence, with 5 publications. The International Journal of Production Research, the International Journal of Productivity and Performance Management, the Journal of Cleaner Production and the International Journal of Advanced Manufacturing Technology completed the group of journals with the most publications associated with, respectively, 4 publications each. Regarding the axis identified as "Other", it represents the journals that had fewer than 4 publications associated with the work. Making a total of 88 journals on the "Other" axis, this group includes journals such as the Central European Journal of Operations Research, the International Journal of Lean Six Sigma, the International Journal of Sustainable Engineering, Quality Engineering and Trends in Food Science and Technology, among others. The high number of associated journals in the distribution of publications based on the concepts "Lean", "Six Sigma",

"Lean Six Sigma" and "Shingo's Model" highlights the scope and diversity of the fields of study related to those subjects.

Figure 6. Distribution of Publications by Scientific Journal.

4.2. Cluster Identification

The construction of the clusters was based on the intersection of articles based on the topics "Lean", "Six Sigma", "Lean Six Sigma" and "Shingo's Model". The first cluster consisted of 17 terms. The second cluster consisted of 14 terms. The third and fourth clusters were composed of 11 terms. The fifth cluster consisted of 10 terms. The sixth and seventh clusters were composed of 8 terms. The eighth cluster consisted of 7 terms. The ninth cluster consisted of 6 terms. The tenth and eleventh clusters were composed of 4 terms, summing up a set of 100 study topics.

By observing the map presented in Figure 7, it seems that the ten most mentioned topics are: "manufacturing, technology, lean manufacturing, productivity, management, lean, efficiency, work, DMAIC and sustainability". The ten topics less mentioned are: "responsibility, leadership, SMED, workstation, rework, variation, automation, energy, VSM and flow".

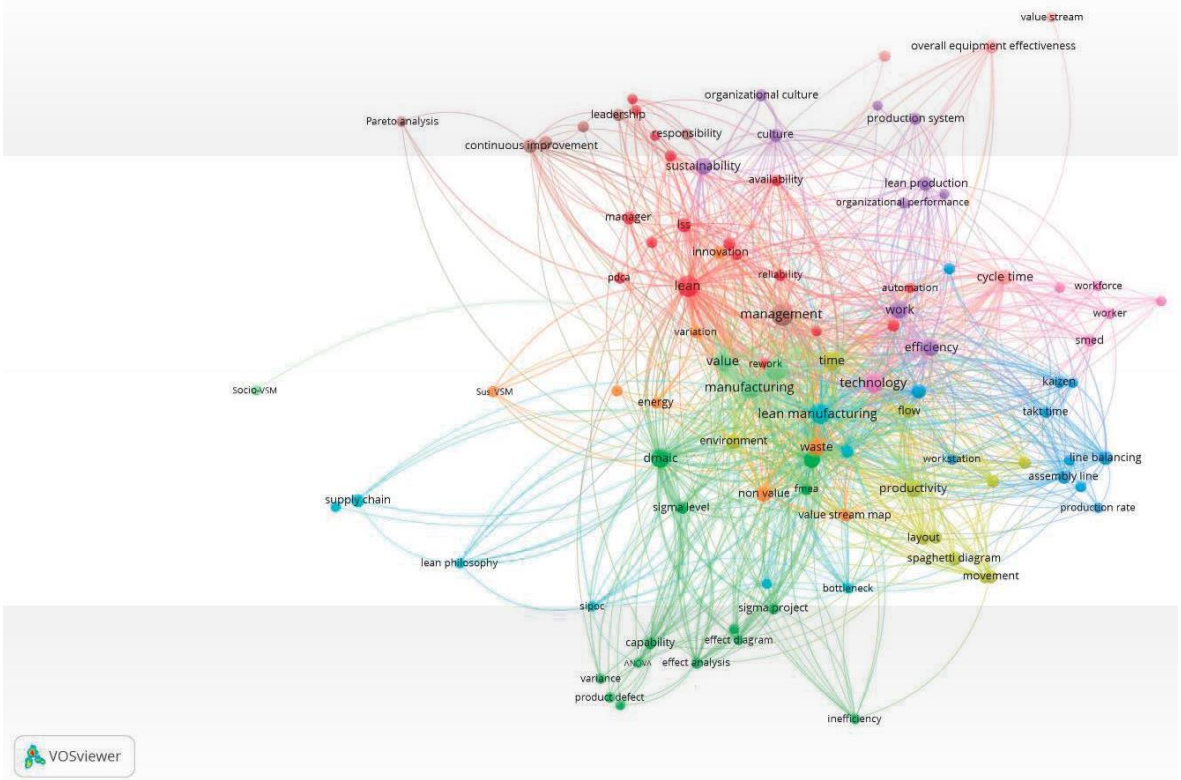


Figure 7. Most important study areas for lean, six sigma, lean six sigma and the Shingo model.

By analyzing Figure 7, it is possible to observe that the most dispersed areas encompass topics such as: "value chain, production rate, movements, bottleneck, sigma design, capability, logistics chain, Sus-VSM and OEE". Later, some of these topics are studied in greater detail.

Following the network visualization map (Figure 7), the constitution of each of the eleven clusters is presented in Table 2.

Table 2. Most important clusters on lean, six sigma, lean six sigma and the Shingo model.

Clusters	Items
Cluster 1 (17 items)	Automation, availability, competitive advantage, green lean, infrastructure, lean, lean six sigma, maintenance, manager, SMEs, operational excellence, PDCA, production cost, reliability, rework, commitment of top management, training;
Cluster 2 (14 items)	ANOVA, "Capability", cost, DMAIC, effect analysis, effect diagram, FMEA, inefficiencies, product defect, product quality control, sigma level, sigma method, sigma design, variance;
Cluster 3 (11 items)	Production line, kaizen, kanban, lead time, line balancing, production rate, takt time, waste reduction techniques, labor standardization, workstation, yamazumi;
Cluster 4 (11 items)	Environment, flow, inventory, layout, lean principle, lean thinking, movements, productivity, spaghetti, staff, time;
Cluster 5 (10 items)	Culture, efficiency, environmental management, lean production, lean production system, organizational culture, organizational performance, production system, sustainability, work;
Cluster 6 (8 items)	Bottleneck, customer satisfaction, inventory management, lean manufacturing, lean philosophy, OEE, SIPOC, logistics chain;
Cluster 7 (8 items)	Energy, innovation, non-value, Sus-VSM, sustainable manufacturing, VSM, variation, waste;
Cluster 8 (7 items)	Business excellence, continuous improvement, leadership, management, Pareto analysis, quality management, responsibility;
Cluster 9 (6 items)	Time set-up, human factor, SMED, technology, worker, workforce;
Cluster 10 (4 items)	Cycle time, OEE, project management, value chain;
Cluster 11 (4 items)	Industry, manufacturing, Socio-VSM, value;

As shown in Table 2, it is possible to identify 11 clusters in relation to the intersection of concepts among lean, six sigma, lean six sigma and the Shingo model. In cluster 1, it shows the correlation between different philosophies, strategic methodologies and critical success factors for the improvement of key indicators. Cluster 2 focuses on the weight of certain tools and methodologies in controlling waste and defects. Cluster 3 shows tools capable of generally improving the operation of production lines. Cluster 4 depicts the connection of some classic waste scum of lean thinking and tools capable of diminishing its effects on organizations and their eventual connections to the environment. Cluster 5 lists concepts such as sustainability, lean and the relevance of culture to the success of these concepts. Cluster 6 describes productivity and flow-related tools that can help meet customer needs. Cluster 7 describes the need to reduce the environmental impact of organizations, more critical areas related to sustainability and some tools capable of helping in this direction. Cluster 8 indicates some critical success factors and support areas for achieving excellence. Cluster 9 contains factors and techniques capable of reducing non-productive times for organizations. Cluster 10 shows classic production and tools capable of increasing the efficiency of production systems. Cluster 11 essentially focuses on the importance that social factors should have in organizations for the production of widespread value.

5. Structural Analysis

5.1. Distribution of Publications by Search Topic and Application Area

Through this analysis, the publications were categorized according to four research topics, which were: lean, six sigma, lean six sigma and the Shingo model (Figure 8). Through this categorization, it was possible to observe that the lean topic was the one with the most associated publications, with a total of 67 (54%). Next, the lean six sigma topic had about 40 (32%) associated publications. The six sigma topic had 12 (9%) associated publications. Finally, the Shingo model topic had 6 (5%) associated publications. This discrepancy in the number of six sigma publications in relation to lean and lean six sigma is explained by the fact that the focus was on the research of methodical structures and not six sigma tools. These data reveal that lean has had greater prominence and importance in studies in the area of industry and whose tendency is to increase the relevance of lean six sigma by being able to adopt concepts and methodologies of both lean and six sigma areas. The Shingo model allows us to relate these concepts to operational excellence.

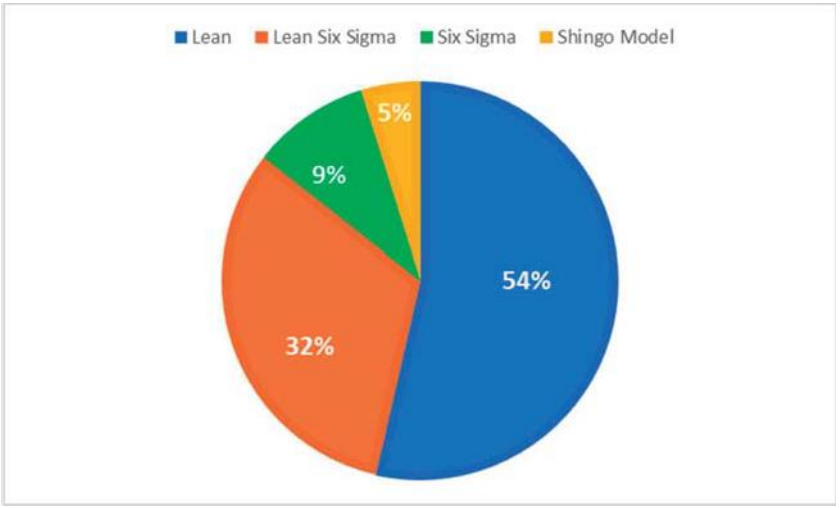


Figure 8. Categorization of publications for each topic.

Table 3 shows a categorization of the papers consulted, taking into account the topic and quantifying the number of papers consulted under each topic.

Table 3. Categorization of the analyzed publications.

Topic	Publications	Total
Lean	[2,4,16–18,21–23,26–28,58–112]	67; 54%
Six Sigma	[3,30–33,35,40,41,113–116]	12; 9%
Lean Six Sigma	[1,5,12,14,15,24,25,29,34,36–39,42–50,117–134]	40; 32%
Shingo Model	[51,52,54–57]	6; 5%

Additionally, a graph (Figure 9) is displayed from which publications are distributed throughout their years and search topics. From this chart, it is possible to verify that publications related to the lean topic were in primacy from the year 2016, with a total of 48 publications until 2021. This corresponds to about 71% of the total publications with the lean topic. Publications with the topic lean six sigma began to gain prominence from the year 2017, with a total of 29 publications by 2021. This is about 72% of the total publications with the topic lean six sigma. Publications with the topic six sigma were

dispersed in a constant way over the years while never surpassing the two associated publications per year. The years 2013 and 2021 were the exceptions that did not present any publications associated with the theme six sigma. Publications with the Shingo model topic were concentrated in the years 2015, 2017, 2018 and 2019. The year 2018 contained half of the publications under this topic, with about 3 publications.

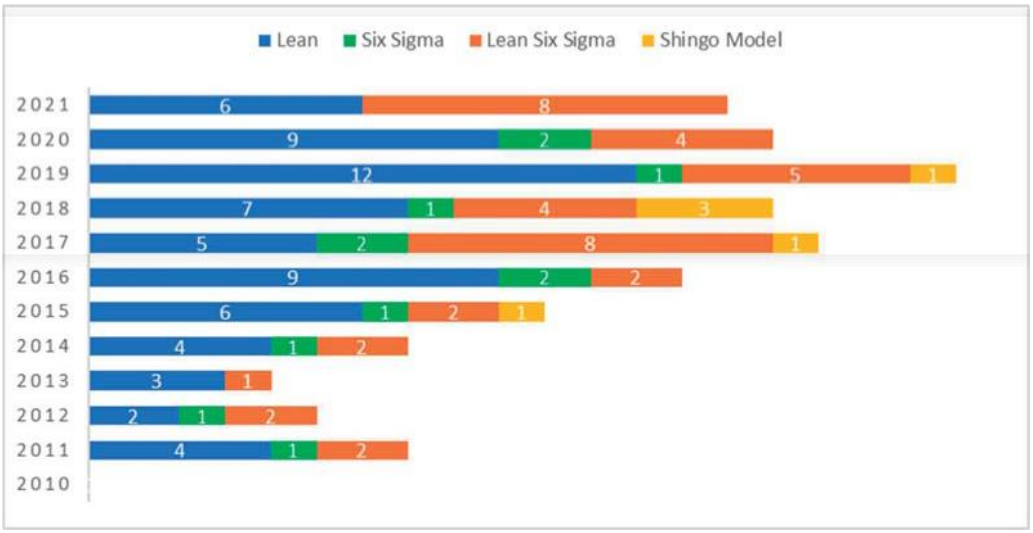


Figure 9. Distribution of publications analyzed by topic.

The publications were also distributed depending on the area of application (Figure 10). From this distribution, it was possible to notice that the most referenced areas were theoretical, automotive and metallurgical, with a total of 30, 17 and 13 publications, respectively. Unsurprisingly, lean dominated the automotive area, whereas lean six sigma began to gain prominence in the theoretical and metallurgical area. The areas that completed the most outstanding ranges were health, multisector, food and textile, with a total of 10, 7, 6 and 5 publications, respectively. In the area classified as "Others", there were documents with areas of application presenting fewer than 5 references, such as services, agriculture, aerospace, electronics, pharmaceuticals and logistics, among others.

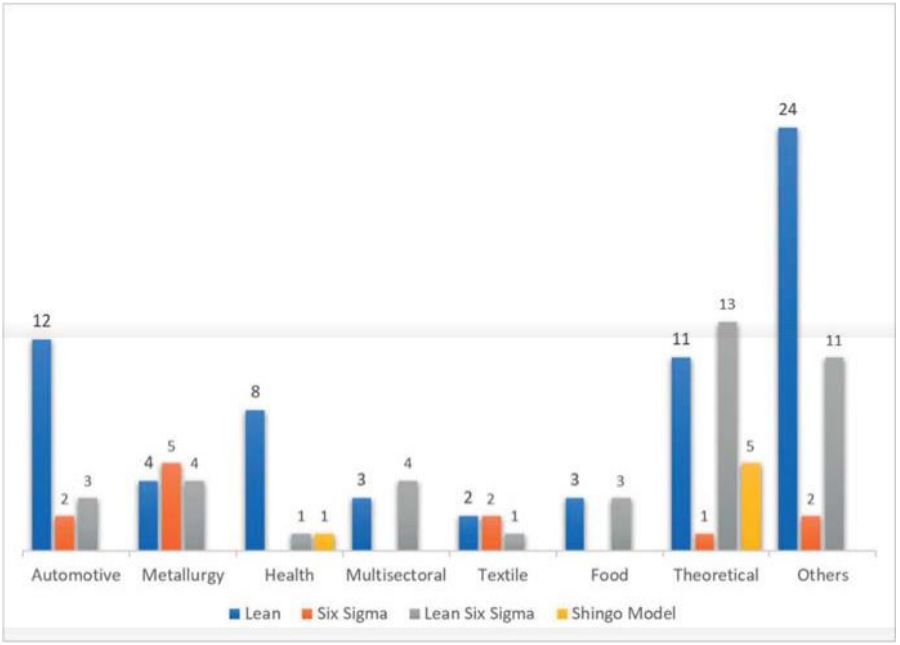


Figure 10. Classification of publications by application area.

5.2. Presentation of Case Studies

Some case studies are presented from the publications analyzed in this research (see Table 4).

Table 4. Description of case studies of the publications analyzed.

Authors	Application Area	Description
[66]	Manufacturing	In this work, the focus was on the implementation of the Work Standardization tool on a production line. The implementation of the tool resulted in a 37.5% decrease in work at one of the workstations and an increase of 304.7% for the daily income at the workstation that was the bottleneck of the production line.
[67]	Car industry	Labor Standardization was applied in several operations of the production line, resulting in a decrease in cycle time by 350 s and reducing setup time by 1500 s. Working procedures were built and placed on all machines in the line; therefore, they were easily accessible to all operators.
[70]	Manufacturing	In this work, the focus was on the Standardization of the Work of a manufacturing company in India, resulting in a decrease of 31.6 s in product cycle time and a production increase to 58 parts that initially floated around 45–50 parts in a 7 h shift. It should be noted that production improvements were achieved without the need for investment in machines or tools by the company.
[71]	Printing Shop	In this work, the focus was on optimizing resources in a small printing shop in order to be able to satisfy requests. To this end, a study was conducted on the times of the processes, the movements of the operators and the respective layout of the production process, identifying sources of waste and opportunities for improvement. Finally, Work Standardization occurred with the help of Process Charts and visual help of the execution of operations, allowing for a reduction in unnecessary movements by 66%, and the standard time on the workstation decreased from 244 to 199 s for each product, increasing the production rate by 63.2% as well.
[72]	Health	In this work, the focus was on improving the processing efficiency of patients in a hospital's emergency department. In order to reduce patient waiting times, two tools were developed that allowed for the standardization of the admission processes of patients in the hospital. After the implementation of the tools, the admission time decreased from 154 to 144 min, although it did not significantly improve the time of admission, but it improved the patients' transfer times (from 30.5 to 21.7 min) and the time required to receive or deliver medical reports (from 3.8 to 2.8 min). Thus, there was a significant improvement in the flow of patients.
[68]	Manufacturing	In this work, the focus was on the implementation of a methodology developed by the author for micro and small enterprises that allowed for the improvement of the OEE index of an operation. After an initial analysis, a set of lean tools was recommended to correct inefficiencies. The practical case presented demonstrated that, after observing the data, availability was the main cause of overall efficiency loss. When applying the Pareto diagram, it was observed that the change in tools was the highest stopping time. The application of SMED was suggested, and, after its implementation, a significant increase in the availability of the machine was observed, increasing the OEE from a range between 70% to 75% to an interval between 81% to 85%.
[69]	Plastic Extrusion	In this work, the focus was to increase the efficiency of an extrusion process of a company in the plastic industry. After the collection and analysis of the process data, it was found that the main cause of the low OEE indicator was the long downtime without producing. To this end, an innovative proposal was developed that involved the use of SMED and preventive maintenance techniques. For the validation of this model, arena simulation software was used to analyze what results this model may lead to, showing that the proposals could result in a reduction in non-productive times by 36.67% and an improvement in the OEE by 9.02%.
[85]	Semiconductor industry	In this work, the author developed an innovative model that allows for a systematic approach to improve the OEE of a system, a framework that incorporates the advantages of OEE with conventional improvement models. It was validated with a 38-week study case by a semiconductor company in Malaysia. The production system had a low OEE of 73.4%, caused by the loss of availability (76.5%). The application of the model developed by the author resulted in an improvement of the OEE and availability to 76.5% and 80%, respectively. In financial terms, it resulted in savings of about 565,000 USD for each conversion of the production line. It should be noted that this model was subject to a single case study. Therefore, it is necessary to test it in different scenarios to prove its robustness.
[86]	Manufacturing	The authors developed a method capable of combining SMED with preset systems (tool anticipation or device adjustments) in order to improve the productivity of production systems. It was validated with a study case in the industry that allowed the following results to be recorded: an 87% reduction in the setup times of the bottleneck resource (labelling machine), a 33.8% increase in the OEE of the labelling machine, a 17% increase in the OEE of the production line and a 45% reduction in lot size.
[87]	Machining	In this work, the objective was to improve the OEE of the CNC machines of a company of the mold industry in Portugal. Initially, they had an OEE value of about 50%. Through the application of tools such as 5S, SMED, Visual Management and Work Standardization, it was possible to improve the performance of the machines. Overall, the OEE was improved by about 20%.

Table 4. *Cont.*

Authors	Application Area	Description
[88]	Pipe Manufacturing	In this work, the authors highlighted the importance of a new indicator capable of combining OEE and Sustainability. This new indicator was designated as Overall Environmental Equipment Effectiveness (OEEE). In order to assess its impact, the authors conducted a case study at a pipe manufacturing company. By analyzing the application of this indicator on a production line, it concluded that the raw material of the product analyzed would have to be replaced by another one in order to comply with the sustainability requirements. Other modifications were also performed, such as the elimination of excessive stocks of raw materials and increased flexibility of the production line (from 2301 to 685 s for the production time of the first part in the line) in order to respond in a timely manner to the customer's needs. With these changes, the cost of production decreased by 6.2%, highlighting the company's increased competitiveness with respect to price, flexibility and sustainability.
[89]	Cellulose	The authors developed an integrated model based on six sigma and TPM in order to improve the performance indicators of the production systems. The model was applied in a manufacturing cell consisting of two machines from a pulp company. The goal of the study was achieved with the application of multiple tools, such as Brainstorming Sessions, Pareto Diagram, Ishikawa Diagram, histograms, FMEA and control charts, among others. At the end of the project, there was a significant improvement in the OEE, which was in a range between 50% and 54% for a range between 76% to 83%, also reducing rework from 22% to 10% and the defect rate from 24.82% to 5%, leading to financial savings of around 2 million USD per year.
[90]	Car industry	In this work, the focus was on the integration of the production teams linked to an assembly system with the measuring system performance indicators in real time. The validation of this system took place in a factory of the automotive industry in Spain. The goal of this system was to focus the organization on value chains and to improve their performance based on the OEE. The system provided real-time OEE values from value chains and allowed production teams to use meetings to discuss and improve the provided indicators. Thus, greater relevance was directed to key points that had a critical impact on production volume. The solution presented allowed for a significant improvement of OEE values in general between 5 and 10% from January 2009 to January 2012 in the case study. It should be noted that this model has been validated with only one practical case. It is necessary to test it in different scenarios to prove its veracity.
[100]	Food industry	In this work, there was a lean implementation in a food company with the help of two tools (SMED and VSM). VSM allowed for the identification of the different wastes associated with the production line (84% of the total production). Then, with the help of SMED, it was possible to reduce setup times by 34% and to promote an increase in line productivity by 11%, allowing the company to avoid the use of temporary workers in periods of high demand.
[101]	Food industry	In this work, there was a lean implementation in a set of companies in the wine sector. VSM was used as the main tool for the determination of waste and points of improvement for the production process. From the VSM information, some tools were selected that were capable of solving the problems found. In the end, it was possible to reduce the lead time between 50% and 65% and to induce a reduction in raw materials between 8% and 16%.
[102]	Logistics	In this work, the focus was on improving the logistics processes of a military unit. VSM and VSD (Value Stream Design) served as the basic tools for improving the processing of item orders, allowing for eliminating or reducing activities that did not add value and improved order processing procedures. The results that were obtained in a simulation showed that the "future state map" could allow for increases in activities that add value, from 44% to 70%, and a reduction in lead time of 69.6% was achieved.
[103]	Car industry	In this work, the focus was on improving the productivity of a production line of an automobile company. For this, VSM and the simulation approach were adopted to validate the improvements. It was observed that it was possible to reduce cycle time by 87.59%, to reduce WIP inventories by 76.47%, to reduce lead time by 95.41%, to reduce the number of operators by 57.14% and to reduce setup times by 70.67%.
[104]	Services	In this work, the focus was on improving the efficiency of services provided by a maintenance team and repairing buildings of a public university. VSM was used as a basis for the identification of waste and improvement points. Then, the simulation was used to validate the proposals. The changes made, based on the simulation, allowed for a reduction in lead time by 26.8% and a reduction in waiting times by 33.6%. This case highlights the increased difficulties of implementing lean concepts in the area of services. However, they can be implemented and provide very good results.
[36]	Theory	In this work, a VSM model focused on sustainability was used, designating it as *Sus-VSM*. It emerged with the emergence of sustainable manufacturing systems. The particularity of this model is that, in addition to evaluating the classic VSM metrics such as cycle time, lead time and material cost, it also analyzes a set of metrics related to the environment and the social environment. For example, it analyzes chemical consumption, water consumption, energy consumption, noise level and the ergonomics of jobs. Thus, the *future state map* is not only aimed at improving the product and process flow, but it also improves environmental performance and work conditions.

Table 4. *Cont.*

Authors	Application Area	Description
[128]	Theory	In this work, a VSM model focused on energy was developed. The authors' model was designated as Lean Energy Six Sigma Value Stream Mapping (LESSVSM) and was based on Energy Value Stream Mapping (EVSM). It has emerged to combat waste existing in the energy area. It evaluates consumption along the manufacturing system chain and identifies foci where consumption can be eliminated or managed more efficiently. The design of the future state map from this model aims to achieve sustainable manufacturing by reducing energy and waste costs, increasing efficiency in their jobs.
[16]	Theory	In this work, a model was proposed that integrates the Eco-Function Matrix with VSM. The process starts with the construction of the current state map in which it identifies and categorizes waste. Areas classified as more critical are configured as requirements in the Eco-Function Matrix. Brainstorming sessions are then held building proposals and improvements that can be designated as attributes. Then, the conventional Procedure of QFD (Quality Function Deployment) begins to consider the environmental perspective in the construction of the matrix and its interrelationships. Finally, the waste and proposals for improvements is ordered as a priority; therefore, the construction of the future state map is one of the most important topics.
[18]	Theory	In this work, a model designated as *Variability Source Mapping* (VSMII) is proposed, with a focus on the identification and reduction in variability throughout the production system. The construction steps are similar to the classic VSM model, but it adds some details, such as the mean, standard deviation and coefficient of variation of the cycle time for each job. It also assesses the variability of the flow on arrival between jobs or phases, developing a system variability metric that is able to identify the most critical locations or jobs with variability levels. With the help of lean tools and control production policies, it is possible to build a future state map that allows for the reduction or elimination of the sources of variability, thus decreasing the variability level of the system
[105]	Theory	In this work, the authors provide a new approach capable of incorporating the PDCA (Plan–Do–Check–Act) methodology with environmental VSM (E-VSM). This is an alternative proposal capable of improving the environmental performance of operations using principles, techniques and lean tools. Reductions in energy consumption and waste production are some of the environmentally analyzed wastes with great focus on E-VSM. The PDCA approach allows for a systematic methodology in the elaboration of the current state map and future state map. According to the author, the main focus of this model is for industrialists who intend to achieve environmentally sustainable operations.
[106]	Theory	In this work, the author presents a new tool called Ergo-VSM, based on the VSM methodology and incorporating ergonomic indicators related to the physical and psychological factors of workers. The goal is to improve the ergonomic conditions of workers without compromising the classic productivity indicators. The inclusion of factors related to the physical environment of workers, such as noise, temperature and luminosity, can affect not only the health of workers but also their own performance. Therefore, this tool can also have a positive effect on productivity.
[107]	Construction	In this work, the authors propose a new model based on the integration of LCA (Life Cycle Assessment) and VSM, called LCA-VSM, a tool capable of prioritizing measures that improve economic and environmental performance, encouraging a continuous process improvement approach. The model was validated by a construction company that produces paint materials and tools, providing a reduction between 5% and 15% in environmental impact (across nine environmental categories), reducing lead time from 103.26 to 24.01 days and promoting a reduction in cycle time from 35.7 to 33.75 s.
[108]	Theory	In this work, the authors provide a model capable of modeling VSM from an economic and environmental perspective. The methodology is called E^2-VSM. It is a simulation model that considers the dynamic behavior of a multi-product production system and assesses its environmental impact, such as energy consumption. The model also evaluates the financial and environmental performance of each of the manufactured products. The goal is to optimize the machines, production orders and production parameters that lead to the best solution through energy efficiency and resources for a production system.
[109]	Multisector	This work shows the practicality of Sus-VSM. Three cases of studies demonstrating their applicability in different areas of industry are presented. It enables improvement in the ratio of activities with added value (such as the classic VSM model) as well as the improvement of environmental and social indicators. At the environmental level, for example, reductions in energy consumption, water consumption and raw materials consumption were achieved. At the social level, for example, workers' exposure to ergonomic hazards and risks in the workplace were also reduced.
[111]	Electronics	This paper presents a new methodology called Socio-VSM, the objective of which is to incorporate environmental and social indictors in order to accelerate the transition to sustainable manufacturing. For the validation of this methodology, a case study was carried out by an electronics company in Malaysia. Indicators such as noise level, ergonomic workstation conditions and classical productivity indicators were evaluated. On the basis of these indicators, changes were made to reduce the risk of injury or occupational disease by workers by reducing noise exposure and ergonomic changes in jobs. At the environmental and economic level, no changes were made to the production system.

Table 4. *Cont.*

Authors	Application Area	Description
[112]	Car industry	This paper presents a new methodology called scrap value stream mapping (S-VSM), a tool that allows for the mapping and identification of scrap and its costs throughout the process chain, from which it is possible to act with lean tools in order to attenuate the volume of scrap and generate potential savings. The validation of this tool was achieved with a case study by an automotive company, in which savings of €44,782 were possible in the following years if the volume of plastic waste remained at the same level in 2015.
[79]	Car industry	In this work, the focus was on minimizing the sources of waste resulting from the transport of raw materials in a manufacturing plant. With the spaghetti diagram, inefficiencies were identified with respect to layout and transport, allowing for optimizing the distances traveled from raw materials in the factory from 152 km to 117 km per year. With respect to time consumed in material transports, a decrease from 67 h to 30.1 h per year was achieved.
[80]	Health	In this work, the focus was on improving the satisfaction of patients in a hospital through the standardization of drug logistics processes. By applying the spaghetti diagram, it was possible to optimize the routes of the medicine cart and thus decrease the travel times through the hospital. About 92% of patients reported that, after the intervention in the cart routes, the medications were provided in less time. In addition, the application of the 5S in the cart allowed for reductions in the time spent in the search for drugs from 50.8 s to 30.2 s per unit.
[81]	Feed	In this work, the focus was on the application of lean philosophy in a food industry factory. A spaghetti diagram allowed for the tracking of worker movements and identifying unnecessary movements that could be eliminated, from which it was possible to redesign the layout, and there was a reduction from 6 m to 2 m of distance traveled by the workers for each cycle of time. Other tools such as VSM, OEE and Job Balancing were applied in the project. Overall, productivity increased by around 40%.
[82]	Health	In this work, the focus was on the application of lean six sigma in the medical records department of a hospital. Several tools were used, including a spaghetti diagram, from which it was possible to record the patterns of movement in the work area under study and to identify unnecessary movements between various points of the department. A new layout was designed to minimize movements and delays. The study resulted in a decrease in the processes, on average, from 19 to 8 min. Overall, the project allowed the hospital to save about 20,000 USD in human resources and fixed costs related to the hospital's bureaucratic processes.
[83]	Car industry	In this work, the objective was to improve the productivity of a seating factory in the automotive industry through the lean methodology. Several tools were used in the project. The spaghetti diagram allowed for the study of the layout, cycle times and movements of the workers. This work led to outlining a new layout proposal that allowed for reducing the number of workstations from 6 to 5, the cycle time from 807 to 697 s and the movements of the workers for each seat produced on the line from 15 to 9.6 m.
[84]	Health	In this work, the focus was on improving efficiency and quality in the provision of medical care in the urology department of a hospital with lean methodology. Data such as patient volume, waiting times, cycle times and the movements of physicians were collected with the help of a spaghetti diagram. As result of that work, it was possible to reduce the average cycle time per patient from 46 to 41 min in a period of 90 days. In addition, it allowed for reductions in waiting times and increases in the available contact time between the doctor and the patient from 7.5 to 10.6 min. The time of added value in the patient's visits to the hospital increased, in proportion, from 30.6% to 66.3% at the end of the 90-day period.
[91]	Car industry	Through the Yamazumi tool, it was possible to analyze three jobs and identify sources of waste. Improvements were made with respect to job design and the sequence of operator activities, allowing for the value of the takt time imposed on the assembly line to be fulfilled.
[94]	Manufacturing	In this work, the objective was to improve the efficiency of an assembly line of a refrigerator factory in Turkey. With Yamazumi's help, the situation presented was analyzed, resulting in improved productivity from 118 units to 155 units per shift. The number of operators was reduced from 32 to 28. The average idle time of the operators dropped from 155 s to 70 s.
[95]	Textile	In this work, the focus was on improving the efficiency of a production line of a textile factory. Yamazumi and 5S were the tools selected for process analysis. The improvement proposals were designed and implemented, resulting in a 34% decrease in production cycle time and a 32% decrease in time without added value. The application of the 5S was crucial for the increase in the line efficiency by 12.5%; therefore, human resources were well-used.

Table 4. *Cont.*

Authors	Application Area	Description
[96]	Graphic	In this work, two practical cases related to two departments of a printing press are presented. The first case was carried out on a line of the production department. Standardization of Work and Yamazumi were the tools chosen to increase productivity. Line balancing was achieved with a reduction in the variation of waste throughout the processes, allowing for decreases in the number of workers from 17 to 15. The bottleneck operation of the production line was optimized to increase production from 16.3 copies per hour to 21.3 copies per hour. The second practical case was carried out in the packaging department. Line balancing was achieved by reducing movement times and reducing material flow distances through changes in layout organization. The bottleneck of the production line was also optimized, and some manual operations were eliminated, resulting in increased productivity from 22 boxes per hour to 25 boxes per hour.
[64]	Polymer industry	In this work, the authors describe the adaptation of a *lean production* system for Industry 4.0. The practical case, which took place in a polymer industry organization, consisted in the development of a *Poka-Yoke* tool through a sensor system, which was able to manage the interactions between the physical components and the corresponding manufacturing processes, thus communicating instructions and corrections through block functions. Lean 4.0 tools can interact with the production database and can be updated depending on the scenario, making Lean 4.0 tools dynamic, intelligent and flexible, and ensuring compliance with lean principles, organization objectives, the elimination of waste and increased productivity and value creation for the customer.
[2]	Aerospace	In this work, the focus was on production in an aerospace company. First, the layout was identified, and the operations in the production lines were sequenced. Through observation, it was possible to reconfigure the layout to reduce transport times and to improve the production flow. With the 5S tool application, a more organized system was constituted, reducing movements and waits and also eliminating inventory and unnecessary materials in the production line. A worker was added at one of the stations to decrease wait times. Work standardization was also crucial to increase efficiency in addition to promoting a better work environment. These changes resulted in increased productivity and decreased cycle times of operations.
[65]	Multisector	In this work, the application of lean techniques in small and medium-sized enterprises in India is analyzed. Nine manufacturing units were subjected to the lean program, which lasted about 18 months. Depending on the diagnosis performed in each manufacturing unit, an improvement project was developed using tools such as VSM, 5S, Kaizen and SMED. Overall, these projects achieved savings in the order of 9 million Rupees (official currency of India) and a reduction in the setup time from 135 min to 45 min, and more than 300 *Kaizen* measures were implemented, resulting in material savings, time and improved working conditions. Manufacturing units have managed to create jobs and compete with more attractive prices and higher quality.
[120]	Logistics	In this work, the focus was on optimizing the time spent by the product in logistics processes. With the application of DMAIC and VSM methodologies, and with the perspective of lean thinking, it was possible to identify foci of waste in order to improve the processes. VSM allowed for the understanding of the logic of flow in logistics and for the optimization of the times of the various processes identified by changing the current map state. The development and application of the future state map allowed for the achievement of reductions in lead time and reductions in processing time.
[36]	Manufacturing	In this work, the DMAIC methodology was applied together with the *Sus-VSM* approach, seeking to achieve sustainable manufacturing. Thus, not only was it possible to make improvements in the set of classical metrics of production management, but improvements in a set of environmental and social metrics were also achieved. The significant reduction in energy consumption and chemicals in the practical case that is presented must be highlighted.

5.3. Tool Effects

Based on the publications analyzed, an impact matrix was constructed in order to evaluate the impact of the tools on the economic, social and environmental dimensions. The "+" sign indicates that the tool has a positive impact, whereas the "-" sign points out that the tool has a negative impact on a given dimension (economic, social and environmental). Regarding the number of repetitions of each signal ("+" or "-"), it represents the relevance of an effect that has been reported in the literature (Table 5).

Table 5. Matrix of tools' impact on economic, environmental and social pillars.

Tool	Effect(s)	Impact Dimension		
		Economic	Environmental	Social
Standardized Work	Reduction in the workforce; Improvement in process productivity; Reduction in non-productive times; Reduction in workers' movements;	++		++
SMED	Improvement in process efficiency; Increased energy consumption;	+	-	
5S	Improved organization and safety; Reduction in material consumption, movements, energy and waste;	++++	+++	++
Visual Management	Improvement in process efficiency; Process control;	++		
TPM	Improvement in process management; Reduction in non-productive times, rework and energy consumption; Prevention of mechanical problems;	+++++	+	
VSM	Improvement in process efficiency; Identification and reduction in waste such as: the excessive use of raw materials, energy, waste, non-productive times, stocks and a reduction in th workforce;	+++++	+++	+
Sus-VSM	Reduction in the environmental and social impact of processes; Reduction in consumption of chemicals, water, energy and noise; Evaluation of ergonomic conditions;	+++	++++	+++
Socio-VSM	Assessment of risk factors for workers' health and safety;	+		+
S-VSM	Identification of and reduction in waste and scrap throughout the process chain;	++	++	
Spaghetti Diagram	Reduction in movements, transport and work;	+++		++
Yamazumi	Balancing jobs; Compliance of takt time; Improvement in process productivity; Reduction in the workforce;	++++		
Poka-Yoke	Reduction in process inefficiencies; Reduction in energy consumption;	+	+	
Kaizen	Reduction in energy, waste and material consumption;	+++	+++	
Kanban	Improvement in the operational efficiency of the processes; Reduction in material consumption;	++	+	
LESSVSM	Reduction in waste related to energy consumption;	+	+	
VSM II	Identification and reduction in the variability of the production system;	+	+	
E-VSM	Identification and reduction in energy waste sources;	+	+	
Ergo-VSM	Evaluation of ergonomic conditions related to physical and psychological factors of workers;			++

5.4. Conceptual Model

Based on the analyzed studies, through a bibliometric analysis, a conceptual model (Figure 11) is proposed. This model is able to relate the different tools analyzed with the different pillars (economic, social and environmental); therefore, organizations can choose the best tools for each scope, serving DMAIC as a structural basis for the construction of the projects, with the ultimate goal of achieving operational excellence. The tools in the economic pillar are the ones that best suit economic growth. The tools that are in the social pillar are the ones that best suit the achievement of social responsibility, i.e., the widespread improvement of working conditions. The tools that are in the environmental pillar are the ones that best suit the achievement of the sustainability of operations and environmental goals. This model aims to help the industry clarify which tools are most relevant for meeting different objectives (economic, social and environmental) [135]. It should be noted that this model was not subjected to practical validation, although it was based on empirical studies.

Figure 11. Conceptual Model.

6. Discussion

6.1. Evolution of Publications

The bibliometric analysis developed in this work, based on the Web of Science, allowed for the distribution of publications per year and average annual citations for the period between 2010 and 2021. Through these fields, it was possible to conclude that these terms are receiving increased attention. With respect to publications, the peak was reached in 2019, with about 19 publications. In relation to the average annual number of citations, the peak was reached in 2021, with about 527 citations. The analysis also involved the design of a cluster map based on the link between keywords, illustrating an intellectual structure that allows for the detection of trends and flaws in research on lean, six sigma, lean six sigma and the Shingo model. This map clarifies that the research based on these four topics considered the following: (1) the strong link of lean tools in combating different sources of the waste of organizations; (2) the strong connection of DMAIC to projects to improve organizations; (3) the strong link between operational excellence and improvement philosophies such as lean, lean six sigma, green lean and PDCA, which allow for the construction of a competitive advantage; (4) the weak link between the environmental concept and lean philosophy; (5) the strong link between organizational culture and sustainability and the overall performance of organizations; (6) the strong link between innovation and factors related to the environmental pillar; (7) the weak link between the tools related to the social pillar and the industry area; and (8) the strong connection of the concepts of responsibility and leadership capacity in achieving a level of business excellence.

6.2. Relationship between Lean, Six Sigma, Lean Six Sigma and the Shingo Model

The bibliometric analysis involved the categorization of the selected publications based on the four research topics (lean, six sigma, lean six sigma and the Shingo model), from which a temporal distribution and application area were made. With respect to research topics, lean was the topic that was most addressed, whereas the Shingo model topic was the least addressed. The results obtained show that:

- For the lean topic, the automotive industry is the most debated area, also being compatible with six sigma through lean six sigma;
- For the lean six sigma topic, the theoretical area is the most debated area, despite the growing importance in the automotive and metallurgical industry that relates lean and six sigma concepts;
- For the six sigma topic, the metallurgical area is the most debated, which relates lean concepts through lean six sigma;
- For the Shingo's model topic, the theoretical area is the most debated, demonstrating a weak relationship of this topic with practical areas, with only one publication with this topic in a practical area (health);
- In the "Other" area, the presence of Lean is highlighted in several areas of which there is a tendency for the adoption of these concepts [135], involving areas such as logistics, aerospace, agriculture and pharmaceuticals, among others.

From this set of studies, the description of positive effects on the economic pillar is highlighted with greater emphasis. With less intensity, there were also positive effects on the social and environmental pillars, demonstrating that the environmental and social pillars suffer detriment to the economic pillar. The literature, in general, corroborates this disproportion of positive effects on the different pillars [9]. Lean interventions may result in green benefits, but not all Lean practices are in line with green strategies [136]. Lean tools and interventions tend not to impact the different pillars of sustainability in an integrated way [7].

However, in order to achieve operational excellence, organizations need to gradually redirect their efforts to these issues; therefore, sustainability is effectively achieved. According to Teixeira et al. [137], although the economic and environmental pillars have a stronger positive relationship with the organizational performance of companies, the social pillar remains relevant for achieving a superior competitive advantage, highlighting the need for

organizations to improve the performance of sustainability pillars in an integrated way to maximize competitive advantage.

In the impact matrix, it is possible to observe that only 3 tools in 18 of those reported had a positive impact on all sustainability pillars (5S, VSM and Sus-VSM). This analysis allowed for the construction of a conceptual model that incorporates different tools in the three pillars of sustainability in order to help organizations achieve better results and achieve operational excellence.

7. Conclusions

This work presents a bibliometric analysis on lean philosophy, six sigma, lean six sigma and the Shingo model. It involves an evaluation of the selected literature based on the temporal distribution of publications and annual average citations. This analysis allows for the design of a new model, through which it is possible to select the best lean tools to improve the operational performance of a company. In fact, companies can present asymmetries with respect to performance regarding each operational pillar. The categorization achieved through the developed model allows for selecting, firstly, the pillar where the DMAIC needs to be focused on, and, after that, for selecting the best tools that are able to fit this goal. Indeed, the different lean tools are categorized considering each pillar of the DMAIC methodology, helping readers and researchers to easily identify the best tools they need to improve each one of the pillars that is usually considered to obtain operational excellence using the DMAIC methodology. This topic represents the main novelty of this paper, contributing to an easier selection of the tools that can lead a company to the operational excellence in each pillar, since companies can be differently prepared to be sustainable in each of the three pillars that are widely and usually considered in the literature. It can be highlighted that this categorization is only possible based on an extensive literature review, which points out each tool that is used and the main purposes behind its use. The contributions, limitations and recommendations for future research are as follows.

7.1. Contributions

This study contributes to the topic under discussion through the following points:

- The identification of the most and least discussed items related to lean, six sigma, lean six sigma and the Shingo's model;
- The categorization of the literature according to the four topics (lean, six sigma, lean six sigma and the Shingo's model), including its distribution by area of application and reporting its main conclusions;
- Highlighting the main effects of the tools identified in the literature and their relationship with the objectives of sustainable development;
- Proposing a conceptual model based on sustainability in order to achieve operational excellence.

7.2. Limitations

This study has the following limitations:

- Research was restricted to peer-reviewed publications;
- Publications came from scientific journals, discarding other sources of information such as dissertations, reports and theses;
- The Web of Science was the only data collection platform in this research, thus rejecting publications from this field of study that are on other platforms and that may have had a significant impact on data representation;
- The conceptual model was not subjected to empirical validation in a real case study.

7.3. Recommendations for Future Research

In future research, some additional efforts are recommended in the identification of tools and their effects in the social and environmental area because they are the pillars

presenting the less volume of tools in the conceptual model, determining a methodology for quantifying the effects of these tools through key performance indicators in order to direct them to more specific objectives. To do so, it is necessary to validate the conceptual model in real case studies, preferably in different sectors of activity, to be able to evaluate the adaptability of the model in different contexts. Moreover, as main future work, researchers can use this model to apply the selected tools in specific sectors and to validate its suitability in achieving the desired results with respect to each pillar.

Author Contributions: The authors confirm their contributions to this paper as follows: Conceptualization, J.C.S., M.R., J.D.-C. and F.J.G.S.; Data curation, J.C.S. and M.R.; Formal analysis, J.C.S., M.R., J.D.-C. and L.P.F.; Investigation, J.C.S., M.R., J.D.-C., F.J.G.S. and G.S.; Methodology, J.C.S., M.R., J.D.-C., G.S. and V.L.; Writing—original draft preparation, J.C.S., M.R. and J.D.-C.; Writing—review and editing, F.J.G.S., G.S., L.P.F. and V.L. All authors have read and agreed to the published version of the manuscript.

Funding: The work of the author Vanda Lima is supported by national funds, through the FCT—Portuguese Foundation for Science and Technology under the project UIDB/04728/2020.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: No data are available.

Acknowledgments: The authors would like to thank CIDEM and LAETA/INEGI/CETRIB for all support provided.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Nandakumar, N.; Saleeshya, P.G.; Harikumar, P. Bottleneck identification and process improvement by lean six sigma DMAIC Methodology. *Mater. Today Proc.* **2020**, *24*, 1217–1224. [CrossRef]
2. Garre, P.; Bharadwaj, V.V.S.N.; Shashank, P.S.; Harish, M.; Dheeraj, M.S. Applying lean in aerospace manufacturing. *Mater. Today Proc.* **2017**, *4*, 8439–8446. [CrossRef]
3. Srinivasan, K.; Muthu, S.; Devadasan, S.R.; Sugumaran, C. Enhancement of sigma level in the manufacturing of furnace nozzle through DMAIC approach of Six Sigma: A case study. *Prod. Plan. Control* **2016**, *27*, 810–822. [CrossRef]
4. Fercoq, A.; Lamouri, S.; Carbone, V. Lean/Green integration focused on waste reduction techniques. *J. Clean. Prod.* **2016**, *137*, 567–578. [CrossRef]
5. Ruben, R.B.; Vinodh, S.; Asokan, P. Lean Six Sigma with environmental focus: Review and framework. *Int. J. Adv. Manuf. Technol.* **2018**, *94*, 4023–4037. [CrossRef]
6. Teixeira, P.; Sá, J.C.; Silva, F.J.G.; Ferreira, L.P.; Santos, G.; Fontoura, P. Connecting lean and green with sustainability towards a conceptual model. *J. Clean. Prod.* **2021**, *322*, 129047. [CrossRef]
7. Teixeira, P.; Sá, J.C.; Silva, F.J.; Santos, G.; Fontoura, P.; Coelho, A. Lean Contribution to the Companies' Sustainability. *IFIP Adv. Inf. Commun. Technol.* **2021**, *610*, 400–408. [CrossRef]
8. Silva, V.; Lima, V.; Sá, J.C.; Fonseca, L.; Santos, G. B Impact assessment as a sustainable tool: Analysis of the Certification Model. *Sustainability* **2022**, *6*, 5590. [CrossRef]
9. Silva, F.J.G.; Sá, J.C.; Ferreira, L.P.; Santos, G.; Nogueira, M.C. The three pillars of sustainability and agile project management: How do they influence each other. *Corp. Soc. Responsib. Environ. Manag.* **2020**, *19*, 1–18. [CrossRef]
10. Silva, F.J.G.; Gouveia, R.M. *Cleaner Production – Toward a Better Future*; Springer Nature Switzerland: Cham, Switzerland, 2020; ISBN 978-3-030-23164-4.
11. Fonseca, L.; Silva, V.; Carlos, S.J.; Lima, V.; Santos, G.; Silva, R. B Corp versus ISO 9001 and 14001 certifications: Aligned, or alternative paths, towards sustainable development? *Corp. Soc. Responsib. Environ. Manag.* **2021**, *29*, 1–13. [CrossRef]
12. Sreedharan, V.R.; Raju, R.; Rajkanth, R.; Nagaraj, M. An empirical assessment of Lean Six Sigma Awareness in manufacturing industries: Construct development and validation. *Total Qual. Manag. Bus. Excell.* **2018**, *29*, 686–703. [CrossRef]
13. Kaswan, M.S.; Rathi, R.; Garza-Reyes, J.A.; Antony, J. Green lean six sigma sustainability—Oriented project selection and implementation framework for manufacturing industry sigma. *Int. J. Lean Six Sigma* **2022**. [CrossRef]
14. Yadav, V.; Gahlot, P.; Rathi, R.; Yadav, G.; Kumar, A.; Kaswan, M.S. Integral measures and framework for green lean six sigma implementation in manufacturing environment. *Int. J. Sustain. Eng.* **2021**, *14*, 1319–1331. [CrossRef]
15. Jordan, E.; Kušar, J.; Rihar, L.; Berlec, T. Portfolio analysis of a Lean Six Sigma production process. *Cent. Eur. J. Oper. Res.* **2019**, *27*, 797–813. [CrossRef]

16. Vinodh, S.; Arvind, K.R.; Somanaathan, M. Tools and techniques for enabling sustainability through lean initiatives. *Clean Technol. Environ. Policy* **2011**, *13*, 469–479. [CrossRef]
17. Azevedo, J.; Sá, J.C.; Ferreira, L.P.; Santos, G.; Cruz, F.M.; Jimenez, G.; Silva, F.J.G. Improvement of production line in the automotive industry through lean philosophy. *Procedia Manuf.* **2019**, *41*, 1023–1030. [CrossRef]
18. Rodrigues, J.; Sá, J.C.V.; Ferreira, L.P.; Silva, F.; Santos, G. Lean MANAGEMENT "Quick-Wins": Results of Implementation. A case study. *Qual. Innov. Prosper.* **2019**, *23*, 3–21. [CrossRef]
19. Dinis-Carvalho, J.; Monteiro, M.; Macedo, H. *Continuous Improvement System: Team Members' Perceptions*; Springer: Berlin/Heidelberg, Germany, 2020; Volume 122.
20. Dinis-Carvalho, J.; Moreira, F.; Bragança, S.; Costa, E.; Alves, A.; Sousa, R. Waste identification diagrams. *Prod. Plan. Control* **2015**, *26*, 1–13. [CrossRef]
21. Arunagiri, P.; Gnanavelbabu, A. Identification of high impact lean production tools in automobile industries using weighted average method. *Procedia Eng.* **2014**, *97*, 2072–2080. [CrossRef]
22. Balamurugan, R.; Kirubagharan, R.; Ramesh, C. Implementation of lean tools and techniques in a connecting rod manufacturing industry. *Mater. Today Proc.* **2020**, *33*, 3108–3113. [CrossRef]
23. Salem, R.; Musharavati, F.; Hamouda, A.M.; Al-Khalifa, K.N. An empirical study on lean awareness and potential for lean implementations in Qatar industries. *Int. J. Adv. Manuf. Technol.* **2016**, *82*, 1607–1625. [CrossRef]
24. Neves, P.; Silva, F.J.G.; Ferreira, L.P.; Pereira, T.; Gouveia, A.; Pimentel, C. Implementing lean tools in the manufacturing process of trimmings products. *Procedia Manuf.* **2018**, *17*, 696–704. [CrossRef]
25. Shokri, A. Quantitative analysis of Six Sigma, Lean and Lean Six Sigma research publications in last two decades. *Int. J. Qual. Reliab. Manag.* **2017**, *34*, 598–625. [CrossRef]
26. Satolo, E.G.; Hiraga, L.E.d.; Goes, G.A.; Lourenzani, W.L. Lean production in agribusiness organizations: Multiple case studies in a developing country. *Int. J. Lean Six Sigma* **2017**, *8*, 335–358. [CrossRef]
27. Gomes, A.M.; Senna, P.; Monteiro, A.; Pinha, D. Study on techniques and tools used in lean healthcare implementation: A literature review. *Braz. J. Oper. Prod. Manag.* **2016**, *13*, 406–420. [CrossRef]
28. Sivaraman, P.; Nithyanandhan, T.; Lakshminarasimhan, S.; Manikandan, S.; Saifudheen, M. Productivity enhancement in engine assembly using lean tools and techniques. *Mater. Today Proc.* **2020**, *33*, 201–207. [CrossRef]
29. Vinodh, S.; Kumar, S.V.; Vimal, K.E.K. Implementing lean sigma in an Indian rotary switches manufacturing organization. *Prod. Plan. Control* **2014**, *25*, 288–302. [CrossRef]
30. Peruchi, R.S.; Junior, P.R.; Brito, T.G.; Paiva, A.P.; Balestrassi, P.P.; Araujo, L.M.M. Integrating multivariate statistical analysis into six sigma DMAIC projects: A case study on AISI 52100 hardened steel turning. *IEEE Access* **2020**, *8*, 34246–34255. [CrossRef]
31. Rahman, A.; Shaju, S.U.C.; Sarkar, S.K.; Hashem, M.Z.; Hasan, S.M.K.; Mandal, R.; Islam, U. A case study of six sigma define-measure-analyze-improve-control (DMAIC) methodology in garment sector. *Indep. J. Manag. Prod.* **2017**, *8*, 1309. [CrossRef]
32. Yu, K.T.; Ueng, R.G. Enhancing teaching effectiveness by using the Six-Sigma DMAIC model. *Assess. Eval. High. Educ.* **2012**, *37*, 949–961. [CrossRef]
33. Pereira, M.T.; Bento, M.I.; Ferreira, L.P.; Sá, J.C.; Silva, F.J.G. Using six sigma to analyse customer satisfaction at the product design and development stage. *Procedia Manuf.* **2019**, *38*, 1608–1614. [CrossRef]
34. Baptista, A.; Silva, F.J.G.; Campilho, R.D.S.G.; Ferreira, S.; Pinto, G. Applying DMADV on the industrialization of updated components in the automotive sector: A case study. *Procedia Manuf.* **2020**, *51*, 1332–1339. [CrossRef]
35. Stanivuk, T.; Gvozdenovic, T.; Mikulicic, J.Z.; Lukovac, V. Application of six sigma model on efficient use of vehicle fleet. *Symmetry* **2020**, *12*, 857. [CrossRef]
36. Costa, T.; Silva, F.J.G.; Ferreira, L.P. Improve the extrusion process in tire production using Six Sigma methodology. *Procedia Manuf.* **2017**, *13*, 1104–1111. [CrossRef]
37. Tenera, A.; Pinto, L.C. A Lean Six Sigma (LSS) project management improvement model. *Sel. Pap. 27th Ipma Int. Proj. Manag. Assoc.* **2014**, *119*, 912–920. [CrossRef]
38. Cheng, C.Y.; Chang, P.Y. Implementation of the Lean Six Sigma framework in non-profit organisations: A case study. *Total Qual. Manag. Bus. Excell.* **2012**, *23*, 431–447. [CrossRef]
39. Cabrita, M.d.R.; Domingues, J.P.; Requeijo, J. Application of Lean Six-Sigma methodology to reducing production costs: Case study of a Portuguese bolts manufacturer. *Int. J. Manag. Sci. Eng. Manag.* **2016**, *11*, 222–230. [CrossRef]
40. de Mast, J.; Lokkerbol, J. An analysis of the Six Sigma DMAIC method from the perspective of problem solving. *Int. J. Prod. Econ.* **2012**, *139*, 604–614. [CrossRef]
41. Girmanova, L.; Solc, M.; Kliment, J.; Divokova, A.; Miklos, V. Application of six sigma using DMAIC methodology in the process of product quality control in metallurgical operation. *ACTA Technol. Agric.* **2017**, *20*, 104–109. [CrossRef]
42. Costa, L.B.M.; Filho, M.G.; Fredendall, L.D.; Paredes, F.J.G. Lean, six sigma and lean six sigma in the food industry: A systematic literature review. *Trends Food Sci. Technol.* **2018**, *82*, 122–133. [CrossRef]
43. Indrawati, S.; Ridwansyah, M. Manufacturing continuous improvement using lean six sigma: An iron ores industry case application. *Procedia Manuf.* **2015**, *4*, 528–534. [CrossRef]
44. Swarnakar, V.; Singh, A.R.; Tiwari, A.K. Evaluating importance of Critical Success Factors in successful implementation of Lean Six Sigma Framework. In Proceedings of the International Conference on Advances in Mechanical Engineering and Nanotechnology (ICAMEN), Manipal, Jaipur, India, 8–9 March 2019; Volume 2148. [CrossRef]

45. da Silva, O.R.; Rosini, A.M.; Guevara, A.J.H.; Palmisano, A.; Venanzi, D. Lean six sigma: Multiple case study. *Risus-J. Innov. Sustain.* **2018**, *9*, 74–84. [CrossRef]
46. Alexander, P.; Antony, J.; Cudney, E. A novel and practical conceptual framework to support Lean Six Sigma deployment in manufacturing SMEs. *Total Qual. Manag. Bus. Excell.* **2021**, 1–31. [CrossRef]
47. Alhuraish, I.; Robledo, C.; Kobi, A. A comparative exploration of lean manufacturing and six sigma in terms of their critical success factors. *J. Clean. Prod.* **2017**, *164*, 325–337. [CrossRef]
48. Venanzi, D.; Faustino, D.L.; Silva, O.R.; Hasegawa, H.L. Lean Six Sigma—Multiple case study. *Rev. Gestão Inov. Tecnol.* **2017**, *7*, 4059–4073. [CrossRef]
49. Gleeson, F.; Coughlan, P.; Goodman, L.; Newell, A.; Hargaden, V. Improving manufacturing productivity by combining cognitive engineering and lean-six sigma methods. *Procedia CIRP* **2019**, *81*, 641–646. [CrossRef]
50. Kumar, P.; Singh, M.; Phull, G.S. Production lessening analysis of manufacturing unit in India: Lean Six Sigma perspective. *J. Proj. Manag.* **2019**, *4*, 281–290. [CrossRef]
51. Toma, S.-G.; Marinescu, P. Business excellence models: A comparison. *Proc. Int. Conf. Bus. Excell.* **2018**, *12*, 966–974. [CrossRef]
52. Wolniak, R. The level of maturity of quality management systems in Poland-Results of empirical research. *Sustainability* **2019**, *11*, 4239. [CrossRef]
53. The Shingo Model—Shingo Institute—Home of the Shingo Prize. Available online: https://shingo.org/ (accessed on 27 June 2022).
54. Kelly, S.; Hines, P. Discreetly embedding the Shingo principles of enterprise excellence at Abbott Diagnostics manufacturing facility in Longford Ireland. *Total Qual. Manag. Bus. Excell.* **2019**, *30*, 1235–1256. [CrossRef]
55. Pakdil, F.; Leonard, K.M. The effect of organizational culture on implementing and sustaining lean processes. *J. Manuf. Technol. Manag.* **2015**, *26*, 725–743. [CrossRef]
56. Edgeman, R. Routinizing peak performance and impacts via virtuous cycles. *Meas. Bus. Excell.* **2017**, *21*, 261–271. [CrossRef]
57. Edgeman, R. Excellence models as complex management systems: An examination of the Shingo operational excellence model. *Bus. Process Manag. J.* **2018**, *24*, 1321–1338. [CrossRef]
58. Leksic, I.; Stefanic, N.; Veza, I. The impact of using different lean manufacturing tools on waste reduction. *Adv. Prod. Eng. Manag.* **2020**, *15*, 81–92. [CrossRef]
59. Palange, A.; Dhatrak, P. Lean manufacturing a vital tool to enhance productivity in manufacturing. *Mater. Today Proc.* **2021**, *46*, 729–736. [CrossRef]
60. Rahani, A.R.; Al-Ashraf, M. Production flow analysis through Value Stream Mapping: A lean manufacturing process case study. In *Procedia Engineering*; Elsevier: Amsterdam, The Netherlands, 2012. [CrossRef]
61. Wahab, A.N.A.; Mukhtar, M.; Sulaiman, R. A conceptual model of lean manufacturing dimensions. *Procedia Technol.* **2013**, *11*, 1292–1298. [CrossRef]
62. Hodge, G.L.; Ross, K.G.; Joines, J.A.; Thoney, K. Adapting lean manufacturing principles to the textile industry. *Prod. Plan. Control* **2011**, 237–247. [CrossRef]
63. Panwar, A.; Nepal, B.P.; Jain, R.; Rathore, A.P.S. On the adoption of lean manufacturing principles in process industries. *Prod. Plan. Control* **2015**, *26*, 564–587. [CrossRef]
64. Dănuţ-Sorin, I.R.; Opran, C.G.; Lamanna, G. Lean 4.0 dynamic tools for polymeric products manufacturing in Industry 4.0. *Macromol. Symp.* **2021**, *396*, 3–5. [CrossRef]
65. Ramakrishnan, V.; Jayaprakash, J.; Elanchezhian, C.; Ramnath, B.V. Implementation of lean manufacturing in Indian SMEs-A case study. *Mater. Today Proc.* **2019**, *16*, 1244–1250. [CrossRef]
66. Lu, J.C.; Yang, T. Implementing lean standard work to solve a low work-in-process buffer problem in a highly automated manufacturing environment. *Int. J. Prod. Res.* **2015**, *53*, 2285–2305. [CrossRef]
67. Nallusamy, S.; Saravanan, V. Enhancement of overall output in a small scale industry through VSM, line balancing and work standardization. *Int. J. Eng. Res. Africa* **2016**, *26*, 176–183. [CrossRef]
68. Dresch, A.; Veit, D.R.; de Lima, P.N.; Lacerda, D.P.; Collatto, D.C. Inducing Brazilian manufacturing SMEs productivity with Lean tools. *Int. J. Product. Perform. Manag.* **2019**, *68*, 69–87. [CrossRef]
69. Poves-Calderno, I.G.; Ramirez-Mendoza, J.A.; Nunez-Ponce, V.H.; Alvarez-Merino, J.C. Application of lean manufacturing techniques in a Peruvian plastic company. In Proceedings of the 2019 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM), Macao, China, 15–18 December 2019; pp. 546–550. [CrossRef]
70. Mor, R.S.; Bhardwaj, A.; Singh, S.; Sachdeva, A. Productivity gains through standardization-of-work in a manufacturing company. *J. Manuf. Technol. Manag.* **2019**, *30*, 899–919. [CrossRef]
71. Realyvásquez-Vargas, A.; Flor-Moltalvo, F.J.; Blanco-Fernández, J.; Sandoval-Quintanilla, J.D.; Jiménez-Macías, E.; García-Alcaraz, J.L. Implementation of production process standardization—A case study of a publishing company from the SMEs Sector. *Processes* **2019**, *7*, 2019.
72. Wolak, E.; Jones, C.; Leeman, J.; Madigan, C. Improving throughput for patients admitted from the emergency department: Implementation of a standardized report process. *J. Nurs. Care Qual.* **2020**, *35*, 380–385. [CrossRef]
73. Cantini, A.; de Carlo, F.; Tucci, M. Towards forklift safety in a warehouse: An approach based on the automatic analysis of resource flows. *Sustainability* **2020**, *12*, 8949. [CrossRef]

74. Gladysz, B.; Santarek, K.; Lysiak, C. Dynamic spaghetti diagrams. A case study of pilot RTLS implementation. *Adv. Intell. Syst. Comput.* **2018**, *637*, 238–248. [CrossRef]
75. Frosini, F.; Miniati, R.; Cecconi, G.; Dori, F.; Iadanza, E.; Vezzosi, S.; Mechi, M.T.; Belardinelli, A. Lean thinking in hospital: Case study at the pathology laboratory. *IFMBE Proc.* **2015**, *45*, 613–616. [CrossRef]
76. Burroni, L.; Bianciardi, C.; Romagnolo, C.; Cottignoli, C.; Palucci, A.; Fringuelli, F.M.; Biscontini, G. Jacopo Guercini Lean approach to improving performance and efficiency in a nuclear medicine department. *Clin. Transl. Imaging* **2021**, *9*, 129–139. [CrossRef]
77. Jessome, R. Improving patient flow in diagnostic imaging: A case report. *J. Med. Imaging Radiat. Sci.* **2020**, *51*, 678–688. [CrossRef] [PubMed]
78. Pitapurapu, R.; Gupta, A.; Maly, K.; Nadeem, T. Dead reckoning with smartphone. *Sensors* **2015**, *1*, 206–217. [CrossRef]
79. Mahajan, M.; Chistopher, K.B.; Harshan; Prasad, H.C.S. Implementation of lean techniques for sustainable workflow process in Indian motor manufacturing unit. *Procedia Manuf.* **2019**, *35*, 1196–1204. [CrossRef]
80. Yang, J.X.; Hunt, T.D.; Ting, H.H.; Henderson, D.; Finkelstein, J.; Davidson, K.W. Improving value-add work and satisfaction in medical residents training: A Resident-Led quality improvement project employing the lean method to improve hospital supply usage. *Postgrad. Med. J.* **2017**, *93*, 193–197. [CrossRef]
81. Tanco, M.; Santos, J.; Rodriguez, J.L.; Reich, J. Applying lean techniques to nougat fabrication: A seasonal case study. *Int. J. Adv. Manuf. Technol.* **2013**, *68*, 1639–1654. [CrossRef]
82. Alfraih, M.M. Productivity and performance improvement in the medical records department of a hospital an application of Lean Six Sigma. *Electron. Libr.* **2016**, *34*, 1–5.
83. Rekha, R.S.; Periyasamy, P.; Nallusamy, S. An optimized model for reduction of cycle time using value stream mapping in a small scale industry. *Int. J. Eng. Res. Africa* **2016**, *27*, 179–189. [CrossRef]
84. Skeldon, S.C.; Simmons, A.; Hersey, K.; Finelli, A.; Jewett, M.A.; Zlotta, A.R.; Fleshner, N.E. Lean methodology improves efficiency in outpatient academic uro-oncology clinics. *Urology* **2014**, *83*, 992–998. [CrossRef]
85. Cheah, C.K.; Prakash, J.; Ong, K.S. An integrated OEE framework for structured productivity improvement in a semiconductor manufacturing facility. *Int. J. Product. Perform. Manag.* **2020**, *69*, 1081–1105. [CrossRef]
86. Pacheco, D.A.D.; Heidrich, G.D.G. Revitalising the setup reduction activities in Operations Management. *Prod. Plan. Control* **2021**. [CrossRef]
87. Pereira, A.M.H.; Silva, M.R.; Domingues, M.A.G.; Sá, J.C. Lean six sigma approach to improve the production process in the mould industry: A case study. *Qual. Innov. Prosper.* **2019**, *23*, 103–121. [CrossRef]
88. Domingo, R.; Aguado, S. Overall environmental equipment effectiveness as a metric of a lean and green manufacturing system. *Sustainability* **2015**, *7*, 9031–9047. [CrossRef]
89. Sharma, R.K.; Sharma, R.G. Integrating six sigma culture and TPM framework to improve manufacturing performance in SMEs. *Qual. Reliab. Eng. Int.* **2014**, *30*, 745–765. [CrossRef]
90. Gregorio, J.O.R. A case study of an integrated manufacturing performance measurement and meeting system. *J. Manuf. Technol. Manag.* **2015**, *26*, 515–535.
91. Sabadka, D.; Molnar, V.; Fedorko, G.; Jachowicz, T. Optimization of production processes using the Yamazumi Method. *Adv. Sci. Technol. Res. J.* **2017**, *11*, 175–182. [CrossRef]
92. Cannas, V.G.; Pero, M.; Pozzi, R.; Rossi, T. Complexity reduction and kaizen events to balance manual assembly lines: An application in the field. *Int. J. Prod. Res.* **2018**, *56*, 3914–3931. [CrossRef]
93. Czifra, G.; Szabó, P.; MÍkva, M.; Vaňová, J. Lean principles application in the automotive industry. *Acta Polytech. Hung.* **2019**, *16*, 43–62. [CrossRef]
94. Yılmaz, F.; Demirel, F.; Zaim, S.; Sevim, S. Assembly line balancing by using axiomatic design principles: An application from cooler manufacturing industry. *Int. J. Prod. Manag. Eng.* **2020**, *8*, 3143. [CrossRef]
95. Kumar, D.V.; Mohan, G.M.; Mohanasundaram, K.M. Lean tool implementation in the garment industry. *Fibres Text. East. Eur.* **2019**, *27*, 19–23. [CrossRef]
96. Chan, C.O.; Tay, H.L. Combining lean tools application in kaizen: A field study on the printing industry. *Int. J. Product. Perform. Manag.* **2018**, *67*, 45–65. [CrossRef]
97. Salonitis, K.; Tsinopoulos, C. Drivers and barriers of lean implementation in the Greek manufacturing sector. *Procedia CIRP* **2016**, *57*, 189–194. [CrossRef]
98. Kafuku, J.M. Factors for effective implementation of lean manufacturing practice in selected industries in Tanzania. *Procedia Manuf.* **2019**, *33*, 351–358. [CrossRef]
99. Eswaramoorthi, M.; Kathiresan, G.R.; Prasad, P.S.S.; Mohanram, P.V. A survey on lean practices in Indian machine tool industries. *Int. J. Adv. Manuf. Technol.* **2011**, *52*, 1091–1101. [CrossRef]
100. Maalouf, M.M.; Zaduminska, M. A case study of VSM and SMED in the food processing industry. *Manag. Prod. Eng. Rev.* **2019**, *10*, 60–68. [CrossRef]
101. Jiménez, E.; Tejeda, A.; Pérez, M.; Blanco, J.; Martínez, E. Applicability of lean production with VSM to the Rioja wine sector. *Int. J. Prod. Res.* **2012**, *50*, 1890–1904. [CrossRef]
102. Acero, R.; Torralba, M.; Pérez-Moya, R.; Pozo, J.A. Value stream analysis in military logistics: The improvement in order processing procedure. *Appl. Sci.* **2020**, *10*, 106. [CrossRef]

103. Singh, J.; Singh, H. Application of lean manufacturing in automotive manufacturing unit. *Int. J. Lean Six Sigma* **2020**, *11*, 171–210. [CrossRef]
104. Cavdur, F.; Yagmahan, B.; Oguzcan, E.; Arslan, N.; Sahan, N. Lean service system design: A simulation-based VSM case study. *Bus. Process Manag. J.* **2019**, *25*, 1802–1821. [CrossRef]
105. Garza-Reyes, J.A.; Romero, J.T.; Govindan, K.; Cherrafi, A.; Ramanathan, U. A PDCA-based approach to Environmental Value Stream Mapping (E-VSM). *J. Clean. Prod.* **2018**, *180*, 335–348. [CrossRef]
106. Dominguez-Alfaro, D.; Mendoza-Muñoz, I.; Montoya-Reyes, M.I.; Navarro-González, C.R.; Cruz-Sotelo, S.E.; Vargas-Bernal, O.Y. Ergovsm: A new tool that integrates ergonomics and productivity. *J. Ind. Eng. Manag.* **2021**, *14*, 552–569. [CrossRef]
107. Salvador, R.; Barros, M.V.; Santos, G.E.T.D.; van Mierlo, K.G.; Piekarski, C.M.; de Francisco, A.C. Towards a green and fast production system: Integrating life cycle assessment and value stream mapping for decision making. *Environ. Impact Assess. Rev.* **2021**, *87*, 106519. [CrossRef]
108. Alvandi, S.; Li, W.; Schönemann, M.; Kara, S.; Herrmann, C. Economic and environmental value stream map (E2VSM) simulation for multi-product manufacturing systems. *Int. J. Sustain. Eng.* **2016**, *9*, 354–362. [CrossRef]
109. Brown, A.; Amundson, J.; Badurdeen, F. Sustainable value stream mapping (Sus-VSM) in different manufacturing system configurations: Application case studies. *J. Clean. Prod.* **2014**, *85*, 164–179. [CrossRef]
110. Santos, D.L.d.; Giglio, R.; Helleno, A.L.; Campos, L.M.S. Environmental aspects in VSM: A study about barriers and drivers. *Prod. Plan. Control* **2019**, *30*, 1239–1249. [CrossRef]
111. Gholami, H.; Jamil, N.; Zakuan, N.; Saman, M.Z.M.; Sharif, S.; Awang, S.R.; Sulaiman, Z. Social Value Stream Mapping (Socio-VSM): Methodology to Societal Sustainability Visualization and Assessment in the Manufacturing System. *IEEE Access* **2019**, *7*, 131638–131648. [CrossRef]
112. Carmignani, G. Scrap value stream mapping (S-VSM): A new approach to improve the supply scrap management process. *Int. J. Prod. Res.* **2017**, *55*, 3559–3576. [CrossRef]
113. Gupta, A.; Sharma, P.; Malik, S.C.; Agarwal, N.; Jha, P.C. Productivity improvement in the chassis preparation stage of the amplifier production process: A DMAIC six sigma methodology. *Int. J. Reliab. Qual. Saf. Eng.* **2016**, *23*, 1–14. [CrossRef]
114. Gandhi, S.K.; Sachdeva, A.; Gupta, A. Reduction of rejection of cylinder blocks in a casting unit: A six sigma DMAIC perspective. *J. Proj. Manag.* **2019**, *4*, 81–96. [CrossRef]
115. Lucato, W.C.; Vieira, M.; Santos, J.C.D. Eco-Six Sigma: Integration of environmental variables into the Six Sigma technique. *Prod. Plan. Control* **2015**, *26*, 605–616. [CrossRef]
116. Rahman, A.; Shaju, S.U.C.; Sarkar, S.K. Application of Six-Sigma using define measure analyze improve control (DMAIC) methodology in garment sector. *Indep. J. Manag. Prod.* **2018**, *9*, 810–826. [CrossRef]
117. Antony, J.; Scheumann, T.; Sunder, V.M.; Cudney, E.; Rodgers, B.; Grigg, N.P. Using Six Sigma DMAIC for Lean project management in education: A case study in a German kindergarten. *Total Qual. Manag. Bus. Excell.* **2021**. [CrossRef]
118. Yadrifil, A.A.; Septyanti, A.M.; Rus, M. Implementation of lean-DMAIC method for reducing packing defect in a flour company. *AIP Conf. Proc.* **2020**, *2227*, 040014. [CrossRef]
119. Kansal, J.; Singhal, S. Application and validation of DMAIC Six-Sigma tool for enhancing customer satisfaction in a government R&D organization. *Int. J. Qual. Res.* **2017**, *11*, 931–944. [CrossRef]
120. De Pinto, J.; Schuwarten, L.A.; de Junior, G.C.; Novaski, O. Proposal the application of DMAIC tools and Value Stream Mapping under the perspective of the Lean phylosophy for process improvement: A case study. *Braz. J. Oper. Prod. Manag.* **2017**, *14*, 556–566. [CrossRef]
121. Tampubolon, S.; Purba, H.H. Lean six sigma implementation, a systematic literature review. *Int. J. Prod. Manag. Eng.* **2021**, *9*, 125–139. [CrossRef]
122. Chiarini, A.; Bracci, E. Implementing Lean Six Sigma in healthcare: Issues from Italy. *Public Money Manag.* **2013**, *33*, 361–368. [CrossRef]
123. Leite, D.G.; Montesco, R.A.E.; Sakuraba, C.S. Increasing a gas distributor net profit through Lean Six Sigma. *Qual. Eng.* **2018**, *30*, 359–370. [CrossRef]
124. Vinodh, S.; Gautham, S.G.; Ramiya, R.A. Implementing lean sigma framework in an Indian automotive valves manufacturing organisation: A case study. *Prod. Plan. Control* **2011**, *22*, 708–722. [CrossRef]
125. Tran, T.-A.; Luu-Nhan, K.; Ghabour, R.; Daroczi, M. The use of Lean Six-Sigma tools in the improvement of a manufacturing company—Case study. *Prod. Eng. Arch.* **2020**, *26*, 30–35. [CrossRef]
126. Nedra, A.; Nejib, S.; Yassine, C.; Morched, C. A new Lean Six Sigma hybrid method based on the combination of PDCA and the DMAIC to improve process performance: Application to clothing SME. *Ind. Text.* **2019**, *70*, 447–456. [CrossRef]
127. Hardy, D.L.; Kundu, S.; Latif, M. Productivity and process performance in a manual trimming cell exploiting Lean Six Sigma (LSS) DMAIC—A case study in laminated panel production. *Int. J. Qual. Reliab. Manag.* **2021**, *38*, 1861–1879. [CrossRef]
128. Verma, N.; Sharma, V.; Badar, M.A. Entropy-based lean, energy and six sigma approach to achieve sustainability in manufacturing system. *Arab. J. Sci. Eng.* **2021**, *46*, 8105–8117. [CrossRef] [PubMed]
129. Kaswan, M.S.; Rathi, R. Investigating the enablers associated with implementation of Green Lean Six Sigma in manufacturing sector using Best Worst Method. *Clean Technol. Environ. Policy* **2020**, *22*, 865–876. [CrossRef]
130. Alhuraish, I.; Robledo, C.; Kobi, A. Assessment of lean manufacturing and six sigma operation with decision making based on the analytic hierarchy process. *IFAC-PapersOnLine* **2016**, *49*, 59–64. [CrossRef]

131. Alnadi, M.; McLaughlin, P. Critical success factors of Lean Six Sigma from leaders' perspective. *Int. J. Lean Six Sigma* **2021**. [CrossRef]
132. Timans, W.; Antony, J.; Ahaus, K.; van Solingen, R. Implementation of Lean Six Sigma in small- and medium-sized manufacturing enterprises in the Netherlands. *J. Oper. Res. Soc.* **2012**. [CrossRef]
133. Stankalla, R.; Koval, O.; Chromjakova, F. A review of critical success factors for the successful implementation of Lean Six Sigma and Six Sigma in manufacturing small and medium sized enterprises. *Qual. Eng.* **2018**, *30*, 453–468. [CrossRef]
134. Gnanaraj, S.M.; Devadasan, S.R.; Murugesh, R.; Sreenivasa, C.G. Sensitisation of SMEs towards the implementation of Lean Six Sigma-an initialisation in a cylinder frames manufacturing Indian SME. *Prod. Plan. Control* **2012**, *23*, 599–608. [CrossRef]
135. Silva, F.J.G.; Ferreira, L.P. *Lean Manufacturing: Implementation, Opportunities and Challenges*; Nova Science Publishers: New York, NY, USA, 2019; ISBN 978-1-53615-725-3.
136. Silva, S.; Sá, J.C.; Silva, F.J.G.; Ferreira, L.P.; Santos, G. Lean Green—The importance of integrating environment into lean philosophy—A case study. *Lect. Notes Netw. Syst.* **2020**, *122*, 211–219. [CrossRef]
137. Teixeira, P.; Coelho, A.; Fontoura, P.; Sá, J.C.; Silva, F.J.G.; Santos, G.; Ferreira, L.P. Combining lean and green practices to achieve a superior performance: The contribution for a sustainable development and competitiveness—An empirical study on the Portuguese context. *Corp. Soc. Responsib. Environ. Manag.* **2022**, 1–17. [CrossRef]

2.5 A New Conceptual Model for Excellence in Business Towards Sustainable Development

As organizações necessitam cada vez mais de modelos de gestão avançados para as ajudar a prosperar num mercado cada vez mais competitivo. Nesse sentido as organizações procuram alcançar a excelência, por forma a poderem responder às exigências dos seus desafios diários e à transformação constante e rápida que enfrentam. A busca pela excelência tem como objetivo não só melhorar a qualidade e o desempenho das organizações, mas também proporcionar resultados sustentáveis (Juran, 1999). Atualmente existem diversos modelos de excelência que as organizações podem adotar, como o Modelo EFQM e o Modelo Shingo, entre outros.

A sustentabilidade, é um tema que tem vindo a gerar preocupação por parte da comunidade, e esta situação tem levado as organizações a questionar se estes modelos de excelência podem contribuir para a sustentabilidade e Adamek (2018) identifica alguns impactos positivos do Modelo EFQM para a sustentabilidade. Jankal & Jankalova (2016) referem mesmo que os princípios e atividades da Responsabilidade Social Corporativa (*Corporate Social Responsibility - CSR*), tem vindo a ser gradualmente incluídos, nas revisões do Modelo EFQM. No mesmo sentido, a opinião de Plenert (2021), é que a adoção de modelos de excelência permite reforçar a sustentabilidade, dado efetuar uma transformação ao nível da cultura das empresas, garantindo desta forma que excelentes resultados possam ser sustentados através da aplicação de princípios e comportamentos.

O artigo "*A New Conceptual Model for Excellence in Business Towards Sustainable Development*" (Sá et al, 2023), pretende estudar se a adoção do Modelo EFQM e do Modelo Shingo, contribuem para a sustentabilidade (Figuura 20). Este estudo foi esenvolvido através de uma revisão de literatura sistemática, o qual pretendeu identificar os principais aspetos que existem na literatura referentes ao Modelo EFQM e ao Modelo de Shingo, que podem contribuir para a sustentabilidade nos seus três pilares (TBL).

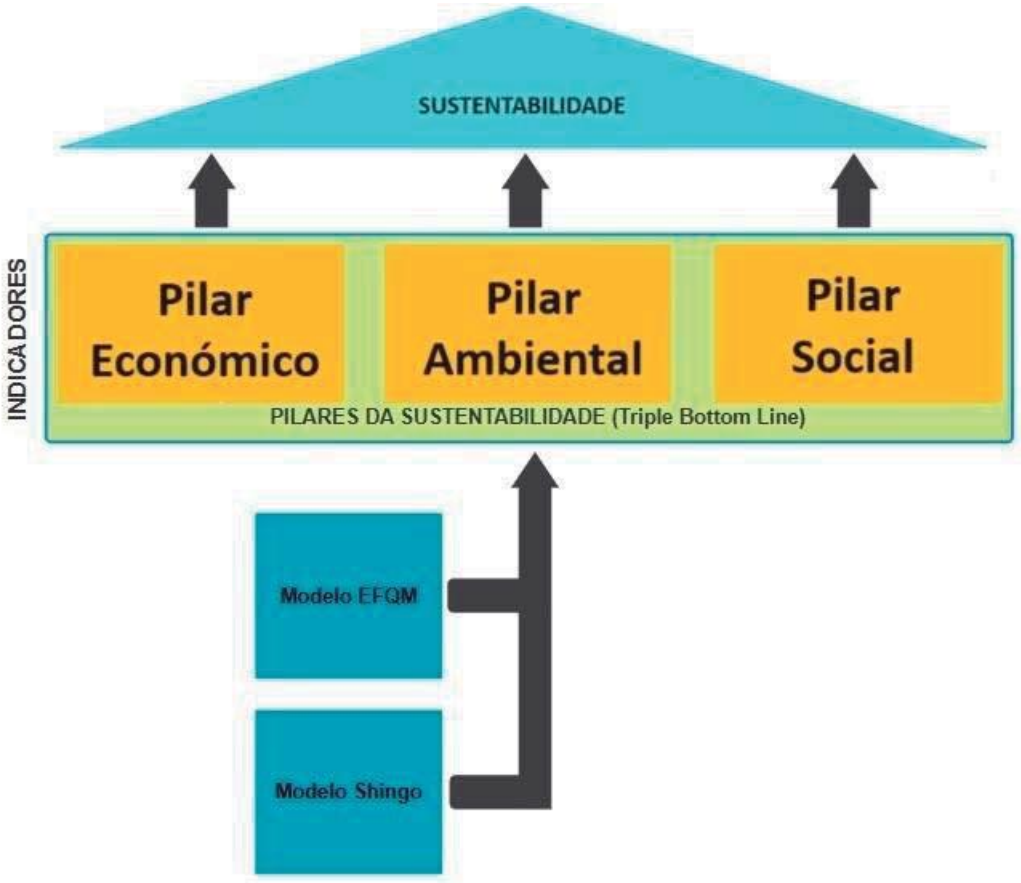


Figura 20 - Impacto do Modelo Shingo e do Modelo EFQM na Sustentabilidade

A New Conceptual Model for Excellence in Business Towards Sustainable Development

DOI: 10.12776/QIP.V27I2.1866

José C. Sá, Ana R. Oliveira, José Dinis-Carvalho, Gilberto Santos, Francisco J.G. Silva

Received: 2023-06-05 Accepted: 2023-07-19 Published: 2023-07-31

ABSTRACT

Purpose: The purpose of this paper is to understand whether or not the European Foundation for Quality Management (EFQM) Model and the Shingo Model promote and are embedded into the three pillars of sustainability, as well as to propose a conceptual model for excellence in business towards sustainability.

Methodology/Approach: Following the PRISMA methodology, 102 articles were included in the review. A bibliometric co-citation network was created based on those publications to understand the link between the topics, using the VOSViewer software. This paper presents a literature review on the topics of the EFQM and Shingo Model, Corporate sustainability (CS), and the relationship between the excellence models and CS.

Findings: Findings from the literature review indicate that effectively the new version of the EFQM Model and the Shingo Model guide organisations towards achieving sustainable economic, social, and environmental results.

Research Limitation/Implication: There are still a restricted number of articles on the Shingo Model and on the relationship between the Shingo Model and CS, as well as, on the latest version of the EFQM Model and therefore on the relationship between this model version and CS, which presents a limitation to this paper.

Originality/Value of paper: This paper contributes to filling the literature gap regarding the lack of studies evolving the EFQM 2020 model version and the Shingo Model, as well as its relationship with CS.

Category: Conceptual paper

Keywords: European foundation for quality management model; Shingo model; corporate sustainability; environmental policy; stakeholder engagement

1 INTRODUCTION

To cope with the daily challenges in organisations and with permanent and rapid transformation, organisations have been implementing excellence models as they seek to achieve levels of excellence that not only allow for an increase in quality and performance but also provide long-term sustainable results. This search for excellence resulted in many excellence models worldwide (Muhammad Din et al., 2021), such as the European Foundation for Quality Management (EFQM), the Malcolm Baldrige National Quality Award (MBNQA), the Deming Prize (DP), and the Shingo Model. These models inspired the creation of many others and essentially differ in the weights given to criteria or in the application framework, as each model is adapted to the sociocultural and economic perspectives where it was created (Periañez-Cristobal et al., 2020).

Business Excellence Models (BEMs) should be considered as a management philosophy, a set of guiding principles, criteria, and approaches that produce the best results in the medium and long term, promoting sustainable future development. To achieve excellent performance, the best practices in terms of leadership, strategy, human resources, customer management, operations, and social responsibility should be embraced. Therefore, business excellence allows for the development and strengthening of management systems and processes in order to enhance organisational performance and create great value for its stakeholders (Zapletalová, 2022).

The EFQM Model provides guidance to implementing a TQM (Total Quality Management) culture and attaining excellent results. Organisations can permanently seek improvement, building their way towards excellence through the self-assessment tool (Sá and Oliveira, 2013). Another important model, but yet not very widespread, mainly in Europe, is the Shingo Model that comprises a set of principles and behaviours and shape organisational culture fostering organisational and operational excellence (Shingo, 2023).

Many organisations still measure their performance based on financial results. However, in order to sustain excellence, social and environmental performance must also be considered. Excellence models have been promoting cultural, social, and environmental factors as one of the keys to success. However, it is important to understand how these models inspire organisations to promote the best sustainable practices and how they perceive them. Concerning the shortcomings previously stated, this paper aims to answer the following research question (RQ):

RQ: How do BEMs inspire the sustainability of organisations?

The remainder of this paper is organised as follows: section 2 comprises the research methodology adopted to carry out the research, and Section 3 provides the results of the literature review, followed by the discussion of the evidence found previously. The paper ends with its main conclusions, contributions, limitations, and future research avenues.

2 METHODOLOGY

In order to understand the evolution of scientific knowledge and its production regarding the EFQM model, the Shingo model, and its relationship with CS, this literature review was accomplished following the PRISMA Methodology 2020 (Page et al., 2021) (Fig. 1), to select the final number of publications (n).

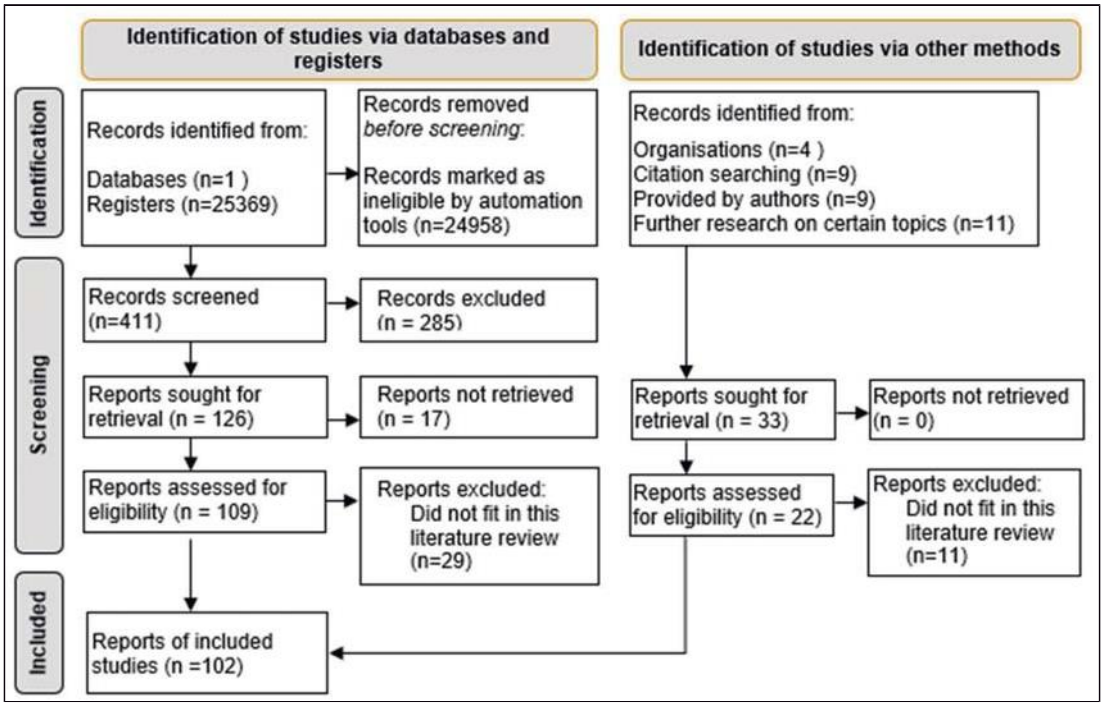


Figure 1 – PRISMA Methodology

The research was conducted from 27th November 2022 to 30th December 2022. The main database used for the purpose was the Web of Science. The searched words were only "EFQM*" or "Shingo*", due to the lack of publications regarding EFQM and Shingo's latest model versions, as well as the lack of publications regarding studies evaluating the relationship of these models with CS. After applying the automatic filters all the abstracts of articles were read for the publications to be selected. The following table (Tab. 1) summarises what criteria are applied.

Table 1 – Inclusion Criteria to Select the Publications

EFQM Model and Shingo Model	**Corporate Sustainability**
i. Searched by topic (title, abstract, author keywords, and keywords plus): "EFQM*" or "Shingo *" ii. From 2013-2022 iii. Articles and proceedings iv. English Language	i. Searched only by keywords: "Corporate sustainability" or "Corporate social responsibility" or "CSR" ii. From 2018-2022 iii. Articles iv. English Language v. Only Highly Cited Papers

Notes: EFQM – European Foundation for Quality Management; CSR – Corporate social responsibility.

After applying automatic tools in the database, according to the inclusion criteria, it was reached a total of 411 publications. Consequently, after reading its abstract only 126 were selected. 17 publications were disregarded as access to them was unable and 29 publications were not considered relevant after reading the whole paper. Due to the lack of publications as already mentioned, grey literature (conference proceedings) was also considered, as well as some documents accessed through the webpage of organisations, and through citation research. Some were provided by the authors and some of them were searched on the Web of Science and in Google Scholar additionally, to complement specific topics, whenever it was necessary throughout the literature review. The literature was selected from the last 10 years (2013-2022).

Using the software VOSviewer it was possible to construct and visualise bibliometric networks of author's keywords co-occurrence (Fig. 2), using the publications selected to study only from Web of Science. Seven keyword clusters were obtained from this analysis, as shown in Tab. 2.

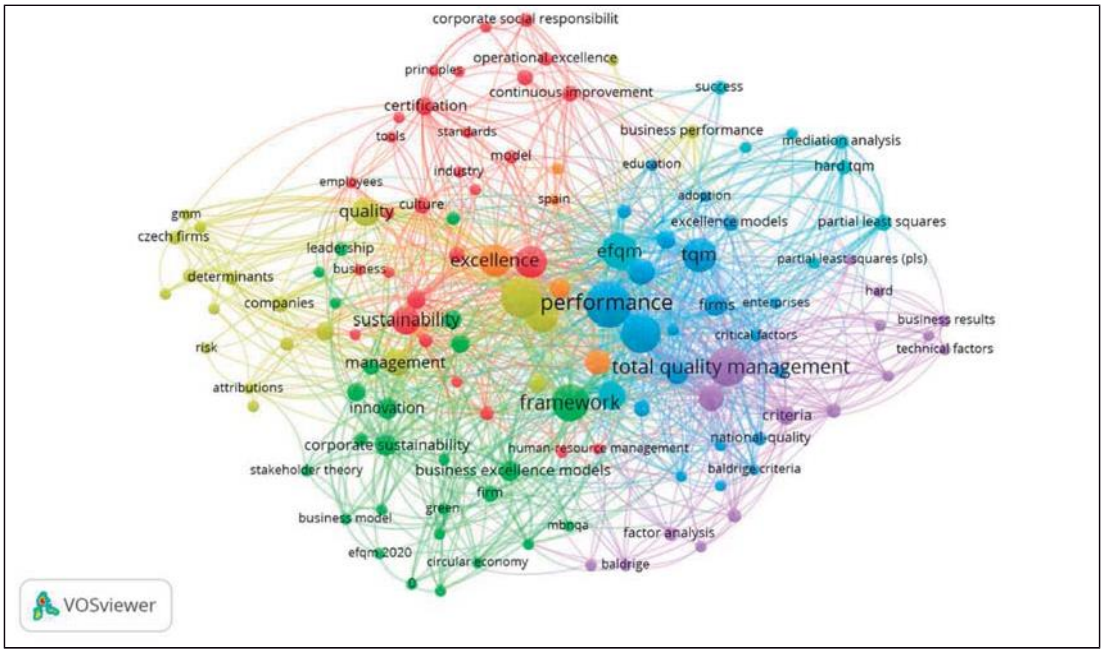


Figure 2 – Bibliometric Network

Table 2 – Clusters Obtained from Bibliometric Networks

Clusters	Keywords
1	Business, certification, commitment, continuous improvement, corporate social responsibility, CSR, culture, employees, engagement, environmental performance, human resource management, industry, ISO 9001, lean, maturity, model, operational excellence, principles, process, quality management, safety, Shingo model, standards, sustainability, systems, tools, values
2	Business excellence models, business model, challenges, circular economy, corporate social responsibility, Deming prize, EFQM 2020, EFQM 2020 model, environmental protection, firm, framework, green, health, innovation, leadership,

Clusters	Keywords
	MBNQA, organizations, stakeholder theory, sustainable development, strategy, supply chain, transformation
3	Adoption, Baldrige criteria, BEMs, competitive advantage, contextual factors, education, enablers, excellence models, firms, human-resource, implementation, mediating role, national quality, organizational performance, results, self-assessment, TQM, TQM implementation
4	Attributions, business performance, companies, Czech firms, determinants, dummy variable, EFQM model, financial performance, governance, impact, management, profitability, quality, reputation, research and development, risk, social responsibility, working capital
5	Awards, Baldridge, criteria, critical success factors, EFQM excellence model, factor analysis, hard, innovation performance, PLS, performance measurement, satisfaction, social factors, technical factors, TQM, validation
6	Business excellence, EFQM, hard TQM, mediation analysis, PLS-SEM, quality management practices, strategic planning, sucess
7	Excellence, excellence model, integration, ISO-9000, Spain

Notes: CSR – Corporate social responsibility; BEMs – Business Excellence Models; EFQM – European Foundation for Quality Management; MBNQA – Malcolm Baldrige National Quality Award; TQM – Total Quality Management; PLS-SEM – Partial Least Squares -Structural Equation Modeling.

Two words may seem outliers "Czech firms" and "Spain". Rotta and Rave (2017) found the same conclusions in their literature review. In fact, Spain and the Czech Republic are the countries that produce more studies on EFQM Model. The following figure (Fig. 3) shows precisely the distribution of the selected publication (from Web of Science) by its country of origin, where the previous premise can be corroborated.

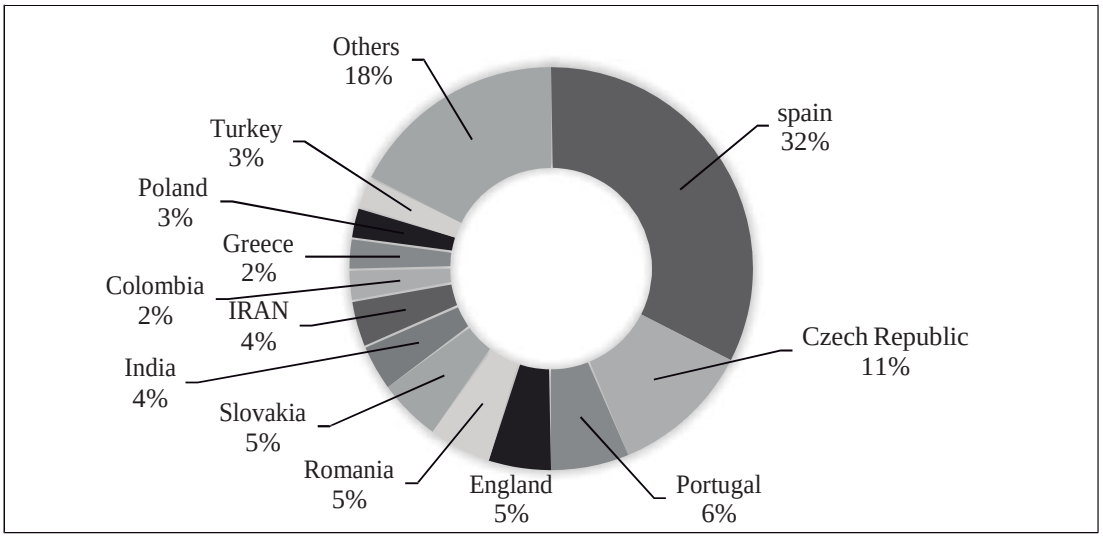


Figure 3 – Distribution of Publications by Country of Origin

Also, Spain is the European country with more applications and recognitions of the EFQM Model (de Menezes, Escrig-Tena and Bou-Llusar, 2021; Yousaf and

Bris, 2020). Shingo Model occurs with not as much relevance as EFQM Model as only nine publications on the Shingo Model were considered to be analysed. Within the selected publications, Portugal and USA are the countries that have published more on Shingo Model (tree articles each).

A scarcity of articles in what concerns the relationship of EFQM Model with CS was also witnessed by Fonseca, Amaral and Oliveira (2021). However, the articles addressing the Shingo Model and CS were substantially even more marginal. The minimum number of articles existing on Operation Excellence is also referred by Carvalho et al. (2019). To contextualize the topic on CS and to analyse its scientific evolution, a section regarding CS was also considered. The number of publications on this subject is substantially higher, thus the inclusion criteria were different. Fig. 4 shows the evolution (exponential growth) of articles concerning CS on the Web of Science, highlighting sustainability as a subject gaining more and more prominence.

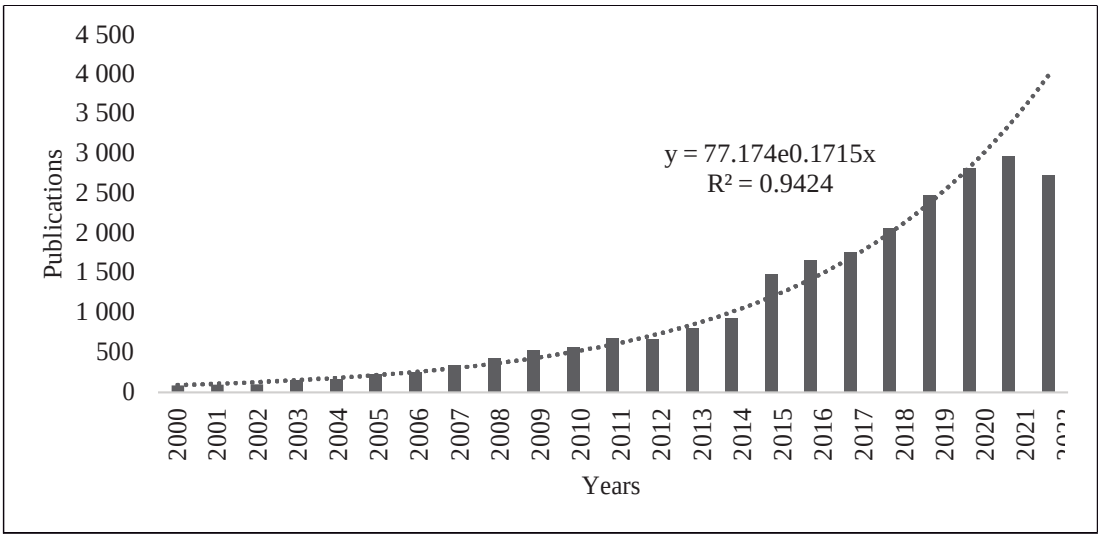


Figure 4 – Evolution of Studies on Corporate Sustainability

3 RESULTS

3.1 EFQM Model

The EFQM model is a comprehensive tool that aims to "support leaders as they manage cultural change and transformation to deliver performance improvements and benefits for their key stakeholders" (EFQM, 2019). EFQM model is dynamic, and constantly subject to revision as it must be improved to accompany the progress and transformations in organisations (Fonseca, Amaral and Oliveira, 2021). Over the years, the EFQM model has shaped the quality of organisations and has identified areas of improvement, as this model constitutes a self-assessment tool that can be used to detect the strengths and weaknesses of an organisation (Zapletalová, 2022). Improvement of the image, client satisfaction, commitment and satisfaction of employees, more profits, innovation, and

optimisation of the use of the information systems are some of the benefits that can be achieved when implementing this model (Suárez et al., 2017).

However, there are still some barriers to the implementation of the Model, such as a lack of knowledge about it, lack of leadership, lack of physical or financial resources, the complexity of the model, etc. These barriers can be characterised mainly in three groups – cultural and behavioural barriers, organisational barriers, and resource barriers (Gómez-López, López-Fernández and Serrano-Bedia, 2017; Suárez et al., 2017). Conversely, the results of EFQM model implementation can be divided into three groups: Internal results, Economic results, and Human resource results. Highly results-oriented organisations usually increase the efficiency of internal processes, which leads to an improvement of image and improvement of administrative procedures. Moderately results-oriented organisations tend to increase the involvement of employees, whereas lowly results-oriented organisations present better internal and human resource results than economic ones (Gómez-López, Serrano-Bedia and López-Fernández, 2019).

This Model can be implemented independently of the type of activity (Calvo-Mora et al., 2015; Suárez et al., 2017), such as in manufacturing, banking, finance, education, management, consultancy, etc. (Wierzbic and Martusewicz, 2022), whether it is a public, private or third sector industry (EFQM, 2019) or regardless of its dimensions (Fonseca, 2022). However, it is important to emphasise that private organisations are more prone to achieve excellence through the implementation of the EFQM model (Zapletalová, 2022) and that results depend on the size of organisations, benefiting the larger ones (Calvo-Mora et al., 2015; Veselova, 2018). Escrig and de Menezes (2016) also reinforce that for large organisations to achieve the best results, efforts should be placed mainly on Leadership and systems.

SMEs (Small and Medium-sized Enterprises) face a huge challenge in the implementation of the EFQM model, mainly, due to four reasons: the definition of the model is abstract (raising the need to create and adapt a model concerning SMEs); lack of transparency in the cause-effect relationships between enablers and results; lack of specification on how to implement the model in certain types of organisations. In addition, absence of subsequent guidelines on what changes or practices should be implemented after an organisation self-assessment (Jaeger and Matyas, 2016), even though they show more flexibility (Veselova, 2018).

EFQM Model is gaining great prominence in the health sector and higher education (Yousaf and Bris, 2020). Portuguese higher education institutions also use the EFQM model as a quality management system (Zgodavová, UrbanCíková and Kisela, 2015). Being a comprehensive model, comprises a disadvantage according to authors, as some of them consider that criteria and/or self-assessment weightage do not fit well in all sectors of activities, as a consequence some authors, like Vukomanovic, Radujkovic and Nahod (2014), proposed

adaptations of the EFQM model, regarding some types of specific industries, in this case specifically the construction industry.

Certified firms generally perform better than non-certified ones, as pointed out by Yousaf (2022a) despite most certified companies not being yet sufficiently efficient (Yousaf, 2022b). However, Yousaf, Bris and Haider (2021) did not confirm the results attained by some other authors that certification on this model increases firms' profitability, as contrary results were experienced. Many organisations have already started their journey towards certification previously with ISO 9001, ISO 14001, B Corp, etc. Fonseca et al. (2022) concluded that these certifications also address CSR and lead organisations towards sustainable development. The same conclusions were taken by Bravi et al. (2020) regarding ISO 14001. Furthermore, Fonseca (2015) compared ISO 9001 with EFQM Model enabling to reach the conclusion that ISO 9001 incorporates many EFQM principles. Also, it was concluded that companies with higher years of ISO 9001 certification tend to have better results in the assessment and recognition of the EFQM Model.

Over the years, researchers have agreed that TQM philosophy inspired and is incorporated in the formulation of this Model, despite having subsequently, evolved by integrating other aspects such as social responsibility, which was not part of the TQM principles initially (Gómez, Martínez Costa and Martínez Lorente, 2017). Implementing TQM is an utterly complex process as it involves changing the working cultures and has an impact on people (Yusof and Aspinwall, 2000). Hence, measuring the critical factors is extremely relevant to control the success of TQM implementation (Hietschold, Reinhardt and Gurtner, 2014). Many authors divide these critical factors into two groups – soft and hard factors (Calvo-Mora, Picón, et al., 2014). In EFQM Model there is no distinction between both TQM factors. However, Calvo-Mora et al. (2020) concluded that soft EFQM factors have a strong direct relationship with customer and people results. It also has an indirect relation with society and key results, whereas these two variables (society and key results) show a strong direct relation with strategic-hard EFQM factors; also, soft factors (leadership and people) have high importance in the management systems and must be disseminated as a mean to develop strategic-hard factors in organisations. Magd, Negi and Ansari (2021) emphasises the importance of implementing TQM practices in order to enhance organisational performance and business sustainability, i.e. to achieve overall success. "TQM Models" were the first models introduced in businesses that briskly evolved to the term "Models of Excellence", with the appearance of MBNQA and EFQM models, raising the question about whether TQM and Excellence Models were similar or not. However, notwithstanding there is a high correlation between the TQM dimensions and the EFQM enablers, some TQM elements are omitted from the EFQM enablers' content, in other words, implementing the EFQM Excellence Model is means to achieve TQM, but not sufficient (Gómez, Martínez Costa and Martínez Lorente, 2017).

EFQM Model consists of a holistic approach (Pop and Pelau, 2017), i.e., to attain excellent results, an integrated and comprehensive perspective of the model criteria must be considered (Suárez, Roldán and Calvo-Mora, 2014). Innovation plays a crucial role in sustainable success, as a consequence, organisations must constantly seek opportunities and be prepared for the change in order to enhance their performance (SpaCek and Vacík, 2016). The newest version of the EFQM Model gives great emphasis to innovation. Actually, as concluded by Para-González, Jiménez-Jiménez and Martínez-Lorente (2022) EFQM Model is directly related to developing radical changes within an organisation.

The Radar chart is a graphical method of displaying multivariate data in the form of a two-dimensional chart of three or more quantitative variables represented on axes starting from the same point. This tool consists of an evolution of the PDCA (Plan-Do-Check-Act) cycle and is extremely important as it can be used as a self-assessment tool to find strengths and opportunities; to have external recognition and to compare the performance with other organisations that implemented the EFQM model and the Radar logic. It provides the possibility to measure the progress of an organisation (EFQM, 2019). Özmen et al. (2017) warn of the importance of the self-assessment process.

To spread the implementation of its Model, EFQM created a recognition mechanism. The purpose of the awards is to promote and recognise innovation and success, inspire the business community, and allow debate (Ghicajanu et al., 2015) to assure the continuous improvement of organisations. However, a few remarks must be noticed. Firstly, gaining a quality award is not directly linked to an increase in performance in a certain organisation. Gómez-López, Serrano-Bedia and López-Fernández (2016) explain that the credibility of some prizes has been compromised, as some companies face bankruptcy after gaining the award, leading to the conclusion that winning a certain prize is not the solution to fix the issues of an organisation. The same authors also state that sometimes the model tends to highlight more the scoring process, while alternatively, the model should provide the right means to attain a specific result. Besides, some criticism lies in the lack of transparency in the prizes awarded. Gómez-Gómez, Martínez-Costa and Martínez-Lorente (2016) report that all BEMs have self-evaluation tools by weighting the different criteria, to show the "degree of excellence" of the organisation, but none of them reports what is the logic behind the weight given to each criterion. Escrig-Tena, Garcia-Juan and Segarra-Ciprés (2019) also emphasise the importance of internalising the EFQM model, since a frequent cause of failure lies in the lack of incorporation of good management practices on the people directly connected to the organisation, as sometimes an organisation can be more focused on obtaining recognition rather than embedding the best practices. Moreover, the authors concluded that to have a proper internalisation of the model, internal reasons are more significant than external ones.

In what concerns organisational culture, hierarchical or market type are the ones that have a positive relationship with the EFQM enablers (Giménez Espín, Costa and Jiménez, 2022). Process management, quality policy and planning are the

criteria with a bigger influence on employee satisfaction (Álvarez-García et al., 2016), since higher levels of employee satisfaction led to the successful implementation of the EFQM Model concluded. Results also show that worse results are obtained from organisations with low results in People Results. In turn, better organisations have higher scores in Business Results and People Results. Also, it was concluded that ownership, size, the criteria Process, Products and Services, and Leadership do not determine if an organisation is successful or not, but rather its strategic vision, proactively fulfilling the stakeholders' expectations and understanding of the importance of human resources – these results are coherent with the orientations of the new EFQM Model (Periañez-Cristobal et al., 2020).

3.2 Shingo Model

Operational Excellence focuses on making improvements at the operational level to achieve a competitive advantage. It can be considered a philosophy of leadership, teamwork, and problem-solving regarding meeting customer expectations, employee empowerment, and optimisation of processes and comprises four dimensions: Cultural Enablers, Continuous Process Improvement, Enterprise Alignment, and Results. Many authors dedicated themselves to developing a model for Operational Excellence. Conversely, it is not possible to specify a certain model as being the most propitious as the diversity of models available ensures sustainable competition and stimulates enhancements (Carvalho et al., 2019; Sony, 2019). However, the most recognised model for Operational Excellence is the Shingo Model, which has been evolving over the years and becoming a more holistic model, namely by exchanging the words "operational excellence" for "enterprise excellence". Shingo Model is not simply a lean program, as highlighted by Kelly and Hines (2019) who affirm that lean organisations centralise attention on achieving certain results, whether Shingo Model comprises wider systems, culture, and guiding principles (holistic perspective).

The Shingo Institute awarded the Shingo Prize to more than 350 organisations worldwide (Shingo Institute, 2022). The awards assigned are based on the assessment of the organisation's results and behaviour, by external examiners from Shingo Institute (Bhullar et al., 2014). Those results must indicate outstanding (world-class) outcomes regarding the manufacturing and service processes, productivity, quality, and service to the customer (Chakravorty, Atwater and Herbert, 2008). The winners of the Prize belong to the most diverse areas, such as medical, healthcare manufacturing, nutrition, pharmaceutical, consumer goods, electronic, logistics, automotive, food and beverages, military, defense, financial, chemical, aviation, and aerospace, etc. (Shingo Institute, 2022). Hines, Taylor and Walsh (2020) report the case of a nickel refinery organisation, in Wales, which won a Shingo Prize, in 2014, due to performing characteristics of advanced Lean.

It must be emphasised that Shingo Model should not be seen as a short-term approach, but instead a set of principles and behaviours that shape organisational culture and, in its turn, lead to organisational and operational excellence i.e., the best long-term results, promoting a continuous and sustainable improvement (Carvalho et al., 2019; Snyder and Edgeman (2021) warn of the importance of permanently "improving the process of improvement".

Another aspect that must be taken into consideration is that the model does not constitute a solution to all the company's problems. Sony (2019) and Carvalho et al. (2019) warn of the difficulties in maintaining outstanding long-term results. Furthermore, the authors report that some companies that won awards, including the Shingo Prize, declared bankruptcy shortly after receiving it. The lack of sustainable results can be justified by the huge and exclusive focus given to the economic dimension by organisations, disregarding the other dimensions of sustainability. According to the Shingo Model (Shingo, 2023) for an organisation to have durable success, it must search for continuous improvement, and improvements can only be possible if there is a culture to which everyone in the organisation is committed.

There are ten guiding principles divided into three dimensions: Enterprise Alignment, Continuous Improvement, and Cultural Enablers. Guiding principles are considered to be the foundation of a culture that lasts and allows to achieve Organisational Excellence (Shingo, 2023). In the previous version of the Shingo Model, there was a fourth dimension named "Results" at the top of the pyramid, whose Guiding Principle was "Create Value for the Customer" (Shingo, 2023). Later, this guiding principle was incorporated into the dimension of "Continuous improvement". The model possesses a cyclical nature. Guiding principles are "universal and timeless", even though they can be manifested differently according to the culture and era (Edgeman, 2018). Due to a cultural transformation, people will coordinate efforts and work in a collective and collaborative environment, aligned with the vision and objectives of the organisation, which leads to continuous improvement and, consequently, excellent results, reinforcing the cyclicality and interrelationships inherent to the model (Edgeman, 2018). Moreover, Edgeman (2017) concluded that people "routinely and voluntarily" cooperate when the culture of the organisation is embedded in people and their practices.

Paper of Kelly and Hines (2019) report successful cases on the implementation of the Shingo Model, under the alliance with the Lean practices. This alliance allows design, develop and maintain effective systems to foster a cultural transformation (Carvalho et al., 2022).

3.3 Corporate Sustainability

Nowadays, balancing financial results with non-financial practices, such as management, innovativeness, the satisfaction of customers, employees, suppliers, and broader society, quality of life and work and even shorting the working

process is imperative (Škafar, 2019). Hence, terms such as CS and Corporate Social Responsibility (CSR) are gaining prominence over time. Most times, the social dimension is considered the most vulnerable pillar, as stated by Meseguer-Sánchez et al. (2021). Usually, it is the constant pressure by organisations' stakeholders that leads organisations to rise concerns regarding social, economic, and ecological aspects, emphasising the role of stakeholders' engagement in the quest for sustainable practices (Meseguer-Sánchez et al., 2021). Stakeholders' engagement is generally more emphasised when the dimension of firms is bigger and when its legal form is a corporation (Carvalho, Santos and Gonçalves, 2020). Bigger firms usually tend to disclose sustainable practices more frequently, as a strategy to enhance their reputation towards stakeholders (Santos, Murmura and Bravi, 2018). Regarding the social pillar, Teixeira et al. (2022) concluded that operational and social performance has a positive impact on competitive advantage, thus, this pillar must be seen as an investment rather than a cost.

About the environmental pillar, CSR also aims to reduce the environmental impact, giving rise to the concept of Circular Economy (CE) – a way to extend the lifetime of products and reduce the waste of natural resources, which is considered a key to achieving corporate sustainability (Khan, Daddi and Iraldo, 2020). Stewart and Niero (2018) states that CE is becoming to gain more attention, consequently, companies have begun the journey towards its implementation, mainly concerning the recyclability of their products and packaging. As a consequence, EFQM new model version highly promotes CE. Sadegh Amalnick and Zarrin (2017) warn of the importance of evaluating integrated health, safety, and environmental systems.

Concerning the economic pillar, although studies are confirming that positive financial results allow the implementation of CSR, leading to social and environmental improvements within the organisation, it was also proven the contrary i.e., CSR induces a better financial performance (Meseguer-Sánchez et al., 2021). Kim, Kim and Qian (2018) present case studies, whose findings report positive relationships between these two constructs. Concerning an organisation's employees – motivated, satisfied, committed, and comfortable ones, help improve economic results (Manresa and Escobar Rivera, 2021).

3.4 Excellence Models and Corporate Sustainability

Sustainability has not yet been considered a relevant topic in many excellence models. The referred models were not created focusing on sustainability, but rather on economic issues by improving organisational performance through TQM principles and concepts (Rocha et al., 2015). However, over the years, as models are constantly being adapted and improved "to maintain its timeliness and relevance" this dimension has been incorporated (Fonseca, 2022). Nowadays, the concept of being an excellent organisation is not only related to having business success but also to the concept of CSR (Wierzbic and Martusewicz, 2022).

According to some authors, the previous EFQM model already showed a positive direct and indirect orientation towards sustainability (de Menezes, Escrig-Tena and Bou-Llusar, 2021). Jankal and Jankalova (2016) affirmed that the EFQM model was already embedded into CSR practices. However, those opinions are divergent among authors, as some emphasise the model barely referred to this topic, creating themselves a different model version to fulfil the requirements of the EFQM model, but in a modified more sustainable-oriented way (Pelantová and Šlaichová, 2017).

In turn, the newest EFQM model version is highly oriented towards promoting sustainability (Muhammad Din et al., 2021; Val, Regaliza and Maraña, 2020). Martusewicz, Szewczyk and Wierzbic (2022) concluded that the model in analysis is a great tool to "create, implement and monitor strategies" regarding environmental practices. Politis and Grigoroudis (2022) affirms that EFQM model specifically addresses the subject of CS. However, due to being a comprehensive model, it does not suggest what would be the better indicators to measure these results, thus, further modifications would be necessary for this model to be considered a sustainability framework. Also, the EFQM model incorporates the United Nations' 17 Sustainable Development Goals and the United Nations Global Compact (UN, 2000) – ten principles for sustainable and socially responsible business (EFQM, 2019). Sustainability is emphasised throughout this Model version, specifically in criteria 1.1, 1.2, 1.3, 1.5, 2.1, 3.1, 3.4, 3.5, 4.3, 5.1, 5.2, 5.3, 5.4, 5.5, 6, and 7, reaffirming the urge to innovate, promote creativity, develop a "disruptive thinking", and promote the use of technology (Fonseca, 2022; Martusewicz, Szewczyk and Wierzbic, 2022; Politis and Grigoroudis, 2022).

Digital transformation enhances sustainability, as it allows, for example, to reduce costs, and improve efficiency, and labour productivity (Zhang, Chen and Hao, 2022), also there is a positive relationship between digital transformation and the achievement of SDGs, within the UN 2030 Agenda (Camodeca and Almici, 2021). Consequently, studies addressing Industry 4.0 (I4.0) and Quality 4.0 (Q4.0) related EFQM 2020 Model version have been accomplished. Yu, Khan and Umar (2022) concluded that I4.0 has a positive impact on the implementation of a circular economy (CE), and, in its turn, a CE has a positive impact on operational and economic performance. Also, as reported by Martusewicz, Szewczyk and Wierzbic (2022), the concept of CE is mentioned in the EFQM model in criteria 5.5 and 6. Turisová et al. (2020) used this model version to analyse the readiness of companies for I4.0 in a specified area. However, according to Fonseca, Amaral and Oliveira (2021) there is a link between I4.0 and the model criteria and guidance points, despite specific references to I4.0 pillars are not clear, as a result of the non-prescriptive nature of the model. Q4.0 allows processes to be controlled and decisions to be taken in real-time (Zgodavova et al., 2020), being positively related to economic, social, and environmental performance (Antony et al., 2022). Despite the current model does not mention how to achieve long-term Q4.0, it is implicitly included in the

model, as it is referred the necessity to transform the organisation for the future and it is also referred that the organisation must have a wide range of perceptions (feedbacks) from its stakeholders (Nenadál, 2020).

Strihavková, Svobodová and Vysloužilová (2021) findings show evidence that successful organisations in the matter of CSR have certifications in environment and quality. Also, it was proved that there is a synergy between the management systems regarding quality, environment, security, and occupational health and the EFQM model. Thus, if they are already implemented in a company, it will be easier to meet the requirements of the EFQM model, in terms of CSR (Quintero-Garzón et al., 2015).

In what concerns the Shingo Model, it gives great emphasis on the organisational culture, on well-being and empowerment of its employees, on people's development and safety, thus it can be concluded that this model promotes enthusiastically the social pillar. The Shingo Model incorporates the Lean philosophy (Sá et al., 2022) in its principles. These lean practices and tools (for instance 5S, Jidoka, JIT, and SMED) help organisations to attain better environmental and economic performance (Teixeira et al., 2022), thus it can be concluded that the environmental and economic pillars of sustainability are also promoted in the model. Moreover, these two pillars (the economic and environmental) are interrelated as, for example, "Identify and Eliminate Waste" (one of the Shingo principles) is not only related to the environmental pillar, as evident, but as it also improves the flow process, it also has a positive influence on the economic pillar and so on. According to this model, sustainability is achieved due to a cultural shift, where principles and behaviours allow the excellent results to endure.

3.5 A New Conceptual Model

Because of the results obtained from the literature review, a new conceptual model is presented (Fig. 5) in order to understand the major relationships between the concepts abovementioned.

Whether the reasons for the implementation of the EFQM Model or Shingo Model are internal or external, it all comes from the ultimate decision of top management. The models will promote adopting the best management practices to attain the desired sustainable results. In order to attain them, the objectives, mission, and vision of the organisation must be aligned with the business strategy. Thus, it is important to have a synergy between processes, resources, and people inside the organisation. As we live in a dynamic world and organisations pursue excellence, it is natural that the strategy changes over time, however, it is essential that the organisation is always fully aligned with the designed strategy, in order to achieve the desired outcomes (Ghonim et al., 2022).

A cultural transformation will be required to have long-term durable results, whose focus must be directed to the most important assets of organisations –

their employees. Thus, empowering them will be crucial to make employees committed to their tasks and the organisation as a whole, as they feel more valued. It will also make employees less resistant to changes, allowing them to promote innovation inside an organisation, as concluded by Santos-Jaén, Madrid-Guijarro and García-Pérez-de-Lema (2021). Satisfied employees are a crucial key to promoting sustainable economic and environmental results. The more embedded employees are in the organisational culture and the more empowered they feel, the best possible results can be achieved, as well as higher levels of commitment and satisfaction, and so on. One of the key aspects of the model is precisely commitment. Top management commitment is crucial to promote employee commitment, as highlighted by Pellegrini, Rizzi and Frey (2018), when an organisation shows great commitment towards sustainability, its employees are more prone to promote sustainable behaviours. A cultural transformation along with implementing the best corporate policies, which encompasses, for example, the quality policy, the environmental policy, the occupational health and safety policy, and the integrated management system policy will lead to the sustainable development of an organisation.

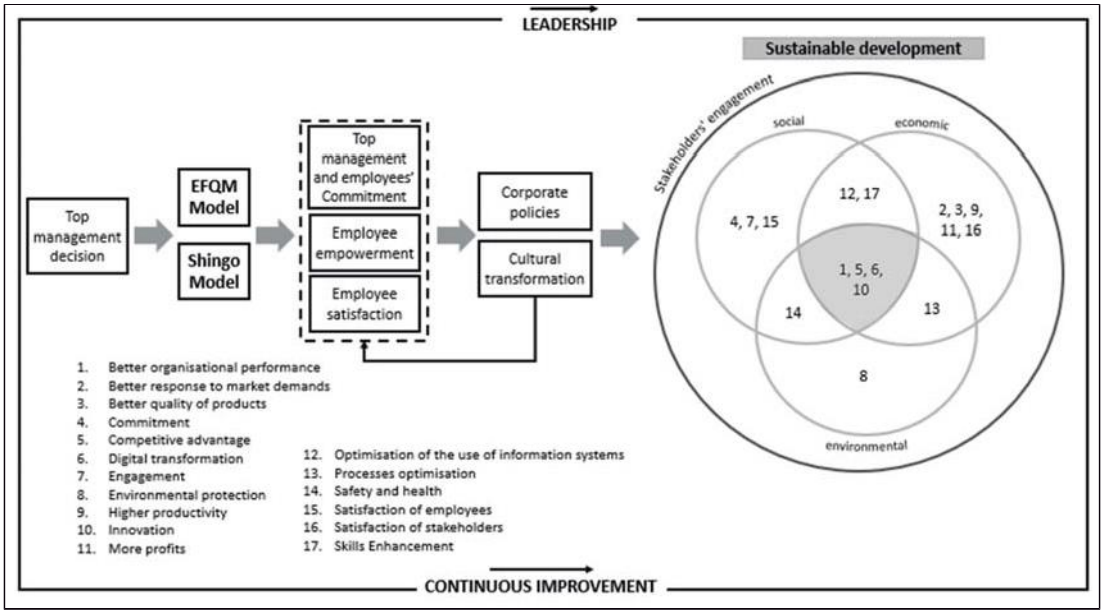


Figure 5 – A New Conceptual Model for Excellence in Business Towards Sustainable Development

Engaging in CS practices comes from a strategic choice as a means to achieve prominent results in each sustainability pillar (Santos, Murmura and Bravi, 2018). From the literature review, 17 results can be achieved with the implementation of the models. Those results were divided into social, economic, environmental, social-environmental, economic-environmental, and socio-economic results, as shown in Fig. 5. The ultimate challenge to all organisations is to ensure that stakeholders' expectations and needs are fully met, thus identify, prioritise and engage them is paramount (Vieira Nunhes et al., 2022). Finally, it is important to highlight that both EFQM and Shingo Model focus on seeking

continuous improvement and promoting the best leadership practices, so that sustainable results may endure (EFQM, 2019; Shingo, 2023).

4 DISCUSSION OF RESULTS

Excellence Models consist of crucial tools that help organisations to achieve excellent performance and to be permanently prepared to cope with change, as well as to be more prepared for future uncertainties. EFQM Model and Shingo Model are constantly evolving and adapting to current needs (EFQM, 2019; Shingo, 2023), which is certainly a positive remark. However, being extremely inclusive can be a negative point. The models can be implemented in larger organisations or SMEs and in many different sectors of activity. Thus, many authors claim attention to the problem of SMEs in implementing these models, as small companies face huge challenges/barriers to the implementation of EFQM or Shingo models (Bhullar et al., 2014). Moreover, authors have been developing adaptations of these models, in order to specify them to a certain type of organisation size or activity (Liu et al., 2021).

Despite being designed from different constructs, with this literature review, it was possible to find some convergence points between the EFQM and Shingo models towards their relationship with CS. Both models consist of a holistic approach and hence, to achieve outstanding results an integrated perspective of the model must be taken (Pop and Pelau, 2017), also as pointed out by Özmen et al. (2017), both the EFQM and Shingo model assessment allows identifying strengths, weaknesses, and opportunities for improvement, helping to assess the maturity of an organisation.

In what concerns the top management, findings from the literature indicate that models warn of the importance of high commitment by top management in all domains and effective leadership, in order to attain the best possible results (Escrig and de Menezes, 2016). Thus, the best management practices, principles, and behaviours must be implemented and embedded into the organisation's culture (Escrig-Tena, Garcia-Juan and Segarra-Ciprés, 2019), to achieve the desired results. Moreover, Su et al. (2022) concluded that CEOs and leaders of the best-performing organisations in terms of corporate responsibility show a specific profile that must be taken into account by managers, as top management positions and decisions inside an organisation are crucial to promoting sustainable practices and attaining excellent results.

Some studies (Carvalho et al., 2019; Gómez-López, Serrano-Bedia and López-Fernández, 2016; Sony, 2019) indicate that certified companies from EFQM Model or Shingo Model perform better, but certification does not promise long-term sustainable results. Outstanding results will only persist if an organisation is committed to the social and environmental aspects, rather than the economic one exclusively, and by permanently seeking continuous improvement, i.e. successful

organisations worry about and promote practices under the three pillars of sustainability, which must coexist "harmonically" (Teixeira et al., 2022).

As employees that perceive the organisation is proactively involved in environmental protection are more willing to cooperate in environmental protection activities (Ahmad et al., 2021). Employees cooperate when the culture of the organisation is embedded in them and their practices (Edgeman, 2017), it is crucial to understand the importance of human resources and empower them as they constitute a critical key to organisational success. Models show the utter importance of promoting high levels of satisfied employees, by empowering and developing them, in whom values of responsibility and commitment will be developed, leading the organisation to achieve durable and sustained results (Kelly, 2016). EFQM Model requires "building a winning culture" (EFQM, 2019) whereas Shingo Model requires beginning a progressive "cultural transformation" (Shingo, 2023).

Having into consideration the aspects abovementioned, the conceptual model presented in the previous section aims to highlight the major constructs found in the literature and their relationships, in what concerns the EFQM and the Shingo Models, in order to achieve excellence in business towards sustainable development.

5 CONCLUSION

The purpose of this paper was to broaden the knowledge of the latest versions of EFQM and the Shingo model towards CS. Over the years, organisations have tried to improve their processes, to obtain better results, whether nowadays, they seem to be increasingly more aware of the urge to incorporate social and environmental practices, if they aim to attain long-term sustainable results. This literature review allowed to conclude that sustainability is emphasised in the models.

Top managers have seen many advantages in the implementation of EFQM and the Shingo model. The 17 reasons identified in the literature review are abovementioned in the conceptual model. However, some managers, especially the ones running SMEs still face some barriers to their implementation, generally due to the complexity of models and the lack of workforce and financial resources. It is important to highlight that both models have a comprehensive nature and that they were designed under the assumption of continuous improvement, to permanently seek to make the best efforts towards achieving the best results. Furthermore, this paper stresses the importance of employee empowerment and satisfaction, as only committed and satisfied employees will help to achieve sustainable results, along with the best organisational culture and environmental policies. It is also focused on the importance of stakeholders' engagement in this process.

5.1 Contributions, Limitations and Future Research Avenues

This paper helps to understand how the EFQM Model and the Shingo Model inspire organisations to promote the best sustainable practices and how they perceive them, having allowed answering the research question initially stated: How do BEMs inspire the sustainability of organisations? Literature suggests that both models promote Sustainability, under its three pillars.

Moreover, this paper provides summarised knowledge on the newest EFQM Model version and the Shingo Model, along with information regarding the relationship between these models and CS. A new conceptual model for excellence in business towards sustainable development is proposed. This model helps organisations to understand the key aspects that must be taken into consideration to achieve sustainable development and their relationships, based on the principles of EFQM and the Shingo Model. Also, the model highlights the outcomes of such implementation divided by the pillars of sustainability and emphasises the need of implementing the policies under the designed constructs of the conceptual model with effective leadership, prioritising continuous improvement, and adequately engaging stakeholders in order to attain sustainable results. Also, as mentioned in the first section, the number of papers available regarding these models, especially the Shingo Model is yet very limited, thus, this paper aims to contribute to fulfil the shortcomings associated with them.

In the process of choosing articles to be as transparent as possible, the PRISMA methodology was implemented. The main limitation is provided by the underlying subjectivity of this paper's authors when choosing the publications by their title and abstract in the records screening phase. Also, there are limitations regarding the only database used – Web of Science, the inaccessibility to some articles, and all the exclusion criteria, namely regarding to the period considered in each search and the single language of the papers considered (English). Furthermore, the difficulty in obtaining publications on the Shingo Model and on the relationship between the Shingo Model and CS, as already mentioned, as well as the existence of a limited number of studies on the latest version of the EFQM Model and therefore on the relationship between this model version and CS, represented adversities in the literature review.

Future research should fill gaps regarding the lack of practical studies on the new version of the EFQM Model and the Shingo model with CS. Moreover, readers are encouraged to study the practical implications of the purposed conceptual model, in order to provide stronger evidence of it, as well as, to enhance the model.

REFERENCES

Ahmad, N., Ullah, Z., Arshad, M.Z., Kamran, H., Scholz, M. and Han, H., 2021. Relationship between corporate social responsibility at the micro-level and environmental performance: The mediating role of employee pro-environmental behavior and the moderating role of gender. *Sustainable Production and Consumption*, [e-journal] 27, pp.1138-1148. DOI: 10.1016/j.spc.2021.02.034.

Álvarez-García, J., del Río-Rama, M. de la C., Saraiva, M. and Ramos-Pires, A., 2016. Dependency relationships between critical factors of quality and employee satisfaction. *Total Quality Management and Business Excellence*, [e-journal] 27(5–6), pp.595-612. DOI: 10.1080/14783363.2015.1021243.

Antony, J., Sony, M., Furterer, S., McDermott, O. and Pepper, M., 2022. Quality 4.0 and its impact on organizational performance: an integrative viewpoint. *TQM Journal*, [e-journal] 34(6), pp.2069-2084. DOI: 10.1108/TQM-08-2021-0242.

Bhullar, A., Gan, C., Ang, A., Ma, B., Lim, R. and Toh, M., 2014. Operational Excellence Frameworks – Case Studies and Applicability to SMEs in Singapore. In: IEEE (Industrial Engineering and Engineering Management), *2014 IEEE International Conference on Industrial Engineering and Engineering Management*. Selangor, Malaysia, 9-12 December 2014. IEEE. pp.667-671. DOI: 10.1109/IEEM.2014.7058722.

Bravi, L., Santos, G., Pagano, A. and Murmura, F., 2020. Environmental management system according to ISO 14001:2015 as a driver to sustainable development. *Corporate Social Responsibility and Environmental Management*, [e-journal] 27(6), pp.2599-2614. DOI: 10.1002/csr.1985.

Calvo-Mora, A., Blanco-Oliver, A., Roldán, J.L. and Periáñez-Cristóbal, R., 2020. TQM factors and organisational results in the EFQM excellence model framework: an explanatory and predictive analysis. *Industrial Management and Data Systems*, [e-journal] 120(12), pp.2297-2317. DOI: 10.1108/IMDS-12-2019-0701.

Calvo-Mora, A., Picón, A., Ruiz, C. and Cauzo, L., 2014. The relationships between soft-hard TQM factors and key business results. *International Journal of Operations and Production Management*, [e-journal] 34(1), pp.115-143. DOI: 10.1108/IJOPM-09-2012-0355.

Calvo-Mora, A., Picón-Berjoyo, A., Ruiz-Moreno, C. and Cauzo-Bottala, L., 2015. Contextual and mediation analysis between TQM critical factors and organisational results in the EFQM Excellence Model framework. *International Journal of Production Research*, [e-journal] 53(7), pp.2186-2201. DOI: 10.1080/00207543.2014.975859.

Camodeca, R. and Almici, A., 2021. Digital transformation and convergence toward the 2030 agenda's sustainability development goals: Evidence from Italian listed firms. *Sustainability* (Switzerland), [e-journal] 13(21), 11831. DOI: 10.3390/su132111831.

Carvalho, A.M., Sampaio, P., Rebentisch, E., Carvalho, J.Á. and Saraiva, P., 2019. Operational excellence, organisational culture and agility: the missing link?. *Total Quality Management and Business Excellence*, [e-journal] 30(13–14), pp.1495-1514. DOI: 10.1080/14783363.2017.1374833.

Carvalho, F., Santos, G. and Gonçalves, J., 2020. Critical analysis of information about integrated management systems and environmental policy on the Portuguese firms' website, towards sustainable development. *Corporate Social Responsibility and Environmental Management*, [e-journal] 27(2), pp.1069-1088. DOI: 10.1002/csr.1866.

Carvalho, M., Sá, J.C., Marques, P.A., Santos, G. and Pereira, A.M., 2022. Development of a conceptual model integrating management systems and the Shingo Model towards operational excellence. *Total Quality Management and Business Excellence*, [e-journal] 34(3-4), pp.397-420. DOI: 10.1080/14783363.2022.2060810.

Chakravorty, S., Atwater, J.B. and Herbert, J.I., 2008. The Shingo Prize for operational excellence: rewarding world-class practices. International Journal of Business Excellence, [e-journal] 1(4), pp.418-433. DOI: 10.1504/IJBEX.2008.018841.

de Menezes, L.M., Escrig-Tena, A.B. and Bou-Llusar, J.C., 2021. Sustainability and Quality Management: has EFQM fostered a Sustainability Orientation that delivers to stakeholders?. *International Journal of Operations and Production Management*, [e-journal] 42(13), pp.155-184. DOI: 10.1108/IJOPM-10-2021-0634.

Edgeman, R., 2017. Routinizing peak performance and impacts via virtuous cycles. *Measuring Business Excellence*, [e-journal] 21(3), pp.261-271. DOI: 10.1108/MBE-03-2017-0003.

Edgeman, R., 2018. Excellence models as complex management systems: An examination of the Shingo operational excellence model. *Business Process Management Journal*, [e-journal] 24(6), pp.1321-1338. DOI: 10.1108/BPMJ-02-2018-0049.

EFQM, 2019. The EFQM Model. [online] Available at: <https://efqm.org/> [Accessed 24 July 2023].

Escrig, A. and de Menezes, L.M., 2016. What is the effect of size on the use of the efqm excellence model? International Journal of Operations & Production Management, [e-journal] 36(12), pp.1800-1820. DOI: 10.1108/IJOPM-11-2014-0557.

Escrig-Tena, A.B., Garcia-Juan, B. and Segarra-Ciprés, M., 2019. Drivers and internalisation of the EFQM excellence model. *International Journal of Quality and Reliability Management*, [e-journal] 36(3), pp.398-419. DOI: 10.1108/IJQRM-08-2017-0161.

Fonseca, L., 2015. Relationship between ISO 9001 certification maturity and EFQM business excellence model results. *Quality Innovation Prosperity*, [e-journal] 19(1), pp.85-102. DOI: 10.12776/QIP.V19I1.556.

Fonseca, L., 2022. The EFQM 2020 model. A theoretical and critical review. *Total Quality Management and Business Excellence*, [e-journal] 33(9–10), pp.1011-1038. DOI: 10.1080/14783363.2021.1915121.

Fonseca, L., Amaral, A. and Oliveira, J., 2021. Quality 4.0: The efqm 2020 model and industry 4.0 relationships and implications. *Sustainability* (Switzerland), [e-journal] 13(6), 3107. DOI: 10.3390/su13063107.

Fonseca, L., Silva, V., José Carlos, S., Lima, V., Santos, G. and Silva, R., 2022. B Corp versus ISO 9001 and 14001 certifications: Aligned, or alternative paths, towards sustainable development? *Corporate Social Responsibility and Environmental Management*, [e-journal] 29(3), pp.496-508. DOI: 10.1002/csr.2214.

Ghicajanu, M., Irimie, S., Marica, L. and Munteanu, R., 2015. Criteria for Excellence in Business. *Procedia Economics and Finance*, [e-journal] 23, pp.445-452. DOI: 10.1016/s2212-5671(15)00388-3.

Ghonim, M.A., Khashaba, N.M., Al-Najaar, H.M. and Khashan, M.A., 2022. Strategic alignment and its impact on decision effectiveness: a comprehensive model. *International Journal of Emerging Markets*, [e-journal] 17(1), pp.198-218. DOI: 10.1108/IJOEM-04-2020-0364.

Giménez Espín, J.A., Costa, M.M. and Jiménez, D.J., 2022. Does culture matter for the EFQM model application?. *Total Quality Management and Business Excellence*, [e-journal] 34(3-4), pp.440-467. DOI: 10.1080/14783363.2022.2068408.

Gómez, J.G., Martínez Costa, M. and Martínez Lorente, Á.R., 2017. EFQM Excellence Model and TQM: an empirical comparison. *Total Quality Management and Business Excellence*, [e-journal] 28(1–2), pp.88-103. DOI: 10.1080/14783363.2015.1050167.

Gómez-Gómez, J., Martínez-Costa, M. and Martínez-Lorente, Á.R., 2016. Weighting the dimensions in models of excellence – a critical review from a business perspective. *Measuring Business Excellence*, [e-journal] 20(3), pp.79-90. DOI: 10.1108/MBE-01-2016-0007.

Gómez-López, R., López-Fernández, M.C. and Serrano-Bedia, A.M., 2017. Implementation barriers of the EFQM excellence model within the Spanish private firms. *Total Quality Management and Business Excellence*, [e-journal] 28(7–8), pp.695-711. DOI: 10.1080/14783363.2015.1106314.

Gómez-López, R., Serrano-Bedia, A.M. and López-Fernández, M.C., 2016. Motivations for implementing TQM through the EFQM model in Spain: an

empirical investigation. *Total Quality Management and Business Excellence*, [e-journal] 27(11–12), pp.1224-1245. DOI: 10.1080/14783363.2015.1068688.

Gómez-López, R., Serrano-Bedia, A.M. and López-Fernández, M.C., 2019. An exploratory study of the results of the implementation of EFQM in private Spanish firms. *International Journal of Quality and Reliability Management*, [e-journal] 36(3), pp.331-346. DOI: 10.1108/IJQRM-01-2018-0023.

Hietschold, N., Reinhardt, R. and Gurtner, S., 2014. Measuring critical success factors of TQM implementation successfully-a systematic literature review. *International Journal of Production Research*, [e-journal] 52(21), pp.6254-6272. DOI: 10.1080/00207543.2014.918288.

Hines, P., Taylor, D. and Walsh, A., 2020. The Lean journey: have we got it wrong?. *Total Quality Management and Business Excellence*, [e-journal] 31(3–4), pp.389-406. DOI: 10.1080/14783363.2018.1429258.

Jaeger, A. and Matyas, K., 2016. Transformation of the EFQM approach from business towards operations excellence. *Production Engineering*, [e-journal] 10(3), pp.277-291. DOI: 10.1007/s11740-016-0665-8.

Jankal, R. and Jankalova, M., 2016. The Application of The EFQM Excellence Model by the Evaluation of Corporate Social Responsibility Activities of Companies. *Procedia Economics and Finance*, [e-journal] 39, pp.660-667. DOI: 10.1016/s2212-5671(16)30313-6.

Kelly, S. and Hines, P., 2019. Discreetly embedding the Shingo principles of enterprise excellence at Abbott Diagnostics manufacturing facility in Longford Ireland. *Total Quality Management and Business Excellence*, [e-journal] 30(11–12), pp.1235-1256. DOI: 10.1080/14783363.2017.1363645.

Kelly, S., 2016. Creating a Culture of Continuous Improvement and Sustainable Management Systems at Abbott Diagnostics Longford. *Global Business and Organizational Excellence*, [e-journal] 36(1), pp.6-24. DOI: 10.1002/joe.21753.

Khan, O., Daddi, T. and Iraldo, F., 2020. Microfoundations of dynamic capabilities: Insights from circular economy business cases. *Business Strategy and the Environment*, [e-journal] 29(3), pp.1479-1493. DOI: 10.1002/bse.2447.

Kim, K.H., Kim, M.C. and Qian, C., 2018. Effects of Corporate Social Responsibility on Corporate Financial Performance: A Competitive-Action Perspective. *Journal of Management*, [e-journal] 44(3), pp.1097-1118. DOI: 10.1177/0149206315602530.

Liu, Y.L., Pen-Fa, K., Chiang, J.T. and Shyr, W.J., 2021. Should the EFQM Excellence Model be Adapted for Specific Industries? A Restaurant Sector Example. *International Journal of Hospitality Management*, [e-journal] 92, 102694 DOI: 10.1016/j.ijhm.2020.102694.

Magd, H., Negi, S. and Ansari, M.S.A., 2021. Effective TQM Implementation in the Service Industry: A Proposed Framework. *Quality Innovation Prosperity*, [e-journal] 25(2), pp.95-129. DOI: 10.12776/qip.v25i2.1594.

Manresa, A. and Escobar Rivera, D., 2021. Excellence in sustainable management in a changing environment. *Sustainability* (Switzerland), [e-journal] 13(4), pp.1-27. DOI: 10.3390/su13042296.

Martusewicz, J., Szewczyk, K. and Wierzbic, A., 2022. The Environmental Protection and Effective Energy Consumption in the Light of the EFQM Model 2020—Case Study. *Energies*, [e-journal] 15(19), 7260. DOI: 10.3390/en15197260.

Meseguer-Sánchez, V., Gálvez-Sánchez, F.J., López-Martínez, G. and Molina-Moreno, V., 2021. Corporate social responsibility and sustainability. A bibliometric analysis of their interrelations. *Sustainability* (Switzerland), [e-journal] 13(4), pp.1-18. DOI: 10.3390/su13041636.

Muhammad Din, A., Asif, M., Awan, M.U. and Thomas, G., 2021. What makes excellence models excellent: a comparison of the American, European and Japanese models. *TQM Journal*, [e-journal] 33(6), pp.1143-1162. DOI: 10.1108/TQM-06-2020-0124.

Nenadál, J., 2020. The new EFQM model: What is really new and could be considered as a suitable tool with respect to quality 4.0 concept? *Quality Innovation Prosperity*, [e-journal] 24(1), pp.17-28. DOI: 10.12776/QIP.V24I1.1415.

Özmen, Ö., Sârbu, R., Sãseanu, A.S. and Toader, C., 2017. The European Foundation for Quality Management (EFQM) Excellence Model in a Low Voltage Switchgear Company. *Amfiteatru Economic*, 19(Special No. 11), pp.1064-1076.

Page, M.J., McKenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C.D., Shamseer, L., Tetzlaff, J.M., Akl, E.A., Brennan, S.E., Chou, R., Glanville, J., Grimshaw, J.M., Hróbjartsson, A., Lalu, M.M., Li, T., Loder, E.W., Mayo-Wilson, E., McDonald, S., … and Welch, V.A., Moher, D., 2021. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *The BMJ*, [e-journal] 372, n71. DOI: 10.1136/bmj.n71.

Para-González, L., Jiménez-Jiménez, D. and Martínez-Lorente, Á.R., 2022. Does EFQM enhance learning and innovation?. *Total Quality Management and Business Excellence*, [e-journal] 33(7–8), pp.727-751. DOI: 10.1080/14783363.2021.1890016.

Pelantová, V. and Šlaichová, E., 2017. The contribution of the integration of management systems oriented to the sustainable and TQM. *Amfiteatru Economic Journal*, 19(11), pp.951-965.

Pellegrini, C., Rizzi, F. and Frey, M., 2018. The role of sustainable human resource practices in influencing employee behavior for corporate sustainability. *Business Strategy and the Environment*, [e-journal] 27(8), pp.1221-1232. DOI: 10.1002/bse.2064.

Periañez-Cristobal, R., Calvo-Mora, A., Rey-Moreno, M. and Suárez, E., 2020. Organisational profiles: key factors and results from the EFQM model perspective. *Total Quality Management and Business Excellence*, [e-journal] 32(15-16), pp.1850-1873. DOI: 10.1080/14783363.2020.1787144.

Politis, Y. and Grigoroudis, E., 2022. Incorporating the Sustainability Concept in the Major Business Excellence Models. *Sustainability* (Switzerland), [e-journal] 14(13), 8175. DOI: 10.3390/su14138175.

Pop, N.A. and Pelau, C., 2017. Correlations within the EFQM Business Excellence Model by Applying a Factor Analysis. *Amfiteatru Economic*, 19(44), pp.28-40.

Quintero-Garzón, M.L., Carrión-García, A., Jordá-Rodríguez, M.A. and Rodríguez-Córdoba, M.D.P., 2015. Corporate social responsibility and the EFQM excellence model as a frame work for integration of management systems in organizations. Ingeniería Y Competitividad, [e-journal] 17(1), pp.9-22. DOI: 10.25100/iyc.v17i1.2197.

Rocha, L., Jose, L., Garza-Reyes, A., Kumar, V., School, B. and Lim, M.K., 2015. Corporate Sustainability and Business Excellence. In: IEOM (Industrial Engineering & Operations Management), *IEOM 2015 – 5th International Conference on Industrial Engineering and Operations Management*. Dubai, United Arab Emirates (UAE), 3-5 March 2015. IEOM Society.

Rotta, D. and Rave, J.P., 2017. A relevant literary space on the use of the European Foundation for Quality Management model: current state and challenges. *Total Quality Management and Business Excellence*, [e-journal] 28(13–14), pp.1447-1468. DOI: 10.1080/14783363.2016.1150168.

Sá, J.C. and Oliveira, J., 2013. Generating Value with Tqm and SIX SIGMA. In: IRF (Integrity, Reliability & Failure) 2013, *4th International Conference on Integrity, Reliability and Failure*. Funchal, 23-27 June 2013. IRF. Available at: <http://paginas.fe.up.pt/clme/IRF2013/index.htm> [Accessed 24 July 2023].

Sá, J.C., Reis, M., Dinis-Carvalho, J., Silva, F.J.G., Santos, G., Ferreira, L.P. and Lima, V., 2022. The Development of an Excellence Model Integrating the Shingo Model and Sustainability. *Sustainability* (Switzerland), [e-journal] 14(15), 9472. DOI: 10.3390/su14159472.

Sadegh Amalnick, M. and Zarrin, M., 2017. Performance assessment of human resource by integration of HSE and ergonomics and EFQM management system: A fuzzy-based approach. Int*ernational Journal of Health Care Quality Assurance,* [e-journal] 30(2), pp.160-174. DOI: 10.1108/IJHCQA-06-2016-0089.

Santos, G., Murmura, F. and Bravi, L., 2018. SA 8000 as a Tool for a Sustainable Development Strategy. *Corporate Social Responsibility and Environmental Management*, [e-journal] 25(1), pp.95-105. DOI: 10.1002/csr.1442.

Santos-Jaén, J.M., Madrid-Guijarro, A. and García-Pérez-de-Lema, D., 2021. The impact of corporate social responsibility on innovation in small and medium-sized enterprises: The mediating role of debt terms and human capital. *Corporate Social Responsibility and Environmental Management*, [e-journal] 28(4), pp.1200-1215. DOI: 10.1002/csr.2125.

Shingo, S., 2023. *The Shingo Institute.* [online] Shingo Award Recipients. Available at: <https://shingo.org/awards/> [Accessed 24 July 2023].

Škafar, B., 2019. (IN)effectiveness of quality management systems and models of excellence in practice. *Management* (Croatia), [e-journal] 24(1), pp.71-84. DOI: 10.30924/mjcmi.24.1.5.

Snyder, K. and Edgeman, R., 2021. Improving the process of improvement. *Total Quality Management and Business Excellence*, [e-journal] 32(1–2), pp.1-4. DOI: 14783363.2018.1522954.

Sony, M., 2019. Implementing sustainable operational excellence in organizations: an integrative viewpoint. *Production and Manufacturing Research*, [e-journal] 7(1), pp.67-87. DOI: 10.1080/21693277.2019.1581674.

SpaCek, M. and Vacík, E., 2016. Design of an innovative business model for mobile virtual network operators. *Quality Innovation Prosperity*, [e-journal] 20(2), pp.69-88. DOI: 10.12776/QIP.V20I2.772.

Stewart, R. and Niero, M., 2018. Circular economy in corporate sustainability strategies: A review of corporate sustainability reports in the fast-moving consumer goods sector. *Business Strategy and the Environment*, [e-journal] 27(7), pp.1005-1022. DOI: 10.1002/bse.2048.

Strihavková, E., Svobodová, J. and Vysloužilová, D., 2021. Corporate Social Responsibility of Organizations as Part of a Quality Management System. *Production Engineering Archives*, [e-journal] 27(4), pp.248-256. DOI: 10.30657/pea.2021.27.33.

Su, R., Obrenovic, B., Du, J., Godinic, D. and Khudaykulov, A., 2022. COVID-19 Pandemic Implications for Corporate Sustainability and Society: A Literature Review. *International Journal of Environmental Research and Public Health*, [e-journal] 19(3), 1592. DOI: 10.3390/ijerph19031592.

Suárez, E., Calvo-Mora, A., Roldán, J.L. and Periáñez-Cristóbal, R., 2017. Quantitative research on the EFQM excellence model: A systematic literature review (1991–2015). *European Research on Management and Business Economics*, [e-journal] 23(3), pp.147-156. DOI: 10.1016/j.iedeen.2017.05.002.

Suárez, E., Roldán, J.L. and Calvo-Mora, A., 2014. A structural analysis of the EFQM model: an assessment of the mediating role of process management. *Journal of Business Economics and Management*, [e-journal] 15(5), pp.862-885. DOI: 10.3846/16111699.2013.776627.

Teixeira, P., Coelho, A., Fontoura, P., Sá, J.C., Silva, F.J.G., Santos, G. and Ferreira, L.P., 2022. Combining lean and green practices to achieve a superior performance: The contribution for a sustainable development and competitiveness—An empirical study on the Portuguese context. *Corporate Social Responsibility and Environmental Management*, [e-journal] 29(4), pp.887-903. DOI: 10.1002/csr.2242.

Turisová, R., Sinay, J., Pacaiova, H., Kotianova, Z. and Glatz, J., 2020. Application of the EFQM model to assess the readiness and sustainability of the implementation of I4.0 in Slovakian companies. *Sustainability* (Switzerland), [e-journal] 12(14), 5591. DOI: 10.3390/su12145591.

UN (United Nations), 2000. *United Nations' 17 Sustainable Development Goals and the United Nations Global Compact*. Retrieved from: <https://sdgs.un.org/goals> [Accessed 24 July 2023].

Val, P.A., Regaliza, J.C.P. and Maraña, P.A., 2020. Quality in organizations: Its capacity for transformation to create sustainable value. *Economics and Business Letters*, [e-journal] 9(4), pp.306-316. DOI: 10.17811/ebl.9.4.2020.306-316.

Veselova, A., 2018. The assessment of European business excellence model criteria performance in Latvian enterprises. In: Latvia University of Life Sciences and Technologies, *Proceedings of the 2018 International Conference "Economic Science for Rural Development"*. Jelgava, Latvia. 9-11 May 2018. pp.409-418. DOI: 10.22616/ESRD.2018.112.

Vieira Nunhes, T., Espuny, M., Lauá Reis Campos, T., Santos, G., Bernardo, M. and Oliveira, O.J., 2022. Guidelines to build the bridge between sustainability and integrated management systems: A way to increase stakeholder engagement toward sustainable development. *Corporate Social Responsibility and Environmental Management*, [e-journal] 29(5), pp.1617-1635. DOI: 10.1002/csr.2308.

Vukomanovic, M., Radujkovic, M. and Nahod, M.M., 2014. EFQM excellence model as the TQM model of the construction industry of southeastern Europe. *Journal of Civil Engineering and Management*, [e-journal] 20(1), pp.70-81. DOI: 10.3846/13923730.2013.843582.

Wierzbic, A. and Martusewicz, J., 2022. The Evolution of the EFQM Model in the Context of Contemporary Challenges for Organizations. In: S. Khalid (eds.), 2019, *Vision 2025: Education Excellence and Management of Innovations through Sustainable Economic Competitive Advantage, Proceedings of the 34th International Business Information Management Association Conference (IBIMA).* International Business Information Management Association. Madrid, Spain. 13-14 November 2019. pp.11200-11209.

Yousaf, M. and Bris, P., 2020. A Systematic Literature Review of the EFQM Excellence Model from 1991 to 2019. *International Journal of Applied Research in Management and Economics*, 2(2), pp.11-15.

Yousaf, M., 2022a. Labour productivity and firm performance: evidence from certified firms from the EFQM excellence model. *Total Quality Management & Business Excellence*, [e-journal] 34(3-4), pp.312-325. DOI: 10.1080/14783363.2022.2054319.

Yousaf, M., 2022b. Working capital management efficiency: a study of certified firms from the EFQM excellence model. *Financial Internet Quarterly*, [e-journal] 18(3), pp.21-34. DOI: 10.2478/fiqf-2022-0017.

Yousaf, M., Bris, P. and Haider, I., 2021. Working capital management and firm's profitability: Evidence from Czech certified firms from the EFQM excellence model. *Cogent Economics and Finance*, [e-journal] 9(1). DOI: 10.1080/23322039.2021.1954318.

Yu, Z., Khan, S.A.R. and Umar, M., 2022. Circular economy practices and industry 4.0 technologies: A strategic move of automobile industry. *Business Strategy and the Environment*, [e-journal] 31(3), pp.796-809. DOI: 10.1002/bse.2918.

Yusof, S.M. and Aspinwall, E., 2000. Total quality management implementation frameworks: Comparison and review. *Total Quality Management*, [e-journal] 11(3), pp.281-294. DOI: 10.1080/0954412006801.

Zapletalová, Š., 2022. The business excellence models and business strategy. *Total Quality Management and Business Excellence*, [e-journal] 34(1-2), pp.131-147. DOI: 10.1080/14783363.2022.2033615.

Zgodavová, K., Bober, P., Majstorovic, V., Monkova, K., Santos, G. and Juhaszova, D., 2020. Innovative methods for small mixed batches production system improvement: The case of a bakery machine manufacturer. *Sustainability* (Switzerland), [e-journal] 12(15), 6266. DOI: 10.3390/su12156266.

Zgodavová, K., UrbanCíková, N. and Kisela, M., 2015. Enhancement of the quality assurance model at the Slovak University: Case study. *Quality Innovation Prosperity*, [e-journal] 19(2), pp.1-17. DOI: 10.12776/qip.v19i2.610.

Zhang, C., Chen, P. and Hao, Y., 2022. The impact of digital transformation on corporate sustainability- new evidence from Chinese listed companies. *Frontiers in Environmental Science*, 10, 14p. DOI: 10.3389/fenvs.2022.1047418.

ABOUT AUTHORS

José C. Sá[0000-0002-2228-5348] (J.C.S.) – Assist. Prof., School of Engineering at the Polytechnic of Porto and Researcher at Associate Laboratory for Energy, Transports and Aerospace (LAETA-INEGI), Porto, Portugal, e-mail: cvs@isep.ipp.pt.

Ana R. Oliveira[0009-0006-5059-9316] (A.R.O.) – Master Student, School of Engineering at the Polytechnic of Porto, Portugal, email: 1180734@isep.ipp.pt.

José Dinis-Carvalho[0000-0002-9724-0312] (J.D.C). – Assoc. Prof., the Production and Systems Department at the School of Engineering, University of Minho, Guimarães, Portugal, e-mail: dinis@dps.uminho.pt.

Gilberto Santos[0000-0001-9628-3272] (G.S.) – Dr.S., Prof., Design School at the Polytechnic Institute of Cávado Ave (IPCA) and Researcher at ID+, Campus do IPCA, Barcelos, Portugal, e-mail: gsantos@ipca.pt.

Francisco J.G. Silva[0000-0001-8570-4362] (F.J.G.S.) – Assoc. Prof., Polytechnic of Porto, Portugal, e-mail: fgs@isep.ipp.pt.

AUTHOR CONTRIBUTIONS

Conceptualization, J.C.S., A.R.O. and J.D.C; Methodology, J.C.S., A.R.O., J.D.C., G.S.; Validation, J.C.S., J.D.C., F.J.G.S. and G.S.; Formal analysis, J.C.S., A.R.O., F.J.G.S. and J.D.C.; Investigation, J.C.S., A.R.O., J.D.C. and G.S.; Resources, J.C.S., A.R.O. and J.D.C.; Data curation, J.C.S. and J.D.C.; Original draft preparation, J.C.S., A.R.O. and J.D.C.; Review and editing, J.C.S., J.D.C., F.J.G.S. and G.S.; Visualization, J.D.C. and F.J.G.S.; Supervision, J.D.C.

CONFLICTS OF INTEREST

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

2.6 Science Based Targets and the Factors Contributing to the Sustainable Development of an Organisation From a Literature Review to a Conceptual Model

A pressão crescente sobre as empresas para se alinharem com os objetivos da Conferência de Paris, centrados na sustentabilidade e na redução das emissões de gases com efeito de estufa, é cada vez maior. Por parte das organizações, tem existido um crescente esforço para desenvolverem objetivos sustentáveis e integrá-los nas suas cadeias de desenvolvimento sustentável. Têm surgido diversas iniciativas públicas e privadas com o objetivo de ajudarem as empresas a atingirem os seus objetivos de sustentabilidade.

Em 2015 surge a iniciativa dos *Science Based Targets* (SBT), os quais resultaram de uma colaboração entre o *World Wide Fund for Nature* (WWF), o *World Resources Institute* (WRI), o *United Nations Global Compact* (UNGC) e o *Carbon Disclosure Project* (CDP). O objetivo desta iniciativa (SBT) é estabelecer metas para a redução das emissões de gases com efeito de estufa, em conformidade com o que foi definido no Acordo de Paris, com o objetivo de limitar o aquecimento global a um aumento de temperatura inferior a 2°C acima dos níveis pré-industriais (Andersen et al., 2021).

No que se refere às organizações, estas não têm por hábito divulgarem os seus cálculos referentes aos seus objetivos de redução de emissões, os quais carecem de algum rigor científico. Existe a necessidade de uma maior transparência por parte das organizações para estas avaliarem de forma justa, as suas reduções de emissões e responsabilizá-las pelas suas ações em relação aos seus objetivos (Bjørn et al., 2023).

Ao longo dos últimos anos tem-se registado uma preocupação por parte das organizações, dado o número de empresas que estabelecem objetivos de emissão de carbono tem vindo a aumentar, com recurso aos objetivos de redução de emissões com base científica (SBT) (Bendig et al., 2023).

Com o objetivo de obter indicadores com base científica para os três pilares da sustentabilidade (TBL), foi publicado o artigo "*Science Based Targets and the Factors Contributing to the Sustainable Development of an Organisation From a Literature Review to a Conceptual Model*" (Sá et al., 2023). O propósito deste artigo é propor um conjunto de indicadores de base científica alargado aos 3 pilares da sustentabilidade (TBL). No que se refere ao pilar ambiental, este modelo propõe incluir mais 3 indicadores, para além do controlo das emissões de gases com efeito de estufa, por forma a consolidar este pilar, em que os objetivos baseados na ciência (SBT), fossem estabelecidos a partir dos objetivos das Nações Unidas (UN). No que se refere ao pilar social, o

modelo propõe que os objetivos baseados na ciência (SBT), sejam estabelecidos pela Organização Mundial de Saúde (WHO), já no que se refere ao pilar económico a proposta é que que este indicador sejam estabelecido por organizações financeiras reguladoras (Figura 21).

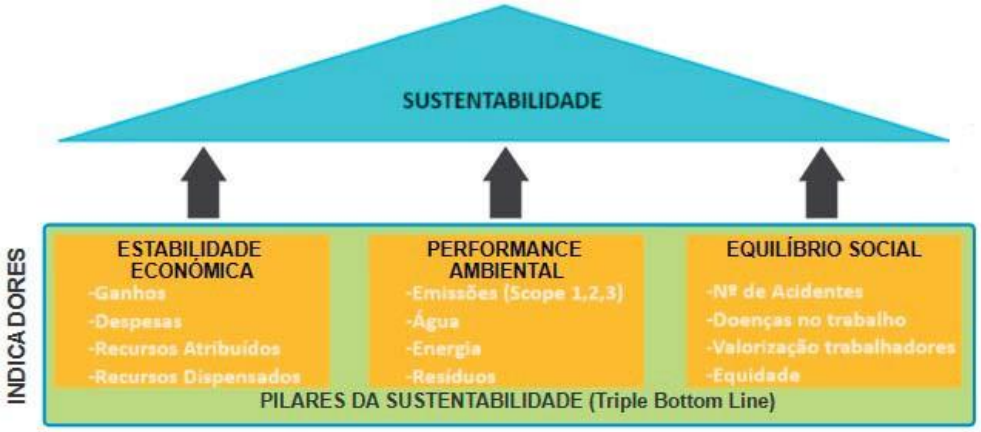


Figura 21 - Indicadores alargados dos Science Based Targets

PRODUCTION ENGINEERING ARCHIVES 2023, 29(3), 241-253

PRODUCTION ENGINEERING ARCHIVES

ISSN 2353-5156 (print)
ISSN 2353-7779 (online)

Exist since 4th quarter 2013
Available online at https://pea-journal.eu

Science Based Targets and the factors contributing to the sustainable development of an organisation from a Literature review to a conceptual model

José Carlos Sá[1*], Afonso Carvalho[1], Luís Fonseca[1], Gilberto Santos[2], José Dinis-Carvalho[3]

[1] School of Engineering - Polytechnic of Porto, Rua Dr. António Bernardino de Almeida, 431 - 4200-072 Porto, Portugal; cvs@isep.ipp.pt (JCS); 1180847@isep.ipp.pt (AC); lmf@isep.ipp.pt (LF)
[2] School of Design - Polytechnic Institute Cávado and Ave, Campus do IPCA - 4750-810 Barcelos, Portugal; gsantos@ipca.pt
[3] Production and Systems Department, University of Minho, Campus de Azurém, 4800-058 Guimarães, Portugal; dinis@dps.uminho.pt
*Correspondence: cvs@isep.ipp.pt

Article history
Received 11.04.2023
Accepted 10.07.2023
Available online 11.09.2023

Keywords
Sustainability
Lean
Green
Key Performance Indicators
Science Based Targets

Abstract
Sustainable development is a subject of intense discussion, mainly due to climate change, pollution, and increased waste, among other factors. The governments of various countries worldwide have been setting environmental targets for emissions and consumption to combat climate change and improve the state of our planet. Therefore, it is necessary to have an environmental policy with stakeholder engagement. The literature review method, bibliometric analysis, and visual mappings were applied to understand how these sustainable targets are formulated and used by companies to comply with the limits proposed by governments. The Web of Science platform allowed data collection about Lean and Green, Key Performance Indicators (KPI), and Science-Based Targets (SBT). The carried analyses identified the most relevant papers using the PRISMA method, including their authors, their temporal distribution, and a correlation map using the VOSviewer tool. Hence, mapping the current state of the art concerning the SBT topic. Furthermore, a novel conceptual model is proposed to integrate lean and green and create new KPI applied to the definition of SBT to give companies a path and tools to achieve the climate targets efficiently. Future research should focus on the implementation of the conceptual model in several companies to understand its impact to correct and improve the conceptual model proposed.

DOI: 10.30657/pea.2023.29.28

1. Introduction

In recent years the pressure to become more sustainable began to rise, mainly due to various environmental problems and the need to fight against the current climate crises. Governments of various countries around the world have been setting environmental targets and policies, to control the emissions and waste produced by companies in order to create a path for a sustainable future.

For this reason, the concept of Science Based Targets began to emerge. The Science Based Targets initiative (SBTi) is a collaboration between the Carbon Disclosure Project (CDP), the United Nations Global Compact (UNGC), the World Resources Institute (WRI) and the World Wide Fund for Nature (WWF), with the objective of giving companies and financial institutions a path of how quickly they need to reduce their greenhouse gas (GHG) emissions to prevent the worst effects of climate change (Bjorn et al., 2021).

However, the initiative is often questioned in the literature as there are few studies proving the effectiveness of SBTs in helping companies achieve their goals, stating that it needs improvement before being implemented on an even larger scale (Bjorn, et al., 2022; Giesekam et al., 2021).

The reduction of emissions is a central need in order to achieve sustainable development, however, just setting targets will not help companies to achieve this reality, it will be necessary a set of indicators that help measure the progress of the desired objective, and it is also necessary a set of tools to help companies to achieve these goals.

The aim of this article is to analyze the existing literature in order to understand which methodologies organizations use to define goals, which indicators are used to measure these goals,

and finally, which tools are used to achieve this goal. Through this information, a conceptual model that integrates these three aspects will be proposed in order to provide a clear path for companies to achieve their sustainable objectives.

2. Literature review

A literature review was made regarding the three central aspects of research:

- What tools organizations use to achieve sustainability?
- What are the indicators used to evaluate the progress of the organization?
- What is the methodology used to determine their sustainable objectives?

2.1. Lean and Green

An analysis of the literature allowed to conclude that the most widely used set of tools to enable companies to achieve better results is the lean methodology.

Lean, initially called Toyota Production System (TPS), was developed by Toyota to reduce and, if possible, eliminate activities that did not add value to the creation of a product to generate more value for the company and customers (Bhattacharya et al., 2019; Caldera et al., 2017; Dieste et al., 2019; Francis and Thomas, 2020; Varela et al., 2019).

Although there are cases where lean can be adapted to achieve "greener" objectives, many researchers suggest that lean practices have not yet reached this level of maturity(Abualfaraa et al., 2020). To solve this problem, it is necessary the complementation with green practices to achieve the objectives related to sustainability and give equal importance to the three pillars of the Triple-Bottom-Line (TBL) (Fig. 1) that are the bases of sustainable development in organizations (Abualfaraa et al., 2020; Henao et al., 2019; Kumar et al., 2016; Leon and Calvo-Amodio, 2017).

.

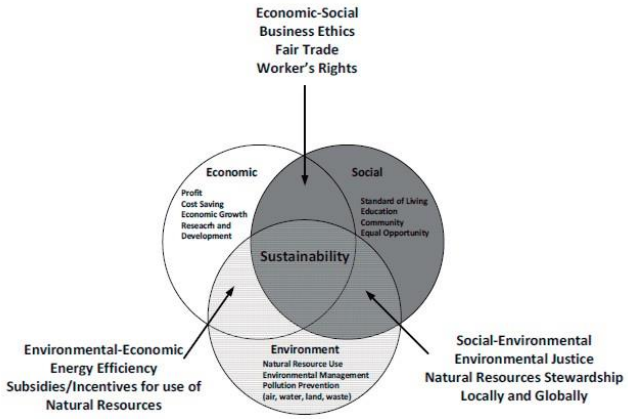


Fig. 1. Triple Bottom Line (Abualfaraa et al., 2020)

Green practices focus on reducing hazardous emissions, eliminating wasteful resource consumption, recycling, minimizing health risks throughout the manufacturing process, and minimizing the environmental footprint throughout the product life cycle.

The link between green and lean practices is the reduction of waste and everything that does not produce value to achieve better results at the business level, being green more focused on the environmental area and lean in the economic area (Abualfaraa et al., 2020; Dües et al., 2013).

In this context, it is practically unanimous among researchers and managers that neither lean nor green practices demonstrated to fully achieve the balance between economic, environmental, and social sectors when implemented individually (Cherrafi et al., 2016). Therefore, combining lean and green practices has been proposed to increase their strengths and mitigate their weaknesses to meet sustainability requirements (Abualfaraa et al., 2020; Cherrafi, Elfezazi, Govindan, et al., 2017; Souza Farias et al., 2019).

Although the integration of Lean and Green shows an increase in environmental and economic performance in companies, they do not seem to have much impact on the social aspect (Ciccullo et al., 2018; Jose Martinez-Jurado & Moyano-Fuentes, 2014), one of the pillars of sustainable development. This is due to the difficulty in implementing and measuring the improvement of social behaviours, being the implementation of social tools a possible object of study.

2.2. Key Performance Indicators

The importance of lean and green practices for the sustainable development of an organisation was previously mentioned. However, to measure current performance and formulate new methodologies to improve the company's activities continuously, it is necessary to measure the performance of organisations through KPI.

One of the problems with using KPI is, as can be observed in the literature, a need for KPI standardisation, mainly because of the wide range of indicators. For example, different KPI are used in finance, operations, and resource performance (e.g., water, energy, non-renewable resources, and waste). Given that KPI rely on industry type (Morella et al., 2020), regarding this information it is possible to create two solutions:

- Create a methodology that adapts to the different sectors
- Create a standard methodology that uses normalized KPI despite the sector

The most viable solution seems to combine the two options, use standard KPI to evaluate the sustainability of a certain company despite their sector, and use specific KPI to better evaluate companies from a specific sector.

The use of indicators is an important element in determining an organization's efficiency. However, nowadays, the air pollution is the most assessed criterion for sustainability, and others, such as water and energy consumption (Morella et al., 2020) and from the articles retrieved about KPI (Marotta et al., 2021; Matlock et al., 2021; Pignatelli et al., 2023), it is possible to conclude that the financial, and social aspects of sustainability are being overlooked, due to the current focus on the environmental policies. The financial KPIs because they are well established, and the social KPIs because it is difficult

to measure social stats, mainly due to them being more subjective and less quantifiable (von Geibler et al., 2006).

2.3. Science Based Targets

With the growing demand from companies to align themselves with the objectives of the Paris conference, there has been a need to set sustainability targets to control the level of emissions produced by companies. As a result, the private sector is increasingly seeking to develop targets and join the "mainstream" of sustainable development.

To define sustainability goals, several initiatives were created, both public and private, to help companies to fulfil the proposed sustainability goals. According to some studies (Faria and Labutong, 2020)) the use of platforms to control emission targets generates a win-win relationship between the commitment to reduce greenhouse gases and the company's financial performance. That is, reducing emissions without sacrificing the company's income is possible.

As referred in the introduction, the Science Based Targets initiative (SBTs), created in 2015, is a joint initiative between the World Wide Fund for Nature (WWF), the World Resources Institute (WRI), the United Nations Global Compact (UNGC) and the Carbon Disclosure Project (CDP) (Giesekam et al., 2021). The initiative consists of setting targets that reduce greenhouse gas (GHG) emissions to meet the measures proposed by the Paris agreement and to keep global warming below 2°C above pre-industrial levels (Giesekam et al., 2021). Its implementation impacted the sustainability theme, and since its foundation, an increasing number of companies have been setting environmental targets (Bjorn et al., 2021).

The environmental scopes (Fig. 2) are a crucial theme for the SBTi, as follows:

- Scope 1: Emissions directly produced by the company, resulting from its operations.
- Scope 2: Indirect emissions produced as a result of the company's energy consumption.
- Scope 3: missions which occur because of the organisation's activities, in sources which do not belong or are not controlled by the company, but rather in its supply chain.

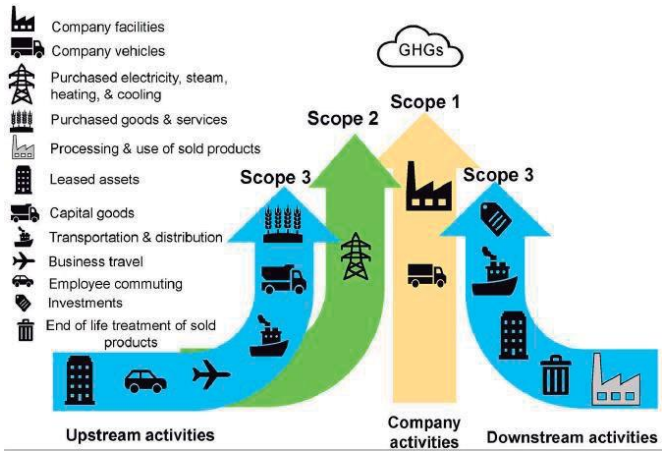


Fig. 2. Environmental scopes (Reavis et al., 2022)

This initiative has shown promising results regarding the definition of targets. Many companies, including large multinationals, have been joining this initiative to meet the conditions proposed by the Paris agreement (Bjorn et al., 2021). The following figure (Fig. 3) shows the increasing number of companies that have defined Science Based Targets. These targets are divided into three, the most conservative at 2°C and the most ambitious at 1.5°C, symbolizing the increase in global temperature since pre-industrial levels.

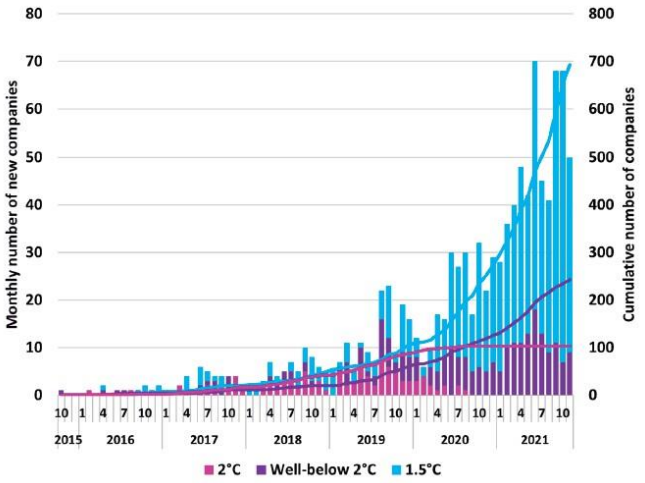


Fig. 3. Growth in adherence to SBTi (Bjorn et al., 2021)

3. Experimental

This study is supported by the literature review method, bibliometric analysis, and visual mappings. A Literature review aims to reflect the state of knowledge in a specific subject supported by a methodical behaviour (Tranfield et al., 2003) and supports the identification of the field's conceptual content and therefore contributes to theory development (Seuring and Müller, 2008). Furthermore, a Bibliometric analysis was applied to encompasses citation patterns and themes, highlighting the subject meaning and research activity and trends (Viglia et al., 2022). Adopting a rigorous methodological process of a Bibliometric literature review methodology with visual mappings (Such as Vos Viewer) contributes to a reliable review of the knowledge on the research subject and the related theory-practice gap. The visualizing similarities (VOS) approach provides a low-dimensional visualization in which objects are arranged in such a way that the distance between any pair of objects most accurately reflects their similarity (van Eck and Waltman, 2010). VOSviewer emphasises the graphical representation of bibliometric maps, consequently particularly helpful for illustrating large bibliometric maps in an easy-to-interpret way (Arici et al., 2022).

The present article research was carried out based on the information obtained from the databases of Web of Science (WoS), this is due to the following factors:

- Being an open access platform.
- Being easy to use.

- Allows the creation of lists in order to better organize the selected articles.
- Allows the analysis of the articles defined according to their specifications.
- Being a renowned platform used as a source of information by several scientific article writers.

For the selection method of the articles was used the PRISMA methodology (Moher et al., 2009).

3.1. Search Criteria

This present investigation was followed by the analysis of the topics related to the research questions asked before:

- What tools organizations use to achieve sustainability?
  Lean and green
- What are the indicators used to evaluate the progress of the organization?
  Key Performance Indicators
- What is the methodology used to determine their sustainable objectives?
  Science Based Targets

From each research question was selected a set of keywords and were applied different criteria according with the topic being researched.

1. Search by author keywords and by Topic.
   - Lean and Green and Literature Review (Topic).
   - Sustainab* and Key Performance Indicator* (Author Keyword).
   - Science Based Target* (Author Keyword).
2. Definition of search date.
   - Lean and Green and Literature Review (2010-2023).
   - Sustainab* and Key Performance Indicator* (2020-2023).
   - Science Based Target* (1900-2023).
3. Selection of articles belonging to journals in the Q1 or Q2 quartile.
4. Selection of the most cited articles in the Lean and Green theme (Top 50).

3.2. Research flowchart

A research flowchart (Fig. 4), based on the PRISMA methodology; was made to better understand the process of the selection of articles used in this literature review.

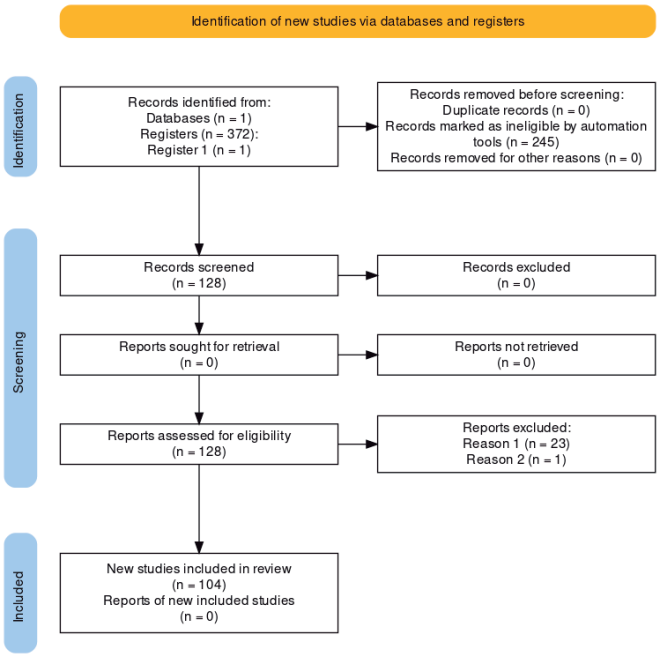


Fig. 4. PRISMA methodology (Haddaway et al., 2022)

From the 104 articles retrieved 27 were from Lean and Green, 51 from the Key Performance indicators and 26 fro7m the Science Based Targets. The table below (Table 1) indicates the quantity of the articles and the authors from each topic.

Table 1. Authors from the articles used in the literature review

Theme	Nº	Authors
Lean and Green	27	(Abualfaraa et al., 2020; Bhattacharya et al., 2019; Caldera et al., 2017; Cherrafi, Elfezazi, Garza-Reyes, et al., 2017; Cherrafi, Elfezazi, Govindan, et al., 2017; Cherrafi et al., 2016; Chugani et al., 2017; Ciccullo et al., 2018; Dhingra et al., 2014; Dieste et al., 2019; Dües et al., 2013; Francis and Thomas, 2020; Garza-Reyes, 2015a, 2015b; Hallam and Contreras, 2016; Henao et al., 2019; Johansson and Sundin, 2014; Jose Martinez-Jurado and Moyano-Fuentes, 2014; Khan et al., 2021; Kumar et al., 2016; Leon and Calvo-Amodio, 2017; Mollenkopf et al., 2010; Sangwa and Sangwan, 2018; Sharma et al., 2021; Siegel et al., 2019; Souza Farias et al., 2019; Varela et al., 2019)
KPI	51	(Becchetti et al., 2022; Cipolletta et al., 2022; Contini and Peruzzini, 2022; Cooper et al., 2020; de Bortoli et al., 2022; Egas et al., 2021; Gackowiec et al., 2020; Goncalves and Silva, 2021; Govindan et al., 2021; Gunduz and Abu-Hijleh, 2020; Gunduz and Lutfi, 2021; Guo and Wu, n.d.; Hristov et al., 2022; Janjua et al., 2020, 2021; Karahasanovic et al., 2020; Karnitis et al., 2021; Kassem and Trenz, 2020; Ma et al., 2020; Marotta et al., 2021; Marrucci and Daddi, 2022; Matlock et al., 2021; Matos et al., 2021; McGinley et al., 2022; Moktadir et al., 2021, 2020; Molavi et al., 2020; Morella et al., 2020, 2022; Mosca and Perini, 2022; K. Naji et al., 2021; K. K. Naji, Gunduz, and Hamaidi, 2022; K. K. Naji, Gunduz, and Naser, 2022; Nawaz et al., 2020; Othman et al., 2022; Patidar et al., n.d.; Patil and Javalagi, 2020; Patrao et al., 2020; Perroni et al., 2020; Pignatelli et al., 2023; Pribicevic and Delibasic, 2021; Radovanovic et al., 2020; Rahman et al., 2022; Romeni et al., 2020; Schipper et al., 2021; Sun and Ertz, 2021; Torabizadeh et al., 2020; Voukkali et al., 2021; Walkiewicz et al., 2021; Yilan et al., 2022; Zaripov et al., 2021)
SBT	26	(Ayoub et al., 2020; Bendig et al., 2022; Bjorn et al., 2017, 2019, 2021; Bjorn, Lloyd, et al., 2022; Bjorn, Tilsted, et al., 2022; Bringezu, 2019; Chang et al., 2022; de Silva et al., 2019; Ermgassen et al., 2022; Faria and Labutong, 2020; Feleki and Moussiopoulos, 2021; Gibassier et al., 2020; Giesekam et al., 2018, 2021; Hadziosmanovic et al., 2022; Hart et al., 2020; Immink et al., 2022; Kuo and Chang, 2021; O'Flynn et al., 2021; Reavis et al., 2022; Spanner and Wein, 2020; Stoknes and Rockstrom, 2018; Walenta, 2020; Watari et al., 2021)

4. Results and discussion

According to the data retrieved from WoS, it was identified that the topics being studied are relatively new. The articles related to the Lean, Green and Key Performance indicators have diversified dates, mainly because these are themes being studied for a while. However, articles related to the Science Based targets are very scarce because they are a recent tool that many people, companies and governments need to be aware of. Two analyses were made:

- A global analysis that contains the distribution of citations, journals, and articles, as well as VOS viewer study.
- An analysis made on the current state of the art of the Science Based Targets theme, where will be studied the contents of all articles that have this theme in their keywords, and it will be analysed the distribution per country and per sector of the companies that are aligned with this initiative.

4.1. Global analyses

As for average citations (Blue line), and publications (Purple columns) per year, as indicate in (Fig. 5), it can be verified increase in recent times, showing that these topics will continue to grow in the coming years.

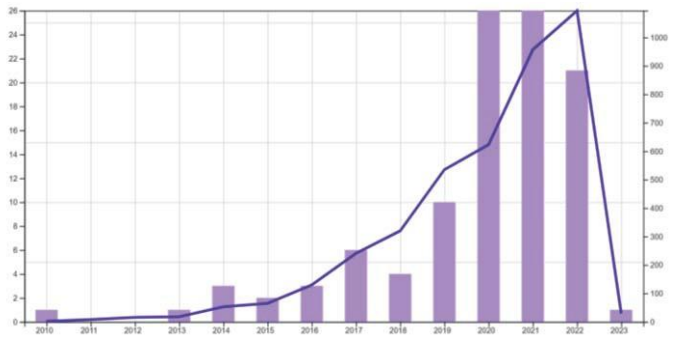


Fig. 5. Publications and Citations of the article searched

As for the journal where more articles were published (Fig. 6), the Journal of Cleaner Production was the most recurrent, followed by the Sustainability journal. Furthermore, it should be mentioned that the column designated as "Others" represents journals that had only one publication.

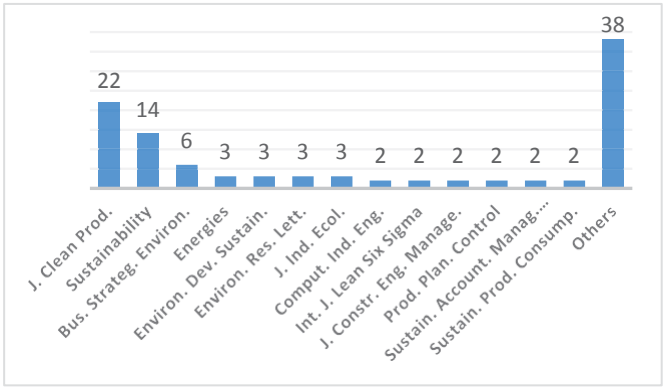


Fig. 6. Journal distribution

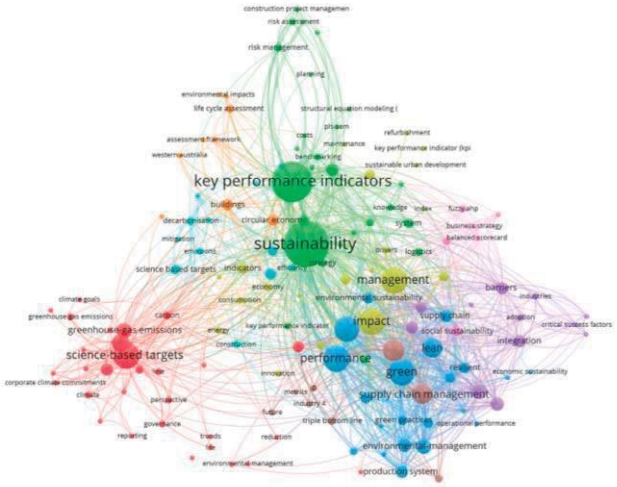


Fig. 7. VOS viewer analyses

To study the connection and junction between the different articles, an analysis was performed using the VOSviewer tool (Fig. 7). For this the keywords that appeared at least twice in each article were considered. After performing the analysis, it was possible to conclude that the main clusters represented in green, which mainly address the sustainability and KPI categories, and the cluster represented in red, which addresses the Science Based Targets, as well as other themes related to this topic.

Next, the keywords with the most occurrences and their respective link strength were mentioned (Table 2).

Table 2. VOS viewer keyword strength

Keywords	Occurrences	Strength
sustainability	20	289
impact	20	182
performance	20	180
green	20	180
model	19	169
management	20	155
key performance indicators	36	148
framework	15	138
supply chain management	13	128
lean	13	123
6 sigma	9	91
science-based targets	20	90
environmental-management	9	88
operations	8	88
implementation	8	81
production system	7	74
integration	7	72
resilient	6	72
supply chain	7	70
barriers	7	64
sustainable development	7	62
literature review	6	60
climate change	11	59
agile	5	58
systematic literature review	5	57
social sustainability	5	56
environmental performance	6	55
design	6	52

Keywords	Occurrences	Strength
decision-making	7	51
environmental sustainability	6	51
green practices	5	51
eco-efficiency	4	47
environment	5	47
strategies	5	47
corporate social-responsibility	6	46
greenhouse-gas emissions	9	45
methodology	4	44
optimization	5	44
circular economy	6	42

4.2. SBT Analysis

In this section, the publications retrieved have been summarised (Table 3) to better understand their contribution to the SBT theme.

Table 3. SBTi articles summary

Authors	Field	Summary
(Bjorn et al., 2017)	Theorical	Study conducted to analyse the ecological limits presented in the sustainability reports of various companies, 40000 reports of 12000 companies from 2000 to 2014 were analysed.
(Stoknes and Rockstrom, 2018)	Theorical	Study looking at sustainable growth in the Nordic countries.
(de Silva et al., 2019)	Theorical	Article that analyses the indicators used by companies at the level of biodiversity, checking whether they are in fact based on scientific data.
(Bjorn et al., 2019)	Theorical	Definition of a methodology for applying absolute environmental targets (EASA) to companies
(Giesekam et al., 2018)	Construction	Study of the impact of sustainable methodologies in the UK construction sector
(Walenta, 2020)	Theorical	Article that analyses the implementation of environmental methodologies in the private sector, more specifically the SBTi
(Giesekam et al., 2021)	Theorical	Article that verifies if the Science Based Targets initiative is actually beneficial for companies. It concludes that most companies meet their sustainability targets, however most of these targets are short term, with few companies making a long term commitment.
(Bjorn et al., 2021)	Theorical	Through the application of the 7 SBTi methodologies, a study was carried out aiming at the efficiency of each methodology. For the experimental calculation 8 fictitious companies were created whose data would enter in the calculation of the result of the targets. They concluded that the best possible methods were the SDA and the CSO, but they pointed out that there was still a lot of research to be done in this area, including the need to carry out this study on a large group of real companies.
(Faria and Labutong, 2020)	Theorical/ Energy	Study that analyses four methodologies belonging to SBTi. They are subsequently applied based on the data of a company (EDP) and the benefits and limitations of each tool are assessed.
(Hart et al., 2020)	Food Industry	An innovative methodology was presented to help the food industry make its operations more sustainable through better management of refrigeration systems. Refrigeration systems were chosen for optimisation as refrigerant leakage is the second largest source of carbon emissions in the UK food industry.
(Ayoub et al., 2020)	Commerce	Modelling a sustainable framework to reduce the carbon footprint of commercial industries at low cost by installing low carbon technologies such as biomethane engines and photovoltaic systems. Two KPIs were defined, CAPEX for capital expenditure and OPEX for operating expenses and reduced carbon emissions. The methodology was applied to 60 companies of this sector in the United Kingdom, and they concluded that if the measures were implemented and considering normal conditions in the next years, several environmental targets would be met in the year 2030.
(Gibassier et al., 2020)	Theorical	Article based on a review of the current literature on climate change and carbon accounting. Based on the research prepared the authors proposed four possible avenues for future research, these being: climate change as a systemic and social problem, the multi-layered transition apparatus for climate change, climate vulnerability and the future of carbon accounting.
(Bringezu, 2019)	Theorical	Discusses the key aspects to consider in the sustainable consumption of resources. It states that consumption of available resources must meet basic human needs but must not exceed planetary limits. It also states that in order to assess and make decisions related to sustainability, it is necessary to monitor current impacts using indicators based on current science and knowledge.
(Watari et al., 2021	Metallomechanics	Article describing the metalworking industry today and how important it is to improve the sustainability of this sector, based on scientifically based objectives. A methodology was elaborated that relates the production of

Authors	Field	Summary
		metals and their emissions with SBTi in order to reach the imposed climate limits. The study was carried out in the industries of the 6 most used metals (Iron, Aluminium, Copper, Zinc, Lead and Nickel) representing, by mass, about 98% of all metal production in the United States.
Kuo and Chang, 2021)	Multisectorial	A study of the impact of Science Based Targets (SBT), Internal Carbon Pricing (ICP) and Carbon Management Reputation (CMR) on companies in Japan. 1,994 companies were analysed over the period 2016-2019. It was concluded that companies using SBTs and ICP show better CMR, with greater contribution to companies' environmental reputation coming from SBTs.
(Bjorn, Tilsted, et al., 2022)	Theorical	Literature review about SBT. The number of companies that adhered to the initiative is analysed as well as its distribution by region and by sector. During the review three aspects are analysed: what motivates companies to define SBTs; are SBTs sufficient to meet the Paris agreement; will voluntary adherence to SBTi continue to grow. The study answers these questions by saying that the companies most likely to join are large organisations, because they suffer more pressure from their stakeholders and use the SBTi as a way to improve their environmental reputation. It states that 42% of the targets are behind schedule 49% are ahead of schedule and 9% are completed, and SBTi is a good platform to meet the conditions of the Paris agreement. Finally, according to the data analysed, adherence to the initiative will grow continuously in the coming years.
(Feleki and Moussiopoulos, 2021)	Urban	Article that develops a methodology to guide cities towards a greener and more sustainable development. The methodology aims to limit GHG emissions in cities located in the Mediterranean, because according to the analysis carried out by the study, the Mediterranean region heats up 20% more than the global average, being an area of high risk regarding environmental disasters. In order to achieve the target of 1.5ºC to stabilize the sea level.
(Spanner and Wein, 2020)	Real Estate	The objective of the study is to verify if the CRREM (Carbon Risk Real Estate Monitor) tool is efficient when it comes to measuring and evaluating the sustainability of companies belonging to the real estate sector. It was concluded that the CRREM tool is very useful in this area because it is the first and only one that provides specific targets according to the location and type of property, and besides measuring emissions and assessing risks it also provides a guide on how to reduce these emissions. These features of the tool are very positive because they are presented in an intuitive way and also combats the lack of transparency evidenced in other tools.
(Ermgassen et al., 2022)	Theorical	Article that assesses the definition of the word nature-positive, highlighting the differences proposed by each organisation. Subsequently, four elements that serve as a basis for the definition of a nature-positive strategy are addressed. It was concluded that from 2016 until 2021 several companies have adopted SMART (Specific, Measurable, Accepted, Realistic, and Time-bound) targets regarding biodiversity and nature.
(Bendig et al., 2022)	Multisectorial	Study of the impact of SBTs on the financial performance of corporations, where they check whether or not it pays to go green. Hypotheses were developed that evaluated the relationship between the following components: CCP (Corporate Carbon Performance), CFP (Corporate Financial Performance) and the CEP (Corporate Environmental Performance). It was concluded that companies that belong to the SBT achieve a positive relationship between CCP and CFP, and that in general it pays to be "green", supporting the hypothesis of a win-win relationship between the economic and environmental levels.
(Hadzi-osmanovic et al., 2022)	Theorical	The article presents an alternative approach to the SBT initiative, based on the cumulative allocation of carbon emissions in order to determine future budgets and limits regarding this issue. It also states that regardless of the approach selected by companies, it is necessary to mitigate the carbon footprint in order to reverse the effects caused by climate change.
(Bjorn, Lloyd, et al., 2022)	Theorical	Article that talks about a comment made by the Science Based Targets initiative to the article (Bjorn et al., 2021), written by the same author. The article responds to some criticism made by the initiative and also mentions that there is a great need for research on the topic of SBT.
(Chang et al., 2022)	Theorical	Study based on the response to the SBT initiative regarding the article (Bjorn et al., 2021), where the 7

Authors	Field	Summary
		methodologies used by SBT were analysed in more detail.
(Reavis et al., 2022)	Food Industry	Study that assesses the emissions produced by the food industry and ways to mitigate them. The sustainability reports and reports to the CDP (Carbon Disclosure Project) of the top 100 companies in the food sector were assessed. They found that despite the number of companies reporting and defining their GHG emissions, 31 of the companies analysed do not have any climate targets.
(Immink et al., 2022)	Theorical	Study of the impact of SBTs on businesses.
(O'Flynn et al., 2021)	Universities	Article written from the perspective of a UK university, where a study is conducted on the incorporation of SBT in medium-sized companies and universities in order to achieve a path to zero emissions. A plan was drawn up to meet environmental targets, consisting of using renewable energy on and off campus, reducing energy consumption through more efficient equipment. It was also mentioned that it is important that organisations calculate all scopes one, two and three and report them properly.

4.3. SBT Distribution

The distribution of the companies that defined SBTi targets is also relevant because it allows a better analysis of which country regions are more likely to join the initiative. Organizations with targets are the ones with objectives defined and verified by the SBTi, while committed organizations don't have a target set but are in the process of having.

It was observed that more than half of the companies that joined the initiative are based in Europe, (Fig. 8 and Fig. 9) which is the leading region, with most of the companies coming from the United Kingdom, followed by North America, whose principal and almost absolute contributor is the United States of America, followed by Asia, with the primary representative in the initiative being Japan.

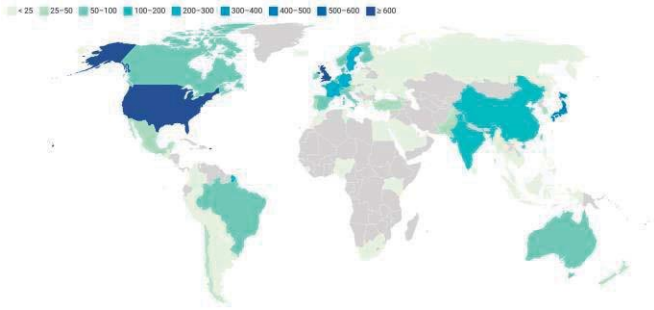


Fig. 8. Organizations committed to the SBTi (per country)

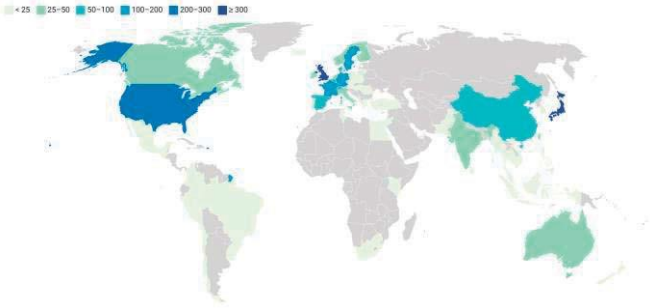


Fig. 9. Organizations wits SBTi targets (per country)

In addition to analysing the number of companies that adhered to the initiative and its distribution, it is also necessary to observe the main sectors of the companies that adhere to SBTi. Hence, the companies that adhere more to the initiative are companies from the "Food Industry" and "Professional Services".

In the following images (Fig. 10 and Fig. 11), we can see the top10 sectors of the organizations committed, and with SBTi targets.

Fig. 10. Organizations committed to the SBTi (per sector)

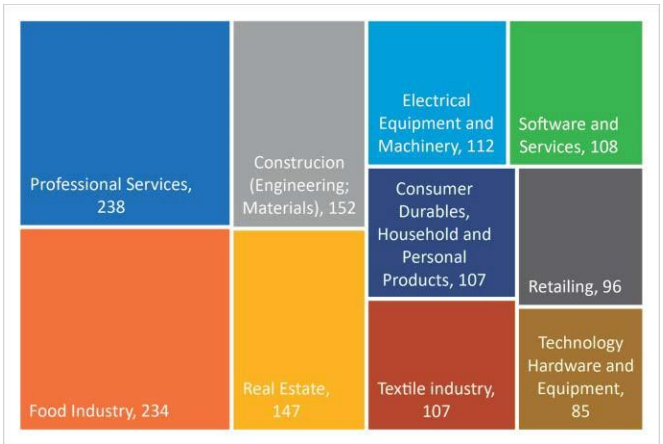


Fig. 11. Organizations wits SBTi targets (per sector)

4.3. Conceptual model formulation

Based on the literature review, it was possible to observe the defects and qualities of the SBT model, and the possible integration of lean, green and KPI concepts in its model. The main contents that were addressed in this article in order to create a new model are:

- Lean and Green are great tools to use to increase a company's environmental and economic performance, however, lacks in the social aspect.
- The use of KPI to evaluate a company's performance is good, however it has two great problems: The lack of standardization and the primary focus on GHG emissions , which is important, yet the other environmental KPI aren't used as much and the social KPI are being somewhat neglected.
- The SBT initiative is a good organization to help the companies to achieve their sustainable targets but can be confusing and non-transparent, since there is not much information available on their platform about the methodologies, they use to set sustainable objectives.

Considering the above statements, a conceptual model was developed taking in regard these concerns. First, since the lean and green tools are well known and already verified in terms of efficiency, it isn't necessary to reformulate them. Second, one of the problems of the KPI usage is their difference between different organizations, so it was proposed a set of 12 base KPI (Fig. 12) that will be used by all organizations despite their sector.

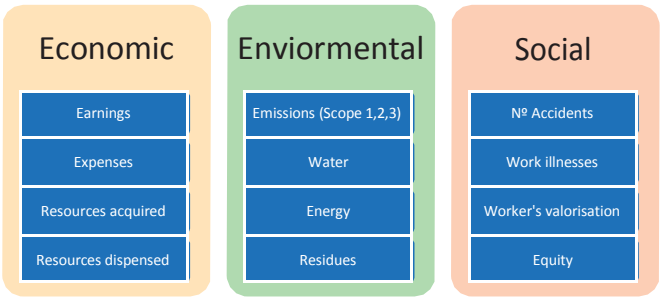


Fig. 12. Base KPI

After having analysed the base KPI, the model proposes an implementation and measurement methodology that companies can take in order to achieve sustainable development. The following figure (Fig. 13) describes the steps to be followed to achieve the proposed methodology.

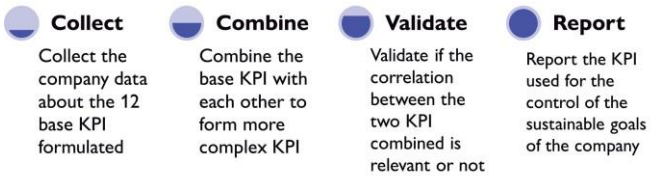


Fig. 13. Methodology for the use of KPI

Considering the above statements, a conceptual model was developed (Fig. 14) to create a future methodology to correct the current methods' problems.

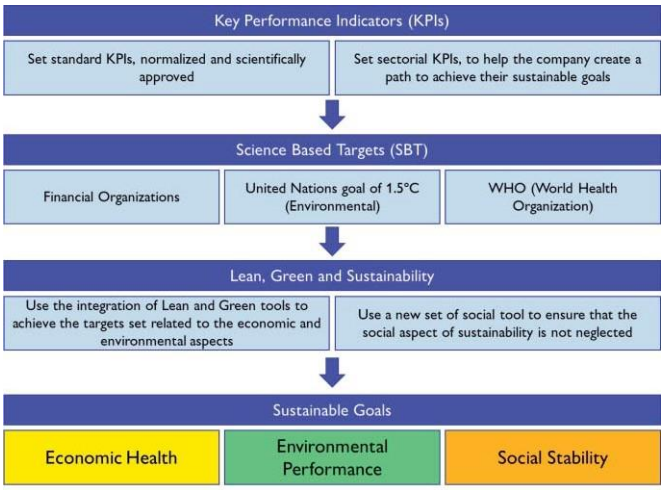


Fig. 14. Conceptual model

The conceptual model presented in this paper presents four stages:

- First stage: Use of standardised KPIs so that companies can fairly compare their results with each other. Use of sectorial KPIs so as to give more relevant ways of measuring each company's sector of activity.
- Second stage: Use the previously defined KPIs to create science-based targets, based on the main regulatory institutions for each pillar of sustainable development.
- Third stage: Use Lean and Green tools, and a new set of social tools, in order to achieve the objectives previously proposed.
- Fourth stage: Fulfilling the objectives proposed in the three areas of sustainability.

The following figure is a simplification of the conceptual model developed (Fig. 15), showing the four different stages very clearly.

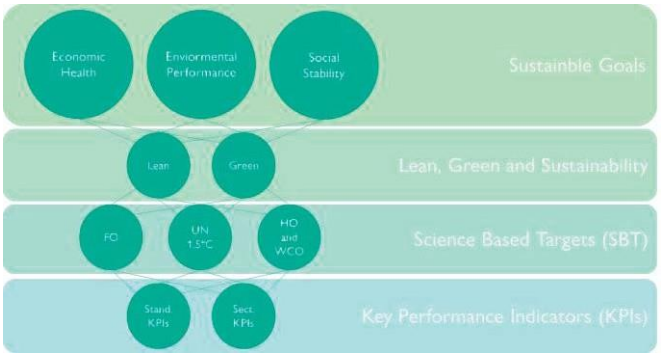


Fig. 15. Simplified conceptual model

*FO: Financial Organizations

*UN: United Nations 1.5º Objective

*HO and WCO: Health Organizations and Workers Conditions Organizations

5. Summary and conclusion

The bibliometric analysis performed in this work, according to the data of the WoS platform, allowed us to understand the similarities between Lean, Green, KPIs and Science Based Targets. This analysis also involved the draft of a map of clusters, using the VOSviewer tool, based on the connection among keywords, which allowed to capture of the connections of the themes studied.

This research is supported by a bibliometric analysis and a literature review on lean, green, KPI and Science Based Targets. This involved evaluating the targeted literature, regarding their publishing year and their annual average citations, drafting a map to observe an underlying intellectual structure, reviewing the current state of the SBT in the literature, pinpointing the most relevant publications and their categorization according to three topics in order to be developed a conceptual model formed by the integration of Lean and Green, Key Performance Indicators, and Science Based Targets following a sequential plan of action for implementation in companies to achieve their sustainable goals.

From the analysis made in the literature review it was possible to answer the proposed research questions:

- RQ1: What tools organizations use to achieve sustainability?

Yes, the use of the Lean and Green set of tools help the corporations to achieve better results when applicated isolated, but when combined they can produce even better results. Although Lean and Green help to contribute to the sustainable development of organizations, in the economic and in the environmental area, the social sustainable pilar appear to be left out.

- RQ2: What are the indicators used to evaluate the progress of the organization?

The companies use a different set of KPI, being this one problem because if everybody uses their indicators, it is difficult to compare results between companies. It was also observed that the environmental indicators are exponentially rising in recent years and that the indicators that are used more are relates to GHG emissions.

- RQ3: What is the methodology used to determine their sustainable objectives?

The Science Based Target initiative are helping companies to meet their objectives and become more sustainable; however, their methodologies need to be refined so that they can be used by all types of companies from all types of sectors, and the conceptual model proposed is intended to help in the search for improvement of their method.

These analyses allowed to better understand the current state about the SBT topic, by reviewing all the current articles that include this topic in their paper keywords.

It was also made a conceptual model that can be used to implement a sustainable methodology for companies to achieve their goals.

A future research direction would be to test the validity of the conceptual model produced, either by questionnaire to companies or by implementation in the companies themselves.

Acknowledgements

This paper is based on the results of the master's graduate dissertation developed by the authors during the academic years.

Reference

Abualfaraa, W., Salonitis, K., A-Ashaab, A., Ala'raj, M., 2020. Lean-Green Manufacturing Practices and Their Link with Sustainability: A Critical Review. Sustainability, 12(3), DOI: 10.3390/su12030981

Arici, H. E., Köseoglu, M. A., Sökmen, A., 2022. The intellectual structure of customer experience research in service scholarship: a bibliometric analysis. Service Industries Journal, 42(7–8), 514–550, DOI: 10.1080/02642069.2022.2043286

Ayoub, A. N., Gaigneux, A., Le Brun, N., Acha, S., Shah, N., 2020. The development of a low-carbon roadmap investment strategy to reach Science Based Targets for commercial organisations with multisite properties. Building And Environment, 186, DOI: 10.1016/j.buildenv.2020.107311

Becchetti, L., Cordella, M., Morone, P., 2022. Measuring investments progress in ecological transition: The Green Investment Financial Tool (GIFT) approach. Journal of Cleaner Production, 357, DOI: 10.1016/j.jclepro.2022.131915

Bendig, D., Wagner, A., Lau, K., 2022. Does it pay to be science-based green? The impact of science-based emission-reduction targets on corporate financial performance. Journal of Industrial Ecology, DOI: 10.1111/jiec.13341

Bhattacharya, A., Nand, A., Castka, P., 2019. Lean-green integration and its impact on sustainability performance: A critical review. Journal of Cleaner Production, 236, DOI: 10.1016/j.jclepro.2019.117697

Bjorn, A., Bey, N., Georg, S., Ropke, I., Hauschild, M. Z., 2017. Is Earth recognized as a finite system in corporate responsibility reporting? Journal of Cleaner Production, 163, 106–117, DOI: 10.1016/j.jclepro.2015.12.095

Bjorn, A., Lloyd, S., Matthews, D., 2021. From the Paris Agreement to corporate climate commitments: evaluation of seven methods for setting `science-based' emission targets. Environmental Research Letters, 16(5), DOI: 10.1088/1748-9326/abe57b

Bjorn, A., Lloyd, S., Matthews, D., 2022. Reply to Comment on `From the Paris Agreement to corporate climate commitments: evaluation of seven methods for setting ``science-based'' emission targets'. Environmental Research Letters, 17(3), DOI: 10.1088/1748-9326/ac548e

Bjorn, A., Richardson, K., Hauschild, M. Z., 2019. A Framework for Development and Communication of Absolute Environmental Sustainability Assessment Methods. Journal of Industrial Ecology, 23(4), 838–854, DOI: 10.1111/jiec.12820

Bjorn, A., Tilsted, J. P., Addas, A., Lloyd, S. M., 2022. Can Science-Based Targets Make the Private Sector Paris-Aligned? A Review of the Emerging Evidence. Current Climate Change Reports, 8(2), 53–69, DOI: 10.1007/s40641-022-00182-w

Bringezu, S., 2019. Toward Science-Based and Knowledge-Based Targets for Global Sustainable Resource Use. Resources-Basel, 8(3), DOI: 10.3390/resources8030140

Caldera, H. T. S., Desha, C., Dawes, L., 2017. Exploring the role of lean thinking in sustainable business practice: A systematic literature review. Journal of Cleaner Production, 167, 1546–1565, DOI: 10.1016/j.jclepro.2017.05.126

Chang, A., Farsan, A., Carrillo Pineda, A., Cummis, C., Weber, C., 2022. Comment on `From the Paris Agreement to corporate climate commitments: evaluation of seven methods for setting ``science-based'' emission targets' Comment. Environmental Research Letters, 17(3), DOI: 10.1088/1748-9326/ac548c

Cherrafi, A., Elfezazi, S., Chiarini, A., Mokhlis, A., Benhida, K., 2016. The integration of lean manufacturing, Six Sigma and sustainability: A literature review and future research directions for developing a specific model. Journal of Cleaner Production, 139, 828–846, DOI: 10.1016/j.jclepro.2016.08.101

Cherrafi, A., Elfezazi, S., Garza-Reyes, J. A., Benhida, K., Mokhlis, A., 2017. Barriers in Green Lean implementation: a combined systematic literature review and interpretive structural modelling approach. Production Planning & Control, 28(10), 829–842, DOI: 10.1080/09537287.2017.1324184

Cherrafi, A., Elfezazi, S., Govindan, K., Garza-Reyes, J. A., Benhida, K., Mokhlis, A., 2017. A framework for the integration of Green and Lean Six Sigma for superior sustainability performance. International Journal of Production Research, 55(15), 4481–4515, DOI: 10.1080/00207543.2016.1266406

Chugani, N., Kumar, V., Garza-Reyes, J. A., Rocha-Lona, L., Upadhyay, A., 2017. Investigating the green impact of Lean, Six Sigma and Lean Six Sigma. International Journal of Lean Six Sigma, 8(1, SI), 7–32, DOI: 10.1108/IJLSS-11-2015-0043

Ciccullo, F., Pero, M., Caridi, M., Gosling, J., Purvis, L., 2018. Integrating the environmental and social sustainability pillars into the lean and agile supply chain management paradigms: A literature review and future research directions. Journal of Cleaner Production, 172, 2336–2350, DOI: 10.1016/j.jclepro.2017.11.176

Cipolletta, M., D'Ambrosio, M., Moreno Valeria Casson and Cozzani, V., 2022. Enhancing the sustainability of biodiesel fuels by inherently safer production processes. Journal of Cleaner Production, 344, DOI: 10.1016/j.jclepro.2022.131075

Contini, G., Peruzzini, M., 2022. Sustainability and Industry 4.0: Definition of a Set of Key Performance Indicators for Manufacturing Companies. Sustainability, 14(17), DOI: 10.3390/su141711004

Cooper, J., Lee, A., Jones, K., 2020. Sustainable built asset management performance indicators and attributes A UK social housing case study example. International Journal of Building Pathology and Adaptation, 38(3), 508–522, DOI: 10.1108/IJBPA-08-2019-0069

de Bortoli, A., Feraille, A., Leurent, F., 2022. Towards Road Sustainability-Part II: Applied Holistic Assessment and Lessons Learned from French Highway Resurfacing Strategies. Sustainability, 14(12), DOI: 10.3390/su14127336

de Silva, G. C., Regan, E. C., Pollard, E. H. B., Addison, P. F. E., 2019. The evolution of corporate no net loss and net positive impact biodiversity commitments: Understanding appetite and addressing challenges. Business Strategy And The Environment, 28(7), 1481–1495, DOI: 10.1002/bse.2379

Dhingra, R., Kress, R., Upreti, G., 2014. Does lean mean green? Journal of Cleaner Production, 85, 1–7, DOI: 10.1016/j.jclepro.2014.10.032

Dieste, M., Panizzolo, R., Garza-Reyes, J. A., Anosike, A., 2019. The relationship between lean and environmental performance: Practices and measures. Journal of Cleaner Production, 224, 120–131, DOI: 10.1016/j.jclepro.2019.03.243

Dües, C. M., Tan, K. H., Lim, M., 2013. Green as the new Lean: how to use Lean practices as a catalyst to greening your supply chain. Journal of Cleaner Production, 40, 93–100, DOI: 10.1016/J.JCLEPRO.2011.12.023

Egas, D., Ponsa, S., Llenas, L., Colon, J., 2021. Towards energy-efficient small dairy production systems: An environmental and economic assessment. Sustainable Production And Consumption, 28, 39–51, DOI: 10.1016/j.spc.2021.03.021

Ermgassen, S. O. S. E. Z., Howard, M., Bennun, L., Addison, P. F. E., Bull, J. W., Loveridge, R., Pollard, E., Starkey, M., 2022. Are corporate biodiversity commitments consistent with delivering `nature-positive' outcomes? A review of `nature-positive' definitions, company progress and challenges. Journal of Cleaner Production, 379(2), DOI: 10.1016/j.jclepro.2022.134798

Faria, P. C. S., Labutong, N., 2020. A description of four science-based corporate GHG target-setting methods. Sustainability Accounting Management And Policy Journal, 11(3, SI), 591–612, DOI: 10.1108/SAMPJ-03-2017-0031

Feleki, E., Moussiopoulos, N., 2021. Setting Emission Reduction Trajectories in Mediterranean Cities with the Use of Science-Based Targets: The Pathway towards Climate Neutrality and the Ambitious European Goals by 2050. ATMOSPHERE, 12(11), DOI: 10.3390/atmos12111505

Francis, A., Thomas, A., 2020. Exploring the relationship between lean construction and environmental sustainability: A review of existing literature to decipher broader dimensions. Journal of Cleaner Production, 252, DOI: 10.1016/j.jclepro.2019.119913

Gackowiec, P., Podobinska-Staniec, M., Brzychczy Edyta and Kuhlbach, C., Oezver, T., 2020. Review of Key Performance Indicators for Process Monitoring in the Mining Industry. Energies, 13(19), DOI: 10.3390/en13195169

Garza-Reyes, J. A., 2015a. Green lean and the need for Six Sigma. International Journal Of Lean Six Sigma, 6(3), 226–248, DOI: 10.1108/IJLSS-04-2014-0010

Garza-Reyes, J. A., 2015b. Lean and green - a systematic review of the state of the art literature. Journal of Cleaner Production, 102, 18–29, DOI: 10.1016/j.jclepro.2015.04.064

Gibassier, D., Michelon, G., Cartel, M., 2020. The future of carbon accounting research: ``we've pissed mother nature off, big time''. Sustainability Accounting Management And Policy Journal, 11(3, SI), 477–485, DOI: 10.1108/SAMPJ-02-2020-0028

Giesekam, J., Norman, J., Garvey, A., Betts-Davies, S., 2021. Science-Based Targets: On Target? Sustainability, 13(4), Doi: 10.3390/Su13041657

Giesekam, J., Tingley, D. D., Cotton, I., 2018. Aligning carbon targets for construction with (inter)national climate change mitigation commitments. Energy And Buildings, 165, 106–117, DOI: 10.1016/j.enbuild.2018.01.023

Goncalves, A., Silva, C., 2021. Looking for Sustainability Scoring in Apparel: A Review on Environmental Footprint, Social Impacts and Transparency. ENERGIES, 14(11), DOI: 10.3390/en14113032

Govindan, K., Aditi, Darbari, J. D., Kaul Arshia and Jha, P. C., 2021. Structural model for analysis of key performance indicators for sustainable manufacturer-supplier collaboration: A grey-decision-making trial and evaluation laboratory-based approach. Business Strategy And The Environment, 30(4), 1702–1722, DOI: 10.1002/bse.2703

Gunduz, M., Abu-Hijleh, A., 2020. Assessment of Human Productivity Drivers for Construction Labor through Importance Rating and Risk Mapping. Sustainability, 12(20), DOI: 10.3390/su12208614

Gunduz, M., Lutfi, H. M. A., 2021. Go/No-Go Decision Model for Owners Using Exhaustive CHAID and QUEST Decision Tree Algorithms. Sustainability, 13(2), DOI: 10.3390/su13020815

Guo, R., Wu, Z., n.d.. Social sustainable supply chain performance assessment using hybrid fuzzy-AHP-DEMATEL-VIKOR: a case study in manufacturing enterprises. Environment Development and Sustainability, DOI: 10.1007/s10668-022-02565-3

Haddaway, N. R., Page, M. J., Pritchard, C. C., McGuinness, L. A., 2022. PRISMA2020: An R package and Shiny app for producing PRISMA 2020-compliant flow diagrams, with interactivity for optimised digital transparency and Open Synthesis. Campbell Systematic Reviews, 18(2), e1230, DOI: 10.1002/cl2.1230

Hadziosmanovic, M., Lloyd, S. M., Bjorn, A., Paquin, R. L., Mengis, N., Matthews, H. D., 2022. Using cumulative carbon budgets and corporate carbon disclosure to inform ambitious corporate emissions targets and long-term mitigation pathways. Journal Of Industrial Ecology, 26(5), 1747–1759, DOI: 10.1111/jiec.13322

Hallam, C., Contreras, C., 2016. Integrating lean and green management. Management Decision, 54(9), 2157–2187, DOI: 10.1108/MD-04-2016-0259

Hart, M., Austin, W., Acha, S., Le Brun, N., Markides, C. N., Shah, N., 2020. A roadmap investment strategy to reduce carbon intensive refrigerants in the food retail industry. Journal of Cleaner Production, 275, DOI: 10.1016/j.jclepro.2020.123039

Henao, R., Sarache, W., Gomez, I., 2019. Lean manufacturing and sustainable performance: Trends and future challenges. Journal of Cleaner Production, 208, 99–116, DOI: 10.1016/j.jclepro.2018.10.116

Hristov, I., Appolloni, A., Chirico, A., 2022. The adoption of the key performance indicators to integrate sustainability in the business strategy: A novel five-dimensional framework. Business Strategy And The Environment, 31(7), 3216–3230, DOI: 10.1002/bse.3072

Immink, H., Louw, R., Garlick, A., Vosper, S., Brent, A., 2022. Country specific low carbon commitments versus equitable and practical company specific decarbonisation targets. Environment Development And Sustainability, 24(8), 10005–10025, DOI: 10.1007/s10668-021-01854-7

Janjua, S. Y., Sarker, P. K., Biswas, W. K., 2020. Development of triple bottom line indicators for life cycle sustainability assessment of residential bulidings. Journal of Environmental Management, 264, DOI: 10.1016/j.jenvman.2020.110476

Janjua, S. Y., Sarker, P. K., Biswas, W. K., 2021. Sustainability implications of service life on residential buildings - An application of life cycle sustainability assessment framework. Environmental and Sustainability Indicators, 10, DOI: 10.1016/j.indic.2021.100109

Johansson, G., Sundin, E., 2014. Lean and green product development: two sides of the same coin? Journal of Cleaner Production, 85, 104–121, DOI: 10.1016/j.jclepro.2014.04.005

Jose Martinez-Jurado, P., Moyano-Fuentes, J., 2014. Lean Management, Supply Chain Management and Sustainability: A Literature Review. Journal of Cleaner Production, 85, 134–150, DOI: 10.1016/j.jclepro.2013.09.042

Karahasanovic, A., Culen, A. L., Skjetne, J. H., Hasle, G., 2020. Key Performance Indicators In Design For Sustainable Rural Transport. Iadis-International Journal On Computer Science And Information Systems, 15(2), 107–122.

Karnitis, E., Bicevskis, J., Karnitis, G., Pukis, M., 2021. Sustainable Development Model of EU Cities Compliant with UN Settings. Mathematics, 9(22), DOI: 10.3390/math9222888

Kassem, E., Trenz, O., 2020. Automated Sustainability Assessment System for Small and Medium Enterprises Reporting. Sustainability, 12(14), DOI: 10.3390/su12145687

Khan, S. A. R., Yu, Z., Golpira, H., Sharif, A., Mardani, A., 2021. A state-of-the-art review and meta-analysis on sustainable supply chain management: Future research directions. Journal of Cleaner Production, 278, DOI: 10.1016/j.jclepro.2020.123357

Kumar, S., Luthra, S., Govindan, K., Kumar Naveen and Haleem, A., 2016. Barriers in green lean six sigma product development process: an ISM approach. Production Planning Control, 27(7–8, SI), 604–620, DOI: 10.1080/09537287.2016.1165307

Kuo, L., Chang, B.-G., 2021. Ambitious corporate climate action: Impacts of science-based target and internal carbon pricing on carbon management reputation-Evidence from Japan. Sustainable Production and Consumption, 27, 1830–1840, DOI: 10.1016/j.spc.2021.04.025

Leon, H. C. M., Calvo-Amodio, J., 2017. Towards lean for sustainability: Understanding the interrelationships between lean and sustainability from a systems thinking perspective. Journal of Cleaner Production, 142(4), 4384–4402, DOI: 10.1016/j.jclepro.2016.11.132

Ma, J., Harstvedt, J. D., Jaradat, R., Smith, B., 2020. Sustainability driven multicriteria project portfolio selection under uncertain decision-making environment. Computers Industrial Engineering, 140, DOI: 10.1016/j.cie.2019.106236

Marotta, I., Guarino, F., Longo, S., Cellura, M., 2021. Environmental Sustainability Approaches and Positive Energy Districts: A Literature Review. Sustainability, 13(23), DOI: 10.3390/su132313063

Marrucci, L., Daddi, T., 2022. The contribution of the Eco-Management and Audit Scheme to the environmental performance of manufacturing organisations. Business Strategy And The Environment, 31(4), 1347–1357, DOI: 10.1002/bse.2958

Matlock, M., Christie, M., Thoma, G., 2021. Analysis of Life Cycle Environmental Impacts of Using Enogen Corn in Beef Cattle Rations. ANIMALS, 11(10), DOI: 10.3390/ani11102916

Matos, R., Rodrigues, F., Rodrigues, H., Costa, A., 2021. Building condition assessment supported by Building Information Modelling. Journal Of Building Engineering, 38, DOI: 10.1016/j.jobe.2021.102186

McGinley, O., Moran, P., Goggins, J., 2022. An Assessment of the Key Performance Indicators (KPIs) of Energy Efficient Retrofits to Existing Residential Buildings. Energies, 15(1), DOI: 10.3390/en15010334

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., Altman, D., Antes, G., Atkins, D., Barbour, V., Barrowman, N., Berlin, J. A., Clark, J., Clarke, M., Cook, D., D'Amico, R., Deeks, J. J., Devereaux, P. J., Dickersin, K., Egger, M., Ernst, E., … Tugwell, P., 2009. Preferred reporting items for systematic reviews and metaanalyses: The PRISMA statement. In PLoS Medicine (Vol. 6, Issue 7), DOI: 10.1371/journal.pmed.1000097

Moktadir, M. A., Mahmud, Y., Banaitis, A., Sarder, T., Khan, M. R., 2021. Key Performance Indicators For Adopting Sustainability Practices In Footwear Supply Chains. E M Ekonomie A Management, 24(1), 197–213, DOI: 10.15240/tul/001/2021-1-013

Moktadir, Md. A., Dwivedi, A., Rahman, A., Jabbour, C. J. C., Paul, S. K., Sultana, R., Madaan, J., 2020. An investigation of key performance indicators for operational excellence towards sustainability in the leather products industry. Business Strategy And The Environment, 29(8), 3331–3351, DOI: 10.1002/bse.2575

Molavi, A., Lim, G. J., Race, B., 2020. A framework for building a smart port and smart port index. International Journal Of Sustainable Transportation, 14(9), 686–700, DOI: 10.1080/15568318.2019.1610919

Mollenkopf, D., Stolze, H., Tate, W. L., Ueltschy, M., 2010. Green, lean, and global supply chains. International Journal Of Physical Distribution Logistics Management, 40(1–2), 14–41, DOI: 10.1108/09600031011018028

Morella, P., Lamban, M. P., Royo, J., Sanchez, J. C., Ng Corrales, L. del C., 2020. Development of a New Green Indicator and Its Implementation in a Cyber-Physical System for a Green Supply Chain. Sustainability, 12(20), DOI: 10.3390/su12208629

Morella, P., Pilar Lamban, M., Royo, J., Carlos Sanchez, J., 2022. Evaluating the impact of new trends in urban freight transportation attending the triple bottom line: A case study. Computers Industrial Engineering, 174, DOI: 10.1016/j.cie.2022.108756

Mosca, F., Perini, K., 2022. Reviewing the Role of Key Performance Indicators in Architectural and Urban Design Practices. Sustainability, 14(21), DOI: 10.3390/su142114464

Naji, K., Gunduz, M., Salat, F., 2021. Assessment of preconstruction factors in sustainable project management performance. Engineering Construction And Architectural Management, 28(10), 3060–3077, DOI: 10.1108/ECAM-05-2020-0333

Naji, K. K., Gunduz, M., Hamaidi, M. F., 2022. Major Factors Affecting Construction Waste Management in Infrastructure Projects Using Structural Equation Model. Journal Of Construction Engineering And Management, 148(10), DOI: 10.1061/(ASCE)CO.1943-7862.0002358

Naji, K. K., Gunduz, M., Naser, A. F., 2022. The Effect of Change-Order Management Factors on Construction Project Success: A Structural Equation Modeling Approach. Journal Of Construction Engineering And Management, 148(9), DOI: 10.1061/(ASCE)CO.1943-7862.0002350

Nawaz, R., Hussain, I., Noor, S., Habib Tufail and Omair, M., 2020. The significant impact of the economic sustainability on the cement industry by the assessment of the key performance indicators using Taguchi signal to noise ratio. Cogent Engineering, 7(1), DOI: 10.1080/23311916.2020.1810383

O'Flynn, C., Seymour, V., Crawshaw, J., Parrott, T., Reeby, C., Silva, S. R. P., 2021. The Road to Net Zero: A Case Study of Innovative Technologies and Policy Changes Used at a Medium-Sized University to Achieve C-zero by 2030. Sustainability, 13(17), DOI: 10.3390/su13179954

Othman, A., El-gazzar, S., Knez, M., 2022. A Framework for Adopting a Sustainable Smart Sea Port Index. Sustainability, 14(8), DOI: 10.3390/su14084551

Patidar, A., Sharma, M., Agrawal, R., Sangwan, K. S., n.d.. Supply chain resilience and its key performance indicators: an evaluation under Industry 4.0 and sustainability perspective. Management Of Environmental Quality, DOI: 10.1108/MEQ-03-2022-0091

Patil, H. R., Javalagi, C. M., 2020. Analysis of key performance indicators for sustainable manufacturing in sugar industry using analytical hierarchy process. Indian Journal Of Engineering And Materials Sciences, 27(4), 959–963.

Patrao, C., Moura, P., de Almeida, A. T., 2020. Review of Smart City Assessment Tools. Smart Cities, 3(4), 1117–1132, DOI: 10.3390/smartcities3040055

Perroni, M. G., Tortato, U., da Silva, W. V., da Veiga, C. P., Senff, C. O., 2020. Analytical method for sustainability science benchmarking: An indicator decomposition approach. Ecological Indicators, 116, DOI: 10.1016/j.ecolind.2020.106470

Pignatelli, M., Moghadam, S. T., Genta, C., Lombardi, P., 2023. Spatial decision support system for low-carbon sustainable cities development: An interactive storytelling dashboard for the city of Turin. Sustainable Cities and Society, 89, DOI: 10.1016/j.scs.2022.104310

Pribicevic, I., Delibasic, B., 2021. Critical sustainability indicators identification and cause-effect relationships analysis for sustainable organization strategy based on fuzzy Dematel. Environment Development And Sustainability, 23(12), 17263–17304, DOI: 10.1007/s10668-021-01360-w

Radovanovic, D., Hoist, C., Belur, S. B., Srivastava, R., Houngbonon, G. V., Le Quentrec Erwan and Miliza, J., Winkler, A. S., Noll, J., 2020. Digital Literacy Key Performance Indicators for Sustainable Development. Social Inclusion, 8(2), 151–167, DOI: 10.17645/si.v8i2.2587

Rahman, T., Moktadir, M. A., Paul, S. K., 2022. Key performance indicators for a sustainable recovery strategy in healthcare supply chains: COVID-19 pandemic perspective. Journal Of Asia Business Studies, 16(3, SI), 472–494, DOI: 10.1108/JABS-05-2021-0200

Reavis, M., Ahlen, J., Rudek, J., Naithani, K., 2022. Evaluating Greenhouse Gas Emissions and Climate Mitigation Goals of the Global Food and Beverage Sector. Frontiers In Sustainable Food Systems, 5, DOI: 10.3389/fsufs.2021.789499

Romeni, G., Appio, F. P., Martini, A., Mercat, B., Jean-Marie, A., Joubert, C., 2020. Enhancing Ecoinnovation Performance: Evidence From a Water Footprint Assessment in the Manufacturing Industry. IEEE Transactions On Engineering Management, 67(3), 724–739, DOI: 10.1109/TEM.2019.2893968

Sangwa, N. R., Sangwan, K. S., 2018. Leanness assessment of organizational performance: a systematic literature review. Journal of Manufacturing

Technology Management, 29(5), 768–788, DOI: 10.1108/JMTM-09-2017-0196
Schipper, C. A., Dekker, G. G. J., de Visser, B., Bolman, B., Lodder, Q., 2021. Characterization of SDGs towards Coastal Management: Sustainability Performance and Cross-Linking Consequences. Sustainability, 13(3), DOI: 10.3390/su13031560
Seuring, S., Müller, M., 2008. From a literature review to a conceptual framework for sustainable supply chain management. Journal of Cleaner Production, 16(15), 1699–1710, DOI: 10.1016/j.jclepro.2008.04.020
Sharma, V., Raut, R. D., Mangla, S. K., Narkhede, B. E., Luthra, S., Gokhale, R., 2021. A systematic literature review to integrate lean, agile, resilient, green and sustainable paradigms in the supply chain management. Business Strategy and The Environment, 30(2), 1191–1212, DOI: 10.1002/bse.2679
Siegel, R., Antony, J., Garza-Reyes, J. A., Cherrafi, A., Lameijer, B., 2019. Integrated green lean approach and sustainability for SMEs: From literature review to a conceptual framework. Journal of Cleaner Production, 240, DOI: 10.1016/j.jclepro.2019.118205
Souza Farias, L. M., Santos, L. C., Gohr, C. F., de Oliveira, L. C., da Silva Amorim, M. H., 2019. Criteria and practices for lean and green performance assessment: Systematic review and conceptual framework. Journal of Cleaner Production, 218, 746–762, DOI: 10.1016/j.jclepro.2019.02.042
Spanner, M. M., Wein, J., 2020. Carbon risk real estate monitor: making decarbonisation in the real estate sector measurable. Journal Of European Real Estate Research, 13(3, SI), 277–299, DOI: 10.1108/JERER-05-2020-0031
Stoknes, P. E., Rockstrom, J., 2018. Redefining green growth within planetary boundaries. Energy Research & Social Science, 44, 41–49, DOI: 10.1016/J.Erss.2018.04.030
Sun, S., Ertz, M., 2021. Dynamic evolution of ride-hailing platforms from a systemic perspective: Forecasting financial sustainability. Transportation Research Part C-Emerging Technologies, 125, DOI: 10.1016/j.trc.2021.103003
Torabizadeh, M., Yusof, N. M., Ma'aram, A., Shaharoun, A. M., 2020. Identifying sustainable warehouse management system indicators and proposing new weighting method. Journal of Cleaner Production, 248, DOI: 10.1016/j.jclepro.2019.119190
Tranfield, D., Denyer, D., Smart, P., 2003. Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review. In British Journal of Management 14(3), 207–222, DOI: 10.1111/1467-8551.00375
van Eck, N. J., Waltman, L., 2010. Software survey: VOSviewer, a computer program for bibliometric mapping. Scientometrics, 84(2), 523–538, DOI: 10.1007/s11192-009-0146-3
Varela, L., Araujo, A., Avila, P., Castro Helio and Putnik, G., 2019. Evaluation of the Relation between Lean Manufacturing, Industry 4.0, and Sustainability. Sustainability, 11(5), DOI: 10.3390/su11051439
Viglia, G., Kumar, S., Pandey, N., Joshi, Y., 2022. Forty years of The Service Industries Journal: a bibliometric review. Service Industries Journal, 42(1–2), 1–20, DOI: 10.1080/02642069.2021.2003341
von Geibler, J., Liedtke, C., Wallbaum, H., Schaller, S., 2006. Accounting for the social dimension of sustainability: Experiences from the biotechnology industry. Business Strategy and the Environment, 15(5), 334–346, DOI: 10.1002/bse.540
Voukkali, I., Loizia, P., Navarro Pedreno, J., Zorpas, A. A., 2021. Urban strategies evaluation for waste management in coastal areas in the framework of area metabolism. Waste Management Research, 39(3, SI), 448–465, DOI: 10.1177/0734242X20972773
Walenta, J., 2020. Climate risk assessments and science-based targets: A review of emerging private sector climate action tools. Wiley Interdisciplinary Reviews-Climate Change, 11(2), DOI: 10.1002/wcc.628
Walkiewicz, J., Lay-Kumar, J., Herzig, C., 2021. The integration of sustainability and externalities into the ``corporate DNA'': a practice-oriented approach. Corporate Governance-The International Journal of Business In Society, 21(3, SI), 479–496, DOI: 10.1108/CG-06-2020-0244
Watari, T., Nansai, K., Nakajima, K., 2021. Contraction and convergence of in use metal stocks to meet climate goals. Global Environmental Change-Human And Policy Dimensions, 69, DOI: 10.1016/j.gloenvcha.2021.102284
Yilan, G., Cordella, M., Morone, P., 2022. Evaluating and managing the sustainability of investments in green and sustainable chemistry: An overview of sustainable finance approaches and tools. Current Opinion In Green And Sustainable Chemistry, 36, DOI: 10.1016/j.cogsc.2022.100635
Zaripov, R. N., Murakaev, I. M., Ryapukhin V, A., 2021. Development of the Organization's Key Performance Indicators System in Order to Improve the Effectiveness of Its Human Capital and Risk Management. Tem Journal-Technology Education Management Informatics, 10(1), 298–302, DOI: 10.18421/TEM101-37

3 IMPACTO DE PRÁTICAS *LEAN* NA SEGURANÇA

3.1 Enquadramento

Os modelos de excelência operacional, como a filosofia *Lean*, o Modelo de Shingo, o Modelo EFQM e o *Toyota Way*, são modelos de gestão que têm impacto na segurança. A pesar dos modelos de gestão referidos anteriormente terem diferentes tipos de abordagem nos seus modelos, todos eles partilham uma preocupação na melhoria da qualidade, eficiência e na cultura organizacional, o que, por sua vez, influencia de forma positiva a segurança no local de trabalho. A filosofia *Lean* e o *Toyota Way* referem a importância de os trabalhadores serem ativos e participativos no processo de melhoria dos processos. Esta situação não aumenta apenas a eficiência dos processos, mas também promove uma cultura de segurança nos locais de trabalho, onde os trabalhadores são desafiados a indicar os problemas de segurança que têm nos seus postos de trabalho.

No que se refere à filosofia *Lean*, ela tem o seu foco na eliminação dos desperdícios, como por exemplo a eliminação de movimentos, transportes e de stocks. Estas ações irão proporcionar aos trabalhadores uma redução da sua exposição situações de riscos ocupacionais, levando a uma diminuição dos acidentes de trabalho. O aparecimento do conceito do "*Lean Safety*", tem consistido em investigar de que forma as práticas *Lean* contribuem para a melhoria da segurança (Hafey, 2010). É importante que as empresas deixem de contabilizar apenas os ganhos obtidos com a implementação das ferramentas *Lean*, mas que comecem a ter conhecimento e a valorizar os ganhos que são obtidos ao nível da segurança.

3.2 The Impact of *Lean* on Occupational Safety in Organisations

A filosofia *Lean* tem demonstrado ser uma opção eficaz para reduzir os desperdícios e os custos, sendo que alguns estudos têm demonstrado que, como seria de esperar, também consegue melhorar a segurança dos trabalhadores. Dehdasht et al. (2018) através da adoção de práticas *Lean* no setor da construção civil, adotou práticas *Lean* para melhorar a produtividade e a segurança da organização, enquanto Sá et al. (2021), demonstram ter conseguido obter melhorias na segurança através da adoção de práticas *Lean* numa unidade industrial. O artigo "*The Impact of Lean on Occupational Safety in Organisations*" (Sá et al, 2022) teve como objetivo estudar se as organizações que têm adotado práticas *Lean*, têm observado melhorias ao nível da sinistralidade, através da redução do número de acidentes de trabalho (*Figura 22*). Para além disso, este artigo pretende identificar quais as práticas *Lean* que têm mais contribuído para essa melhoria. Para esse efeito, foi realizado um inquérito através do envio de um questionário a 1 600 organizações portuguesas, abrangendo todo o país, incluindo as ilhas, que potencialmente utilizam ferramentas *Lean*.

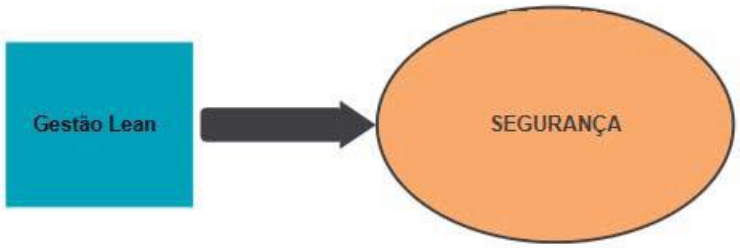


Figura 22 - Impacto do *Lean* na Segurança

The Impact of Lean on Occupational Safety in Organisations

José Carlos Sá[1(B)], José Dinis-Carvalho[2], Helena Fraga[3], Vanda Lima[4], Francisco J. G. Silva[1], and João Bastos[5]

[1] INEGI, ISEP, Instituto Politécnico do Porto, Rua Dr. António Bernardino de Almeida, 4249-015 Porto, Portugal
{cvs,fgs}@isep.ipp.pt

[2] Production and Systems Department, School of Engineering, University of Minho, Campus de Azurém, 4800-058 Guimarães, Portugal
dinis@dps.uminho.pt

[3] ISEP, Instituto Politécnico do Porto, Rua Dr. António Bernardino de Almeida, 4249-015 Porto, Portugal
1170056@isep.ipp.pt

[4] CIICESI, ESTG, Instituto Politécnico do Porto, Rua do Curral, 4610-156 Felgueiras, Portugal
vlima@estg.ipp.pt

[5] INESC TEC, ISEP, Instituto Politécnico do Porto, Rua Dr. António Bernardino de Almeida, 4249-015 Porto, Portugal
jab@isep.ipp.pt

Abstract. Occupational safety is a major concern these days because it is an important social issue promoting financial implications for organisations, employees, and society. But while occupational safety is an important concern, the top management of organizations usually prioritize waste and cost reduction. Therefore, there is a need for a technique that reduces waste and simultaneously improves occupational safety. Lean has been effective in reducing waste and costs. Some researchers have shown that Lean can also improve occupational safety. The objective of this work was to determine wether, in organizations where Lean tools were implemented, if there was an improvement in occupational safety conditions, namely in the reduction of accident rates, and to verify which Lean tools contributed the most to that improvement. A survey was conducted by sending a questionnaire to Portuguese organizations, from north to south and islands, who had potentially Lean tools implemented. In total, 189 answers have been obtained from organizations, 59 of which had Lean tools implemented, being considered valid answers for the study. Through statistical analysis of the data obtained, it was found that no organisations had worsened their safety indicators, some had maintained the same level and a reasonable number stated that their indicators had improved. Of these, the vast majority said that their accident rates had decreased by 20%, this being the figure that statistically showed the best results in terms of change.

Keywords: Safety · Lean philosophy · Lean tools · Lean safety · Occupational safety

Published by Springer Nature Switzerland AG 2023
O. McDermott et al. (Eds.): ELEC 2022, IFIP AICT 668, pp. 184–192, 2023.
https://doi.org/10.1007/978-3-031-25741-4_16

1 Introduction

Fatal accidents at work in Portugal, after a decrease for some years, had a substantial increase in 2018. Thus, the area of safety assumes a relevant importance in organizations. Although safety at work is a major source of concern, top management generally prioritizes reducing waste and cutting costs. Therefore, there is a need to adopt measures that reduce waste and costs while improving safety. The Lean approach has been effective in reducing waste and costs while at the same time it can improve safety at work [1, 2]. Accidents at work and occupational diseases most often happen because organisations do not comply with safety standards and do not act preventively [3]. This study aims to see how Lean tools can help organisations to identify potential occupational risk situations, and the impact they have on reducing accidents. Money and time spent on accidents and workers' compensation is classified as a waste, which is something that should be avoided based on the Lean philosophy. Lean aims to reduce the 3 M's (Muda, Mura, and Muri), and safety aims to reduce accidents at work and occupational diseases, looking at these two goals they end up intersecting. This is because occupational diseases and accidents generate waste, and Lean tools have an impact on the aspects related to occupational safety. For several authors, Lean has been frequently associated with safer, high quality, and high-commitment work environments, by sustainable human performance. For example, many Lean operating practices increase the level of workplace "transparency" (clear visibility of hazards, cleaner work environment, etc.) so that workers can identify, evaluate and suggest controls. And this helps reducing health and safety risks in the workplace. In particular, visual boards and other display artefacts are devices that make human/technology interactions easier and more effective. This means that effective and safe standards and procedures can be maintained, and continuous improvement processes can be facilitated. In this way, systems can provide information, signal deviations, control and ensure the correctness of processes, and, in turn, improve safety in the workplace [4]. This work aims to verify wether, in the Portuguese organizations where Lean tools were implemented, if there was a positive impact on the reduction of the accident rates, Incidence Rate (Ii), Frequency Rate (If), and Severity Rate (Ig).

2 Literature Review

2.1 Lean Approach

Lean designates a concept that is known to increase manufacturing effectiveness [5, 6]. Toyota has been successful in Lean deployment, and this has inspired many organisations around the world to start a 'Lean journey'. The Lean concept is now discussed as relevant not only in manufacturing, but also in services and healthcare delivery [7, 8]. Lean focuses on reducing the 3M's, maximizing value-adding activities from the customer's perspective. Moreover, from the customer's perspective, value is equivalent to whatever the customer is willing to pay for a provided product or service. Thus, the elimination of waste (*Muda*) is one of the basic concepts linked to Lean production [9]. An

essential aspect of Lean philosophy is continuously striving for perfection in products that can be delivered customer-specific, on-demand, without waste of material, labor hours, and other resources (energy) in a safe working environment (physical, emotional and professional) [10]. The application of Lean principles depends on an organisation's commitment to continuously improving the value delivered to a customer [11].

Womack and Jones [12] proposed a set of principles to achieve a Lean enterprise. Companies should adopt these principles and incorporate them into their operations, sequentially. Thus, the Lean approach can be summarized in six principles: value specification, value chain identification, value stream, pull system, perfection, and respect for people [13].

2.2 Occupational Safety

Safety is defined as a state in which hazards and conditions leading to physical, psychological, or material harm are controlled to preserve the health and well-being of individuals and the community [14, 15]. This state is not only related to the absence of intentional or unintentional injuries. It should also lead to a perception of being pro- tected from danger [16]. Therefore, it includes two dimensions: one is objective and is assessed by measuring the number of injuries or factual behavioural and environmental parameters (e.g., traffic-related deaths recorded in a community, number of collisions at a dangerous intersection) [17]. The other is subjective and assessed according to the feeling of being out of danger. Both dimensions can sometimes influence each other positively or negatively [18]. Safety results from a complex process in which humans interact with their physical, social, cultural, technological, political, economic, and organisational environments [19]. Safety in companies plays a major role in motivating workers [20]. Any business knows that employee attrition and absenteeism can be major obstacles [16]. When a healthy and safe workplace is created, these problems are reduced in several ways. By budgeting for safety improvements and making safety part of the operating plan, trust is built. Involving employees in safety decisions - through reports, committees, guidelines, and meetings - demonstrates that their opinion matters to the employer. If top management pays attention to employees' opinions and improve their safety, this can tangibly prove that comapny care about their welfare [21].

2.3 Integration of Lean and Safety

Lean can be an opportunity to avoid professional risks as long as it is possible to approach it without changing the steps and without distorting the spirit. Today, the implementation of the Lean model is done with much more care. The implementation of a Lean approach can, and should, be accompanied by reflections in favor of health and safety at work [22–24]. The results will depend on how the Lean tools relate to the policy of prevention of risks at work. They will vary greatly from one company to another [20]. But taking this approach can also be an opportunity for prevention. Some situations allow addressing occupational health and safety issues either as part of standard performance

improvement objectives or as a site-specific objective [16]. The two biggest challenges in the construction industry are low productivity and high injury rates, and they can be addressed simultaneously by combining Lean production strategies and traditional safety analysis tools. A study was conducted that integrated safety and a Lean tool, Kaizen, into the construction of modular housing [22]. The research team analysed the current process, determined, and implemented process improvements, and analysed the improved process. The changes made resulted in a 16% increase in the value added to the activities and by making these low-cost changes, safety risks were reduced or eliminated in some situations. These results support the hypothesis that productivity and safety can be improved simultaneously through combined safety and Lean tools [22]. In 2002, the largest Danish construction company conducted an experiment on the impact of implementing Lean tools on profit (level and predictability), safety, customer satisfaction, and administrative costs. This implementation was carried out in about 30 projects that the company had in progress. To confirm the impact of the Lean tools, projects that used Lean tools were compared with projects not using Lean tools.

With only a limited number of projects with Lean tools implemented, they found that customer satisfaction increased by two decimal points on a scale of 1 to 5. It had a positive impact on profit; the average profit of three projects with Lean tools implemented is approximately 25 percent higher than the average profit of projects that did not have Lean tools implemented. It was also proved that the accident rate is lower for projects with Lean implemented [25].

3 Methodology

The type of approach was qualitative research of basic nature, involving a biblio- graphic survey on the topic under study. Subsequently, as a data collection technique, the option fell on the elaboration of a questionnaire, whose questions were carefully thought out to provide an answer to the proposed problem. The questionnaire includes 13 questions with the following content (Table 1):

Table 1. Questionnaire sent to companies

Questions	
1.	Name of the Organization
2.	In which department does the person responsible for completing the questionnaire work
3.	Location of the Organization
4.	Sector of Activity
5.	No. of Workers in the Organization
6.	If the Organization is safety certified
7.	How many years ago the certification occurred (ranges: less than 1 year | between 1 and 3 | between 3 and 5 | between 5 and 10 | more than 10),
8.	If company knows Lean tools,
9.	Identify the Lean tools that company knows,
10.	It the organization have any Lean tools implemented,
11.	Identify the Lean tools implemented in the organization and how many years ago they were implemented (ranges: less than 1 year | between 1 and 3 | between 3 and 5 | between 5 and 10 | more than 10),
12.	After the implementation of Lean tools there was an improvement in the Accident Rates (options: Worsened | No change | -20% | -40% | -60% | -80% | -100%)
13.	Indicate up to 5 tools, which in the company's opinion contributed to the improvement of safety. Number, considering value 5 for the one that had more impact and value 1 for the one that had less impact.

4 Development and Results

A set of 1600 Portuguese organisations was selected, from north to south and islands, potentially with Lean tools implemented, to which the questionnaire was sent via email. Only those that had Lean tools implemented were analysed. A total of 189 organisations have responded, 59 of which had Lean tools implemented (Fig. 1), which were considered valid responses for the study.

The data collection process took place from 7 August 2019 to 06 October 2019. All responses to the questionnaires were recorded and automatically transferred to an MS Excel® file, functions provided by the Google Forms® platform. This also helped to make the research more reliable as it provided easy traceability of the data obtained. These data were subsequently worked/coded in MS Excel® and then transferred to the SPSS® (Statistical Package for the Social Sciences) application. The organisations that make up the sample are located essentially in the northern region and with special incidence in the metalworking sector. Concerning their size, the vast majority are medium and large sized. The sample includes 27 organisations with safety certification, 14 of which have been certified for over 10 years .

According to the data obtained in Table 2, it was observed that there are no organizations that have worsened their rates, some have maintained the rates and a reasonable

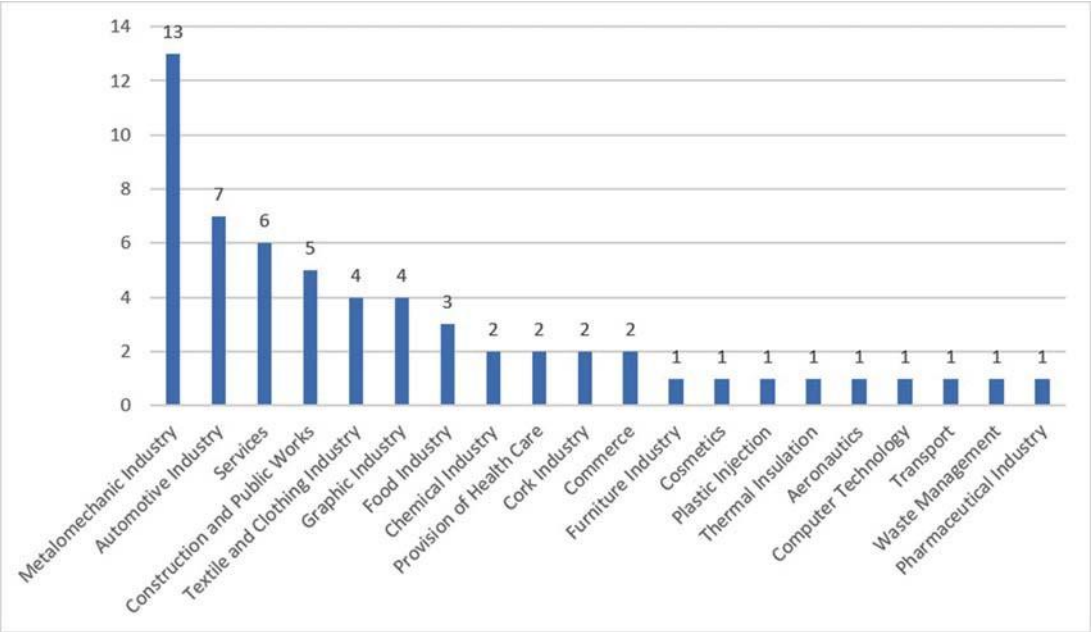


Fig. 1. Characterization of the sample of companies that responded to the survey

number attested that the rates suffered improvement alterations, of these, their great majority, said that the accident rates decreased 20%, making this the value that statistically presented the best results in terms of improvement. A correlation test was conducted between the Lean tools implemented and the three accident rates, which confirmed that there are statistically significant correlations between the Lean tools. But they are not correlated with the accident rates. The accident rates have a strong correlation between them, most probably, the higher the accident rate, the higher the probability of having serious accidents. It was found that there is no correlation between accident rates and the variables of activity sector, organisation size, safety certification, and years of certification. From the descriptive statistical analysis, it was found that the implementation of Lean tools has an impact on accident rates. Most of the companies that managed to improve their accident rates were within the 20% threshold. The thresholds of improvement of accident rates between 20% and 60% has been chosen and analysed for the three rates to ascertain if there was a difference between the groups for four variables: activity sector, number of workers, safety certification, and years of certification.

The test chosen, based on the type of variables available was the Kruskal Wallis (KW). According to Pestana and Gageiro [26], the KW test is an extension of the Wil- coxon-Mann-Whitney test, which is a non-parametric test used to compare three or more populations. It is used to test the null hypothesis that all populations have equal distribution functions against the alternative hypothesis that at least two of the populations have different distribution functions. From the KW test for the incidence index, differences were found between the groups for the variable safety certification, ($p = 0.04$) and years of certification ($p = 0.014$). No significant differences were found between the groups for the variable sector of activity ($p = 0.7$) and the number of workers ($p = 0.472$). Based on these results, it was tried to confirm which group was causing the difference. Applied the KW test for the Frequency Index, it was found that there are no significant differences between the groups for the variables, activity sector

Table 2. General table of impact by index

	Percentage of answers	Organisations	Marginal percentage
Incidence index	No changes	36	61,00%
	− 20%	16	27,10%
	− 40%	5	8,50%
	− 60%	1	1,70%
	− 100%	1	1,70%
Frequency index	No changes	34	57,60%
	− 20%	15	25,40%
	− 40%	8	13,60%
	− 60%	1	1,70%
	− 100%	1	1,70%
Severity index	No changes	37	62,70%
	− 20%	12	20,30%
	− 40%	7	11,90%
	− 60%	2	3,40%
	− 100%	1	1,70%
Total valid		59	100%

($p = 0.793$), the number of workers ($p = 0.126$), safety certification, ($p = 0.551$) and years of certification ($p = 0.051$). The KW test was applied to the Severity index, and it was verified that there is no difference between the groups for the variables: sector of activity ($p = 0.947$), number of workers ($p = 0.223$), safety certification ($p = 0.153$) and years of certification ($p = 0.430$). With the KW test for the grouping variable Index of Incidence, it was possible to verify that there are differences between groups for the variable's certification and years of certification. However, with this test, it was not possible to affirm if these differences had a certain linear pattern. Thus, it was opted for a comparison of means. For the certification variable, the average of the incidence index was calculated separately for non-certified and certified organisations, and it was found that the average value increased, which leads to the conclusion that in certified companies the impact of the implementation of Lean tools on the incidence index is statistically more significant.

Next, it was analysed whether, within the group of organisations certified in safety, the variable years of certification influenced the incidence rate. This analysis was again based on the comparison of averages, in this case, the average *Ii* was calculated for each date interval. For the interval of less than one year of certification, no case was registered.

The mean comparison analysis showed that there is an upward trend in *Ii* from the interval 1 to 3 years to the interval 5 to 10 years of certification. In the interval of more than 10 years, the average drops significantly. It cannot be said that the average value of *Ii* increases as the years of safety certification also increase. What can be said is that for

the organisations that participated in the study, there was more impact of Lean tools in improving the incidence index in the certified organisations whose certification occurred in the interval between 5 and 10 years. Statistical analysis showed that it was possible to prove that Lean tools have positive impact on safety by reducing accident rates.

5 Conclusion

Safety has historically been treated as a separate function or issue which could be improved in isolation away from production. However, safety is an integral part of every production process, not an afterthought or an add-on, because safety depends on all actions, materials and people used. Work processes are inherently safe or hazardous according to the safety risks present at each step required to complete a process. Safety performance depends on the nature of the work and must be maintained and continuously improved as part of these processes [14, 16]. Based on the data collected from the organisations that participated in this study and through statistical analysis, some support was obtained for the prediction that the acci dent rates will be improved with the implementation of Lean tools.

It was found that no organisations had worsened their rates, some had maintained their rates and a reasonable number stated that their rates had improved. Of these, the vast majority said that their accident rates had decreased by 20%, which was the value that statistically presented the best results in terms of change. The KW test was applied to the three accident rates and it was found that there were differences between groups for the variables certification (in safety) and years of certification in relation to the Incidence Index. With this test, it was not possible to affirm if these differences had a certain linear pattern. Thus, it was opted to make a comparison of means. It could not be affirmed that the *Ii* increases as the years of certification in safety also increase. What could be affirmed is that for the organisations that participated in the study, there is more impact of the Lean tools in the improvement of the incidence index in those that are certified and whose certification took place between 5 and 10 years. It was possible to demonstrate that Lean tools have a positive impact on the occupational safety of organisations, through the reduction of accident rates.

The analysis and discussion presented in this paper provide a theoretical and empir ical rationale for the link between Lean tool implementation and improved occupational safety outcomes.

Research Funding. The work of the author Vanda Lima is supported by national funds, through the FCT— Portuguese Foundation for Science and Technology under the project UIDB/04728/2020.

References

1. Cordeiro, P., Sá, J.C., Pata, A., Gonçalves, M., Santos, G., Silva, F.J.G.: The impact of lean tools on safety—case study. In: Arezes, P.M., et al. (eds.) Occupational and Environmental Safety and Health II. SSDC, vol. 277, pp. 151–159. Springer, Cham (2020). https://doi.org/10.1007/978-3-030-41486-3_17

2. Sá, J.C., et al.: Lean safety-assessment of the impact of 5S and visual management on safety. In: IOP Conference Series: Materials Science and Engineering, vol. 1193(1), p. 012049 (2021)
3. Bastos, A., Sá, J., Silva, O., Fernandes, M.C.: A study on the reality of Portuguese companies about work health and safety. Occup. Saf. Hyg. II **1**, 687–691 (2014)
4. Camuffo, A., De Stefano, F., Paolino, C.: Safety reloaded: lean operations and high involvement work practices for sustainable workplaces. J. Bus. Ethics **143**(2), 245-259. (2017). https://doi.org/10.1007/s10551-015-2590-8
5. Kim, C.S., Spahlinger, D.A., Kin, J.M., Coffey, R.J., Billi, J.E.: Implementation of lean thinking: one health system's journey. Jt. Comm. J. Qual. Patient Saf. **35**(8), 406–413 (2009)
6. Womack, J.P., Jones, D.T.: Lean thinking—banish waste and create wealth in your corporation. J. Oper. Res. Soc. **48**(11), 1148–1148 (1997)
7. Pettersen, J.: Defining lean production: some conceptual and practical issues. The TQM Journal **21**(2), 127–142 (2009)
8. Antas Aguiar, J., Telhada, J., Sameiro Carvalho, M., Sá, J.C.: Value measurement in health care delivery process for a paediatric hospital in guinea- bissau. In: International Conference Innovation in Engineering, pp. 186–196. Springer, Cham (2023). https://doi.org/10.1007/978-3-031-09360-9_16
9. Arlbjorn, J., Freytag, P.: Evidence of lean: a review of international peer- reviewed journal articles. Eur. Bus. Rev. **25**(2), 174–203 (2013)
10. Fullerton, R., Wempe, W.: Lean manufacturing. Int. J. Oper. Prod. Manag. **29**, 214–240 (2009)
11. Bartels, N.: Lean in the most generic sense. Manuf. Bus. Technol. **23**, 32–36 (2005)
12. Womack, J., Jones, D.T.: Lean Thinking. Simon and Schuster, New York (1996)
13. Shah, R., Ward, P.T.: Defining and developing measures of Lean production. J. Oper. Manag. **25**, 785–805 (2007)
14. Koskela, L.: Application of the New Production Philosophy to Construction, vol. 72. Stanford university, Stanford, CA (1992)
15. Maurice, P., Lavoie, M., Chapdelaine, A., Bélanger-Bonneau, H.: Safety and safety promotion: conceptual and operational aspects. Chronic Dis Canada **18**(4), 179–186 (1997)
16. Morgado, L., Silva, F.J.G., Fonseca, L.M.: Mapping occupational health and safety management systems in portugal: outlook for ISO 45001:2018 adoption. Procedia Manuf. **38**, 755–764 (2019)
17. Cooper, M.D.: Towards a model of safety culture. Saf. Sci. **36**, 111–136 (2000)
18. Baram, M., Schoebel, M.: Safety culture and behavioral change at the workplace. Saf. Sci. **45**, 631–636 (2007)
19. Hudson, P.: Implementing a safety culture in a major multi-national. Saf. Sci. **45**, 697–722 (2007)
20. Brito, M., Vale, M., Leão, J., Ferreira, L.P., Silva, F.J.G., Gonçalves, M.A.: Lean and Ergonomics decision support tool assessment in a plastic packaging company. Procedia Manuf. **51**, 613–619 (2020)
21. Reason, J.: Managing the Risks of Organizational Accidents. Ashgate, Aldershot (1998)
22. Ikuma, L.H., Nahmens, I., James, J.: Use of safety and lean integrated kaizen to improve performance in modular homebuilding. J. Constr. Eng. Manag. **137**(7), 551–560 (2010)
23. Arezes, P.M., Dinis-Carvalho, J., Alves, A.C.: Workplace ergonomics in Lean production environments: a literature review. Work **52**(1), 57–70 (2015)
24. Carter, B., Danford, A., Howcroft, D., Richardson, H., Smith, A., Taylor, P.: 'Stressed out of my box': employee experience of Lean working and occupational ill- health in clerical work in the UK public sector. Work Employ. Soc. **27**(5), 747–767 (2013)
25. Thomassen, M.A., Sander, D., Barnes, K. A., Nielsen, A.: Experience and results from implementing lean construction in a large Danish contracting firm. In: Proceedings of 11th Annual Conference on Lean Construction, pp. 644–655, July 2003
26. Pestana, M.H., Gageiro, J.N.: Análise de dados para ciências sociais: a complementaridade do SPSS (2008)

3.3 Assessment of the Impact of *Lean* Tools on the Safety of the Shoemaking Industry

A metodologia VSM (*Value Stream Mapping*) desenvolvida por Mike Rother e John Shook, é apresentado no livro "*Learning to see: value stream mapping to add value and eliminate muda*" (Rother & Shook, 2003) e tem sido amplamente utilizada por organizações como ferramenta de diagnóstico e de melhoria contínua, nas jornadas de adoção da filosofia *Lean*. Com objetivo de estudar o impacto das práticas *Lean* na segurança, o artigo "*Assessment of the Impact of Lean Tools on the Safety of the Shoemaking Industry*" (Sá et al., 2023) apresenta esse estudo recorrendo ao SVSM (*Safety Value Stream Mapping*). O SVSM é uma ferramenta de diagnóstico, a qual foi desenvolvida a partir do VSM, tendo sido adicionada uma nova dimensão de segurança, recorrendo a uma avaliação de riscos ocupacionais em 5 domínios: riscos físicos, riscos ergonómicos, riscos químicos, riscos biológicos e riscos mecânicos. Este artigo apresenta inicialmente um SVSM de diagnóstico, e posteriormente um segundo SVSM após implementar algumas ferramentas *Lean*, por forma a identificar a existência de alterações ao nível da segurança.

safety

MDPI

Article

Assessment of the Impact of Lean Tools on the Safety of the Shoemaking Industry

José Carlos Sá [1,*], Leonardo Soares [1], José Dinis-Carvalho [2], Francisco J. G. Silva [1] and Gilberto Santos [3]

[1] ISEP, Polytechnic of Porto, 4200-072 Porto, Portugal; 1180061@isep.ipp.pt (L.S.); fgs@isep.ipp.pt (F.J.G.S.)
[2] Production and Systems Department, University of Minho, Campus de Azurém, 4800-058 Guimarães, Portugal; dinis@dps.uminho.pt
[3] School of Design, Polytechnic Institute Cávado and Ave, Campus do IPCA, 4750-810 Barcelos, Portugal; gsantos@ipca.pt
* Correspondence: cvs@isep.ipp.pt

Abstract: Both the Lean philosophy and occupational safety and health have been widely studied, although this has usually been carried out independently. However, the correlation between Lean and occupational safety and health in the industrial context is still underexplored. Indeed, Lean tools can be applied to ensure the best safety environment for workers in each kind of manufacturing process, and this deserves to be studied. The study described here aims to understand the influence of each of a set of four Lean tools used in an industrial context with a strong manual labor component, seeking to determine the influence of each of these Lean tools on the increase in safety obtained through their application. For this purpose, four Lean tools that are quite commonly applied are selected, taking into account previously presented work that pointed to the positive influence of the application of each of these tools on worker safety: total productive maintenance system, Gemba walk, visual management and Yokoten. This study aims to apply these Lean tools and to analyze their impact on productivity, and then, on the safety of a company selected as a target in order to validate the concept. For this purpose, a new tool is created. In the first instance, the tool analyzes the current state of the productive process and the safety level through the study of the risk levels detected in the plant. In terms of productivity results, a reduction between 7% and 12% in cycle time is achieved in four areas of the plant. The feedback from employees showed increased satisfaction with the processes' simplification. To conclude, a 50% reduction in the number of work accidents per month is observed as a result of the implementation of Lean tools. The influence of the selected Lean tools on increasing both productivity and safety is clear, and our results prove the selection of tools to be largely adequate.

Keywords: Gemba walk; Lean safety; orthopedic footwear; total productive maintenance; value stream mapping; Yokoten; overall equipment effectiveness

Citation: Sá, J.C.; Soares, L.; Dinis-Carvalho, J.; Silva, F.J.G.; Santos, G. Assessment of the Impact of Lean Tools on the Safety of the Shoemaking Industry. *Safety* **2023**, *9*, 70. https://doi.org/10.3390/safety9040070

Academic Editor: Raphael Grzebieta

Received: 5 August 2023
Revised: 22 September 2023
Accepted: 2 October 2023
Published: 5 October 2023

1. Introduction

Lean manufacturing is highly used in industrial and service sectors today in order to eliminate waste (*muda*) and normalize processes [1]. Through a number of tools, the Lean philosophy has gained followers all over the world due to its effectiveness in several areas, with particular attention paid to the flexibility brought to production systems [2–4] and maintenance [5–7]. In addition to their negative impact on people's well-being and morale, injuries at work can in some ways be considered waste because they negatively affect productivity [8,9]. However, it can be stated that occupational safety and Lean philosophy are perfectly interconnected and aligned [10]. It is well known that the use of hand tools is connected with the appearance of hand injuries, namely, musculoskeletal problems in the upper body [11], and Lean tools try to avoid those situations, creating better work behavior. At the safety level, it is important to share information regarding occupational diseases

outbreaks and accidents that occur, with the aim of preventing their recurrence for the same reasons [12]. Workplace safety has been gaining prominence in the industrial environment, changing the way safety management systems are managed [13]. Due to the nature of their job functions, there are more chances of a work accident happening when workers are left to make decisions regarding their safety [14]. Work-related musculoskeletal disorders are disorders in muscles and tendons that result from working conditions. They occur due to multiple factors, such as the physical load applied or by psychological factors [15].

Next, a review of the literature that served as the basis for this work is presented in order to provide the reader with some of the research previously published on this topic. The review is divided into two main topics: safety and Lean tools.

1.1. Occupational Safety and Health

Several authors have addressed security problems by integrating Lean tools. This integration has given rise to new tools that result from frameworks developed based on different approaches and a combination of Lean tools. Marques Filho [16] created a new tool called SVSM (safety value stream mapping), according to which the author allows the reinforcement and removal of the best of two tools, namely VSM and SSM (safety stream mapping). This SVSM tool allowed the representation and identification of traditional waste and existing occupational safety problems. To validate the success of this tool, the author stated that it needed to be tested in different industrial sectors. Brito et al. [17] developed an operational tool to help researchers and professionals prioritize and evaluate ergonomic and safety implementations, as well as overall conditions, in an integrated way. The authors found that the highest scores obtained were the result of good interactions between the Lean system, ergonomics and safety. Aqlan et al. [18] integrated the principles of Lean manufacturing and ergonomics in order to redesign and improve the internal transport process of electronic parts in a company. Based on the concepts of Lean philosophy and ergonomics, the transport flow was redesigned. The new design introduced the "Lean tool" poka-yoke, which prevents operators from stacking cards, thus eliminating safety and ergonomic risks. Pereira et al. [19] developed a project whose main objective was to improve operators' working conditions and define the most suitable augmented reality (AR) for each material handling and movement process. To this end, they developed a methodology called risk assessment for ergonomics and safety in logistics (RAES-Log) to analyze and define the requirements for implementing AR so as to mitigate existing risks and improve ergonomic conditions. Although aware of the difficulties they faced in implementing the Lean philosophy, the company's ergonomists recognized the importance of this philosophy in improving working conditions in the logistics area. For Crema et al. [20], the reduction in resources used in healthcare and the need to ensure high levels of quality has led hospitals to develop projects that report multiple performances. In order to try to improve patient safety and efficiency at the same time. Thus, "Lean & safety" projects (L&S projects) can be implemented, combining Lean healthcare management (HLM) and clinical risk management (CRM). In the case study presented by the authors in the article, through the Lean healthcare management project, actions were implemented that led to efficiency, eliminated costly and unnecessary activities and materials, but above all led to positive results in terms of patient safety. Near misses and errors were completely reduced by 84.38%, enhancing patient safety. Pereira and Xavier [21] developed the SMILE approach in the workplace and developed a new conceptual model to be implemented in organizations to achieve a safety culture. According to the authors, adopting this integrated Lean safety model in an organization can definitely help the company to reap good benefits in terms of an accident-free organization, performance excellence, and huge financial benefits. The project team (Six Sigma team) should be trained to solve the safety-related problems in industry using the DMAIC (Define – Measure – Analyse – Improve – Control) approach. Ateekh-ur-Rehman [22] presented a study that aimed to use the Six Sigma philosophy to identify and reduce the occurrence of accidents at work in a company. According to the author, in order to achieve zero injuries or minimize workplace accident rates

and/or financial losses, it is necessary to use control methods. This study demonstrated the effectiveness of the DMAIC methodology approach of the Six Sigma philosophy in reducing occupational safety risks. In the article presented by Tsung and So [23], DMAIC from the Six Sigma philosophy was used to analyze historical data on injury rates in a company. The authors chose to focus the project on "manual handling injuries", as these accounted for almost 50% of lost time injuries (LTIs) and medical time injury (MTIs). The critical factors were then identified, as well as the most dangerous activities related to workplace injuries. Using the continuous improvement procedures outlined in the Six Sigma philosophy, they identified the critical factors and defined action plans that can be used to mitigate the safety risks. Umar et al. [24] took a very interesting approach to analyzing the impact of lean tools on safety. They developed a framework that provided additional insight into the 3M concept of lean with the integration of ergonomics. The research carried out by the authors showed that the three concepts underpinning the 3Ms, which are muda (waste), mura (inconsistency), and muri (over-burdening), can also be seen from the worker's perspective in a way that considers the physical and mental resources of the workers. These are vital to the performance of the workers and will directly influence the overall performance of the processes in the organization. Other authors have also referred in a more general way to the harmful aspects of problems related to occupational safety and health. Abu Aisheh [25] argues that work accidents can be seen as waste, being obstacles to a smooth process. By making the process more efficient, with reduced cycle and material handling times, it reduces workers' exposure to sources of possible accidents [26].

For Moldovan [27], Lean and Six Sigma methods can be used to improve labor practices to, in the end, improve medical organizations, which will benefit the safety of patients.

Singh [8] concluded in his study that, with the implementation of Lean tools, in particular the 5S and poka-yoke, it is possible to improve the safety and health of employees. Mutaza [28] concluded after the literature review that, theoretically, the 5S tool helps in reducing occupational accidents, but that the tool however should be accompanied by systematic monitoring, such as internal audits. Moreover, James [29] observed the reduction in risk in two areas of modular house construction. Thus, it was concluded that it is a good tool to improve productivity and safety.

1.2. Lean Tools with Interest for the Present Work

1.2.1. Value Steam Mapping (VSM)

Visual stream mapping is very useful for visualizing and quantifying the complex production process on the shop floor [30]. In addition to enabling the visualization of the production process, it also allows the visualization of cycle times, inventory buffers, and information flow, as well as the transformation of raw material into finished products [31,32]. Olakotan [33], after applying the VSM tool to the clinical decision support system that generates medication alerts, detected that it was possible to identify several wastes throughout the clinical procedures. Arifin [34], in an attempt to identify the error factors in laboratories, concluded that Lean tools are applicable to assessments of the laboratory process in a structured and rigorous manner.

1.2.2. Visual Management

Visual management is a tool for decision support and process improvement [35]. This tool leads to an improvement in the efficiency and effectiveness of communication, displaying indicators [36]. The impact of visual management in safety was also approached by Babur [12] and Sá [37]. The first author [12] created a roadmap in a Turkish shipyard using Lean tools to significantly reduce work accidents, absenteeism, and manufacturing costs. The second one [38] applied two tools, visual management and 5S, allowing for a better organization of the process, a 40% reduction in activities considered wasteful, and productivity levels of 74% and 87% to be reached in the finishing and cabinetry sections, respectively.

1.2.3. Yokoten

From the safety point of view, Yokoten enabled the dissemination of measures aimed at preventing and, in this sense, reducing absenteeism, the development of occupational diseases, and the occurrence of accidents at work [12]. In his case study, Machikita [38] concluded that 5S and Yokoten can make organizational routines necessary to improve knowledge transfer capabilities. In a case study performed by Fernando [39] interviewing a company, the company itself stated that Yokoten focuses a great deal on sharing in order to identify waste and systematically reduce it.

1.2.4. TPM

TPM (Total Productive Maintenance) idealizes a scenario of zero stoppages, zero defects and zero accidents. This requires a commitment and culture of continuous improvement from operators to the top management [40]. Biazzo [41] concluded in his study that the application of tools such as 5S, TPM and Kaizen has enabled the mitigation of multiple risks and hazards, and the elimination of wasteful activities. Sá [42] also reported significant gains in terms of OEE (pverall equipment effectiveness) and the availability of equipment in two different sectors of a metalworking industry after the implementation of just some pillars of the TPM principles.

1.2.5. Gemba Walks

The Gemba walk allows managers to go out into the field and identify and try to understand the main challenges and problems facing the shop floor. It is hoped that with this learning process, where problems are analyzed and solutions are created, the outcomes will result in improved operational performance and capacity [43].

1.2.6. Standard Work

Standard work is a tool that aims to reduce waste and maximize individual and team performance through the creation of procedures [44]. For MÍkva [45], procedures allow workers to be informed about the best method of carrying out the task. Each change to the process will only be complete when creating or updating these. The use of procedures allows companies to reduce error variation, increase security, improve communication and increase the visibility of problems [46].

Considering the sectors analyzed in the reviewed works and the fact that no studies were found that specifically dealt with the footwear industry, there is a gap that this work intends to fill. In fact, the footwear industry still involves a high amount of manual work, with obvious risks to workers given the small size of the product, the proximity of risk factors to workers' limbs, and fatigue from routine operations repeated countless times during each work shift. Taking this scenario into account, it was considered appropriate to extend some previous studies to this sector and integrate new concepts more adapted to the specific characteristics of this type of industry.

The main goal of this work is to study the impact of the application of precious selected Lean tools to improve productivity and occupational safety. To validate the research, an orthopedic footwear company was selected, because, traditionally, this kind of companies present high level of human labor, some competitiveness problems, and some lacks in safety procedures. Thus, the work aimed to analyze the production process and the safety level of the company, apply the Lean tools from the set of tools described in the previous section that better fit the problems identified, measure the results, and draw conclusions about the application of the tools.

2. Materials and Methods

In this research, the methodology known as action research was applied because it is intended to solve an existing problem and extrapolate the corresponding knowledge to future similar situations. Mello et al. [47] state that "research-action is the production of knowledge guided by practice, with the modification of a given reality occurring as part of the research

process". Following the procedures used by Marinho et al. [48] Mourato et al. [49], and Martins [50], the methodology is composed of five phases, as can be seen in Table 1.

Table 1. Presentation of the stages of the methodology action research.

Step	Content
Diagnosis	An SVSM map was built to be able to have an overview of productivity and safety on the shop floor by showing the cycle time, the changeover time, and the risk of each area.
Action planning	Based on the literature, Lean tools Gemba walk, TPM, visual management and Yokoten were chosen, and their implementation was planned.
Implementation	The Lean tools were implemented, and a summary of their actions was presented.
Evaluation	Taking into account the indicators used in the diagnosis, results after the Lean tool implementation were compared to those initially obtained.
Monitoring	Definition of indicators to control and monitor the situation in the future were created.

2.1. Diagnosis

In order to diagnose the initial situation and performed the first stage of the action research methodology, it was necessary to understand the influence that each productive section had on the workflow in terms of productivity and safety. As a first approach, we measured the cycle time (C/T), the changeover time (C/O) and the distance travelled (D/T) of each area. As a second approach, a risk map was built for each area. In Table 2, it is possible to observe the production parameters mentioned above for the different areas. Data were collected through the MES (manufacturing enterprise system), such as productive data, between the initial and final dates for analysis, which will be provided later in this study. The accidents at work are also reported in a specific module of the MES used by the company. These have undergone some customization in terms of the specific requirements of the company. The same procedure was used to perform analysis after the Lean tool implementation.

Table 2. Distribution of the number of workers, cycle time, changeover time and distance travelled for five production areas of the company used as target for this work.

Areas	Number of Workers	C/T (min)	C/O (min)	D/T (m)
Translation & Supply	8	48.30	3	72
Lasts	5	31.00	5	32
Modeling	9	125.3	8	10
Cut & Stitching	26	197.3	15	32
Assembly & Soles	20	133.3	12	38

The method used to analyze the risks for each task was the simplified MARAT (methodology for risk assessment and accidents at work) [51]. The classification of hazards is based on the calculation of the risk level (NR). The calculation is performed on the basis of the relationship between variables that assess probability, consequence, exposure, and disability. The risks of each area were evaluated in five different categories: mechanical (NR MEC), physical (NR FIS), ergonomic (NR ERG), chemical (NR QUIM) and biological risk (NR BIO). Table 3 summarizes the average risks by category and by production area, showing the total average risk in the last column.

Table 3. Distribution of average risk levels divided into five categories regarding six stages of the production process.

Areas	NR BIO	NR ERG	NR FIS	NR MEC	NR QUIM	Mean
Conveying & Supply	0	94	150	22	20	106
Lasts	0	75	0	91	84	83
Modeling	25	200	0	30	0	85
Cut & Stitching	0	110	0	163.5	65	123
Assembly & Soles	0	208	0	142.5	60	137
Finishing & Dispatch	0	82,5	0	60	50	61

Once all the information was gathered, the SVSM was built, which can be seen in Figure 1.

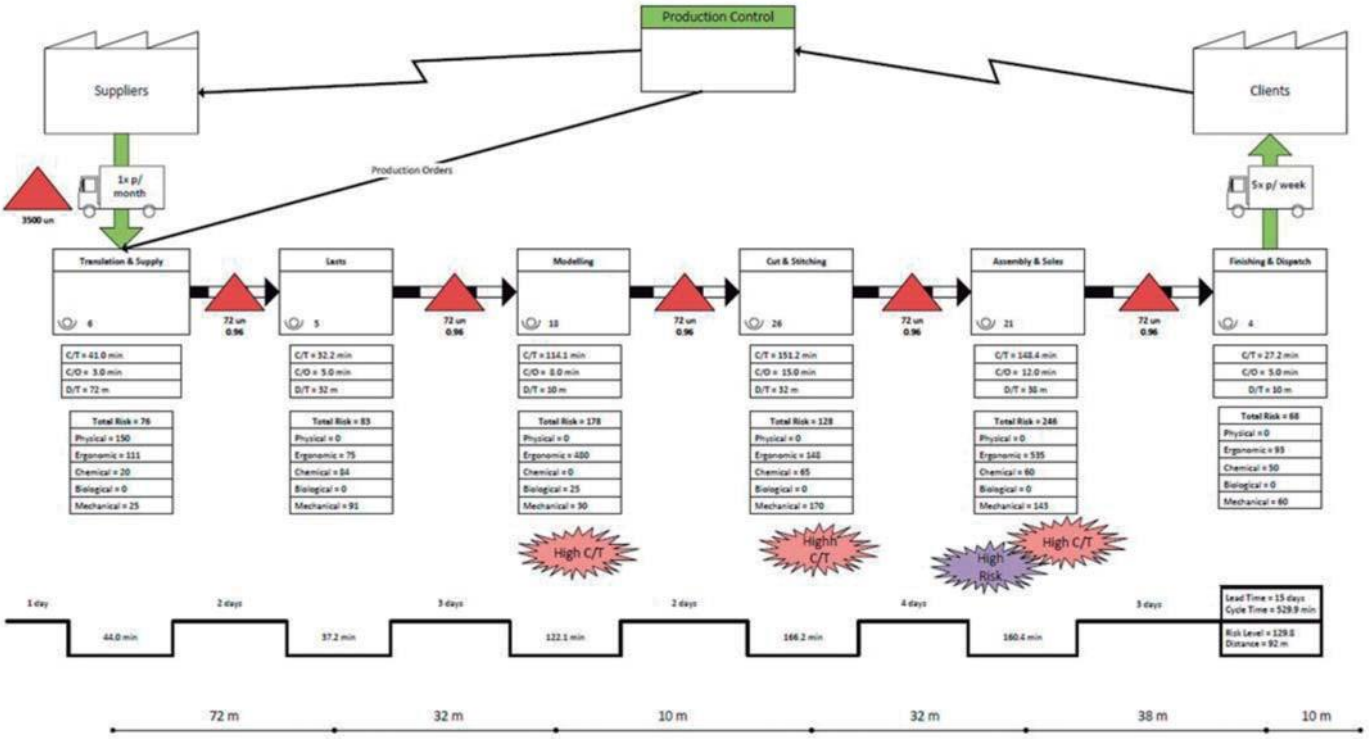


Figure 1. SVSM map before tool implementation.

2.2. Action Planning

It was hypothesized whether Lean tools would have a positive impact on the company's productivity and production flow and, consequently, what effect they would have on safety. For this study, based on previous approaches referred to in the literature, four Lean tools were chosen: TPM, Gemba walk, visual management and Yokoten.

The implementation of a TPM system aims to reduce the waiting time for a problem to be solved and to contribute to the better organization of maintenance operations in order to manage them by priority, duration, or deadlines. The Gemba walk aims to identify and reduce all types of production waste, as well as identify and act on possible safety risks. Visual management aims to speed up the movement of late products through a productive area so that, at the end of the process, companies meet the deadlines agreed with the customer. Finally, Yokoten intends to act on safety in order to reduce the incidence of work accidents. It is believed that these four tools together will be enough to face the usual problems of productivity and safety observed on the company's shopfloor and that this paper intends to identify and help to overcome.

After the implementation of Lean tools, the following positive results are expected: a reduction in the cycle times of each area with the application of Gemba walk and visual

management Lean tools and a reduction in the risk levels in each area with the implementation of TPM and Yokoten Lean tools. It must remain clear that the only component that can be reduced in a work risk is the probability of it happening (the consequence remains unchanged).

2.3. Lean Tool Implementation

Next, the way in which each Lean tool was implemented in practice is described, one by one, in the specific case of the company selected to implement this study.

2.3.1. TPM

To highlight TPM orders, it was decided to create identifying labels, as shown in Figure 2. The three categories are the following: Maintenance (red), Safety (green) and Production (blue). About 264 tags were opened, distributed as follows: 107 for Maintenance, 95 for Production and 62 for Safety. Figure 3 presents the distribution of open tags by problem location.

Figure 2. Template of TPM labels for the categories Maintenance, Safety and Production, respectively.

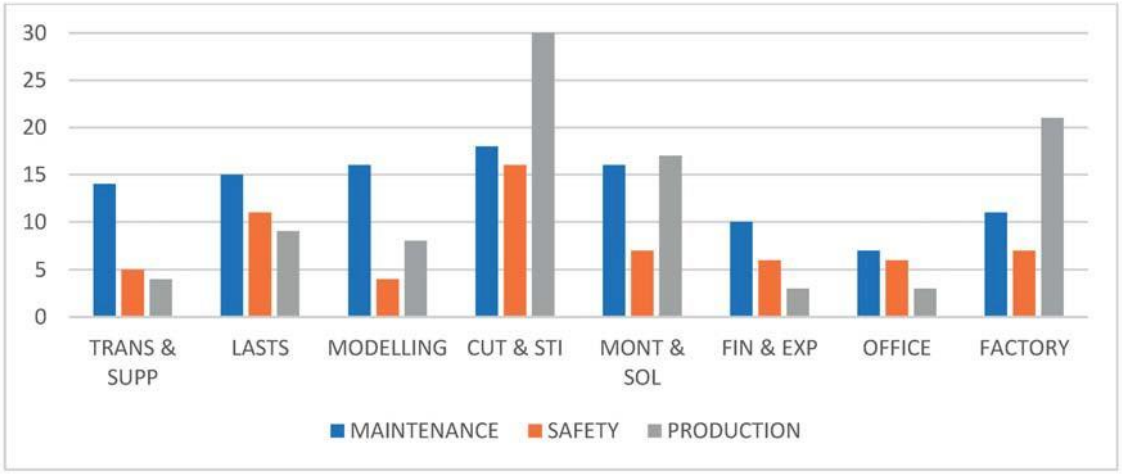


Figure 3. Distribution of open tags by problem location.

2.3.2. Gemba Walk

The second Lean tool implemented was the Gemba walk. For the implementation of this tool, a specific team was created. Moreover, the duration of the experience was set at three days, during which the team made a distribution of subjects to be given greater attention, in addition to a general follow-up with workers in this area and their tasks. In terms of deadlines for solving each task, this was determined considering the availability of those responsible, the priority of the task and its complexity. The areas chosen were

the Supply, Conveying (Trans), Lasts, and Finishing. The graphs in Figures 4 and 5 show, respectively, the distribution of responsibility for resolving all the reported problems by each area visited and the distribution of deadlines for completion.

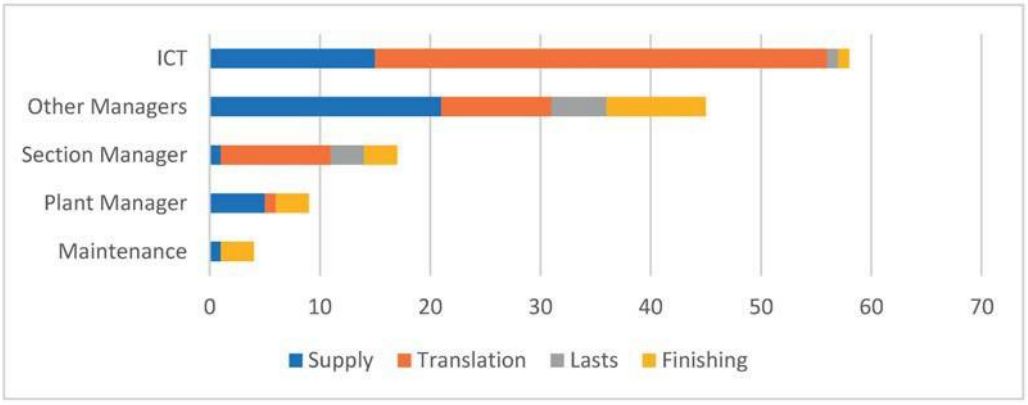


Figure 4. Distribution of responsibility for resolving all the identified problems.

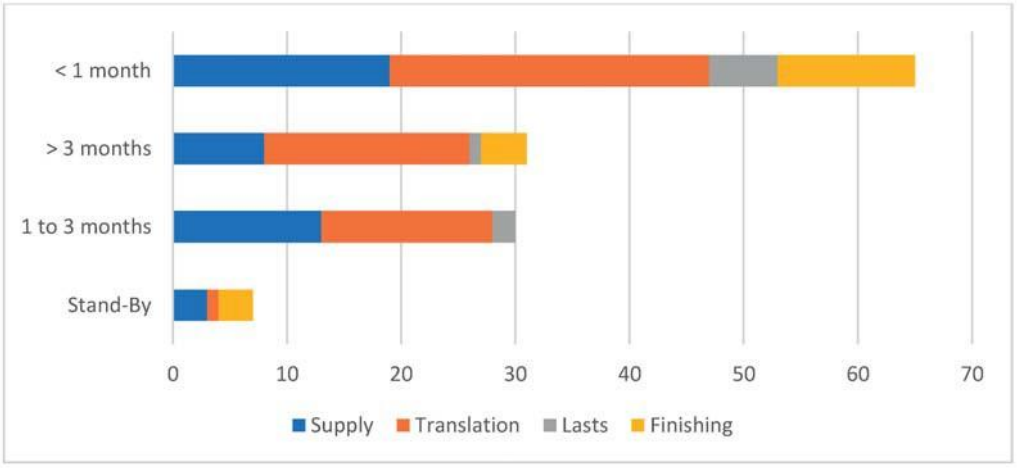


Figure 5. Distribution of deadlines for conclusion.

2.3.3. Visual Management

Regarding the application of the visual management tool, the study assessed the presence of late products in the areas because they are not a permanent focus of attention. It was decided to create a card printed on brightly colored paper indicating that a specific pair is a late pair and needs to be completed urgently. In an experimental phase, the Soles area was chosen (Figure 6).

2.3.4. Yokoten

Regarding safety issues, it was decided to create a document to inform the company workers about accidents and near-accidents at work. The form adopted was a table containing the following information: the description, the material agent of the activity and the type of consequence caused to the worker in terms of injury and days off.

Figure 6. Application of the Visual Management as solution for late pairs on the shop floor (Par Atrasado = Late Pair).

3. Results

This section depicts the "Evaluation" phase of the methodology followed. Table 4 presents the values for the mentioned parameters before and after the implementation of the mentioned tools.

Table 4. Comparison of the values recorded for cycle times, changeover time and distance travelled before and after the implementation of the tools.

Parameter	Time Frame	Translation & Supply Chain	Lasts	Modeling	Cut & Stitching	Assembly & Soles	Finishing & Dispatch
Workers		6 6	5 5	18 16	26 26	22 21	4 4
Dif		0	0	−2	0	−1	0
C/T (min)		41.0 37.0	32.2 28.3	114.1 105.5	151.2 157.5	148.4 155.4	27.2 28.3
Dif (%)		−9.7	−12.0	−7.5	4.2	4.7	4.3
C/O (min)		3 3	5 5	8 8	15 15	12 12	5 5
Dif (%)		0	0	0	0	0	0
D/T (m)		72 72	32 32	10 10	32 32	38 38	10 10
Dif (%)		0	0	0	0	0	0

Regarding safety, first the risks present in each area were reassessed. In relation to the list drawn up at the first moment, there was only one change. The risk levels for each area were recalculated and can be seen in Table 5. The construction of the SVSM map after the application of Lean tools is presented in Figure 7.

Table 5. Distribution of average risk levels divided into five categories present in the production process after the application of the selected Lean tools.

Areas	NR BIO	NR ERG	NR FIS	NR MEC	NR QUIM	Mean
Conveying & Supply	0	109	150	22	20	75
Lasts	0	75	0	91	84	83
Modeling	25	480	0	30	0	178
Cut & Stitching	0	148	0	170	65	128
Assembly & Soles	0	535	0	143	60	246
Finishing & Dispatch	0	93	0	60	50	68

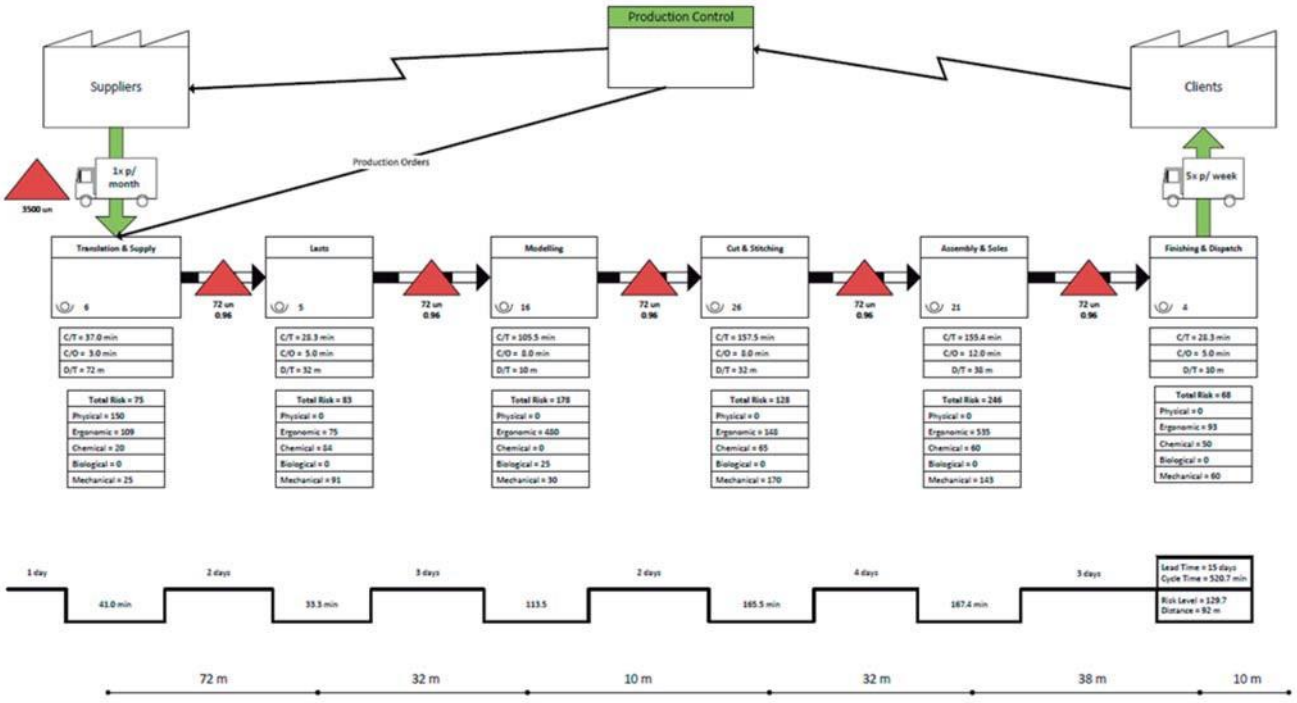


Figure 7. SVSM after the implementation of tools.

A study was carried out for the evolution of the number of accidents in 2021 and 2022, with a special focus on the period from September 2021 to July 2022, the period in which this project was carried out. Figure 8 presents a graph displaying the evolution of the number of accidents at work from January 2021 to July 2022. In blue represents the time before the implementation of the tools and with orange during the implementation.

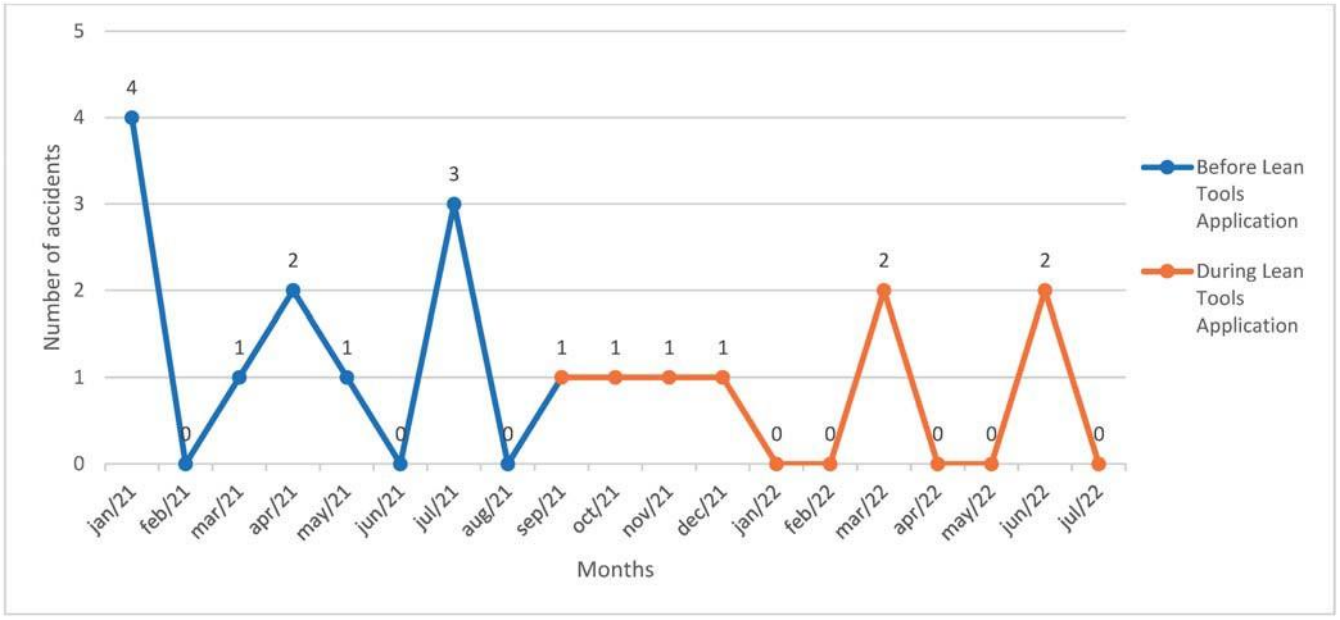


Figure 8. Evolution of the number of accidents at work from January 2021 to July 2022. Blue color: before implementation; Orange color: after implementation.

4. Discussion

The implementation of a set of Lean tools in a company dedicated to the personalized manufacture of shoes to order and still performing a high degree of manual work is a

challenge. Given that the company used to validate the concept has MES software and computerized data collection, possible deviations were minimized as much as possible. Possible errors could be related to forgetting to open or close tasks, joining different tasks in the same record, or stopping the equipment without announcing its stop (micro-stops). It was estimated that the error associated with these factors, in the overall calculation of the study, does not exceed 2%.

Analyzing the new SVSM drawn after the Lean tool implementation, the most time-consuming processes were found to be Cut & Stitching, followed by Assembly & Soles, and finally Modeling. These are areas with a very long cycle time, implying that a greater number of people are required so that the planned level of shoe production for the day can be fulfilled. It is possible to observe that the areas with a higher average risk are Assembly & Soles. The most affected area has a very high ergonomic risk due to the use of hand tools, use of machines and inadequate posture.

Analyzing Table 4, it can be seen that the first three areas underwent a positive change regarding the cycle time, thus managing to complete their work in less time. On the other hand, the remaining areas suffered a slight increase, between 4% and 5%. Gemba walk proved to be a very effective tool in terms of cycle time reduction, promoting a decrease in the cycle time in three of the four intervened areas. With regard to the Gemba walk, at first sight, the number of improvement opportunities proposed clearly indicates that it has a very positive impact through the elimination or improvement of non-optimized actions. Upon questioning the workers, we found their opinions to be directed towards various categories: greater fluidity of the conveying process through the elimination of small, repetitive and tedious steps; greater interconnection between the most relevant IT processes; and the handover of decision making to the IT system in the back office. In the Lasts and Finishing area, the addition of some necessary machines and the layout change in the area has created the necessary workflow and harmony. Also using the Lean VSM, Gemba walk and standard work tools, Rahani and al-Ashraf [52] managed to reduce operator working time by 16.9% and machine time required to assemble a front disc brake system by 14.2%. In this case, a "cocktail" of Lean tools was also used to achieve the desired results in terms of decreasing the cycle time that was necessary.

The implementation of the TPM tool allowed us to register the work performed and what remains to be done, planning the tasks according to priority and the time needed for each intervention. The managers and team leaders highlighted the ease of opening labels and the feeling that their requests are no longer forgotten. These results are corroborated by other research [6,7,48] where a better organization of the maintenance service has induced higher levels of productivity due to less time being wasted on waiting by overcoming equipment breakdowns, tasks scheduling, spare-part management, and so on. This tool can also be supported by other Lean tools, such as SMED (Single Minute Exchange of Die) and others. In the case of this work, allied to the visual management tool, it has produced the required results while also making the workers' workflow easier.

The introduction of the labels on delayed pairs also used the visual management tool and this allowed for a faster identification of these late pairs and for the workers to have a greater focus on the identified work. This urgency becomes more important due to the need to enable the company meet the date agreed upon with the customer. Monteiro et al. [53] also used visual management and other Lean tools to reduce the non-conformities in a metalworking firm. The implementation of new procedures has induced a decrease of 2.04% in the non-conformities detected internally and 3.99% in the non-conformities detected by the customer, improving in this way the image of the company and its performance in the market.

Regarding the Yokoten document, Figure 8 shows the number of accidents from January 2021 to August 2022, with an average value of 1.4 accidents per month. In the period from September 2021 to July 2022, an average of 0.7 accidents per month was reported. This report signals a reduction by half regarding to the previous period. That is a 50% improvement in safety. Sá et al. [37], analyzing a furniture company, stated that 40%

of the workers considered that the implementation of the tools made the workspace more safe.

As in Morgado [46], when the companies are asked about "What are the benefits of a workplace health and safety management system implemented in your company?", some answers were also found in this study, specifically, "Reduction in work accidents", "Improved workers satisfaction" and "Increased productivity".

It is necessary to promote the identification of possible hazards and respective risks and to provide safety training to workers in order to avoid risks and problems.

Monitoring

Monitoring is the last step of the action research methodology. The SVSM map should be updated after fixed periods of time, whenever the people in charge decide so and in the case of regression in terms of productivity or safety indicators. A continuous improvement team should be called to the field in order to approach the situation. This group can act with the intention of intervening through the application of the Lean tools already mentioned, such as the Gemba walk, or others not yet applied and understood as beneficial for each case to be overcome.

To complement the map, which may not be updated daily, a KPI should be built to evaluate the production pace of an area according to the number of pairs made over the time elapsed, and at the safety level this way carried out, to indicate the area's risk levels.

To monitor the visual management tool, surprise internal audits should be carried out to assess whether late pairs are identified and whether workers are aware if they are working on a late pair.

The Yokoten document should be updated whenever there is a new accident and, in the kaizen meeting at the beginning of the following day, the workers should be informed of the event so that it may serve as a precaution against the occurrence of more accidents due to the same reason.

Although this research has achieved its objectives, showing how lean practices have an impact on issues of occupational safety of workers, future research could involve the study and application of SVSM in other types of companies in order to consolidate this study, and help to verify what gains the Lean philosophy brings to the safety of workers at their workplaces. Other tools are suitable for use in this in addition to the four used. Ahmad et al. [54] stated that the use of poka-yoke was able to reduce the risk score from 9 to 3, a reduction of 55.6% in the risk. Kaizen is another tool that can be used, with James [29] stating that the tool improved safety in construction-related industries.

It is important to make it clear that the impact of the different Lean tools used is different. It becomes evident that the Gemba walk and TPM tools provide the best results and offer the least limitations in terms of applicability and universality of solutions. On the other hand, the Yokoten tool presents higher limitations, as it does not produce direct effects on productivity and does not act directly on risk factors, eliminating them or drastically reducing the chances of them occurring. It can be seen that the tools used have a greater relevance to the productivity factor than to directly reducing risk. However, by acting on the productivity factor, tools such as TPM and Gemba walk are producing indirect effects on workers' safety, which gives them greater security and satisfaction at work. Therefore, some questions arise: Is it actually necessary to use the four selected tools simultaneously? Are there other Lean tools capable of producing better effects in terms of reducing accident risks? Regarding the first question, it is clear that TPM and Gemba walk are absolutely necessary, and that the application of TPM can be assisted using visual management. However, visual management was essentially more useful in safeguarding delivery deadlines for batches of shoes that, for whatever reason, were delayed in production. The Yokoten tool had greater limitations than it did a positive impact on the results obtained. As for the second question, which clearly addresses future work, it made sense to apply the 5S tool with a view to improving the conditions of each workplace. In addition, tools such as root cause analysis and 5 whys should be considered whenever an accident occurs, allowing greater

knowledge about its causes, which could help prevent the same from happening again. The application of the PDCA (plan–do–check–act) tool to resolve problems, once the cause has been identified, could also be a valuable aid in pursuing more effective security procedures. These last tools would not be applied permanently, but only when any accident arises. The application of 5S should be intensive and permanent.

The footwear industry is largely located in developing countries, where labor is not yet extremely expensive. In medium or small companies, top management does not always have the appropriate preparation to outline long-term strategies. The methodologies mentioned here can help to assist top managers who are less prepared in terms of management tools to understand the benefits they can extract from the application of these tools, as well as their ease of application. This could induce top management to create training routines for its workers in Lean tools, which could multiply the chances of new ideas and methodologies emerging that could contribute in a much more positive way to increasing the productivity and safety of companies with these specificities.

5. Conclusions

After carrying out this case study, it became clear that, in the first instance, workers who are present at workstations every day have a wide knowledge about equipment and daily operations, and their opinions are a good starting point for identifying what should be improved in the production process. In this aspect, the Gemba walk and the TPM are the most effective tools because they facilitate cooperation between the workers and the management team and create continuous improvement teams in a joint objective of optimizing the production process. Figure 9 shows a summary of the advantages and disadvantages of the Lean tools applied.

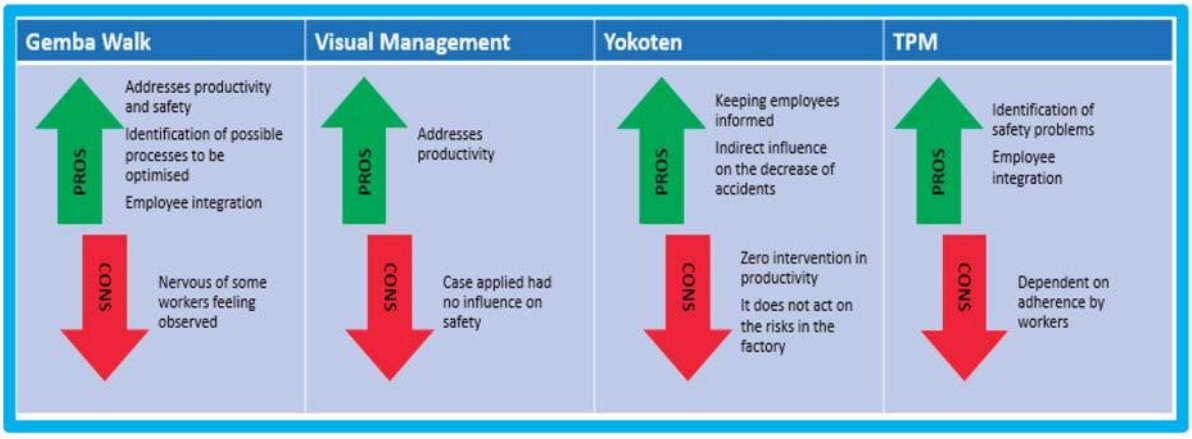


Figure 9. Graphical summary of advantages and limitations on the application of each Lean tool.

These four Lean tools were chosen for this case study was due to the fact that they present great adaptability and are often referred to in the literature as excellent tools for producing effective results after implementation. Nowadays, in a company that already has a Lean culture rooted or is still introducing it, the presence of a TPM system is mandatory. The Gemba walk tool is recommended for its effectiveness in identifying less optimized processes.

During and after the implementation of these tools in the present study, some limitations emerged because the sample in any two moments was not perfectly the same. The fact of being an orthopedic footwear company allows the customer to choose a high quantity of requirements for the shoes in order to make them into a unique piece. This makes it difficult to evaluate the improvements felt after the implementation of Lean tools in a statistical way because the variants to which the production process is exposed are too wide to control. Another conditioning factor is the fact that this is a handcraft company.

This kind of process is very dependent on the knowledge of each worker and the pace of work is dictated by their physical and mental availability, and not by machines.

In conclusion, this study supports the theory that organizations that implement Lean tools can achieve benefits in safety and productivity. In order to draw more conclusions about the impact of Lean tools on occupational safety in a company, more case studies should be conducted in other companies from the most varied sectors. A more adequate selection of Lean tools to the type of product manufactured and to the type of manufacturing could produce more expressive results that contribute to our conclusions as to the impact of the tools.

Author Contributions: The authors made the following contributions to this work: concept about the idea, J.C.S.; J.D.-C. and L.S.; Data Curation, J.C.S.; G.S. and L.S.; Problem analysis J.C.S.; J.D.-C. and L.S.; Investigation J.C.S.; J.D.-C. and L.S.; Methods, J.C.S.; J.D.-C. and F.J.G.S.; Writing—original draft, J.C.S., L.S. and F.J.G.S.; Writing—proofreading improvement and editing, J.C.S.; J.D.-C. and F.J.G.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research did not receive external funding.

Institutional Review Board Statement: ISEP have been contacted by the authors of the manuscript for publication at the Safety Journal. According to the Portuguese legislation, this study caried out in the field of occupational health and safety does not require a pre-approval of an Ethical Committee.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data are available on request.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Silva, F.J.G.; Ferreira, L.P. *Lean Manufacturing – Implementation, Opportunities and Challenges*; Nova—Science Publishers: New York, NY, USA, 2019; ISBN 978-1-53615-725-1.
2. Zhang, B.; Niu, Z.; Liu, C. Lean Tools, Knowledge Management, and Lean Sustainability: The Moderating Effects of Study Conventions. *Sustainability* **2020**, *12*, 956. [CrossRef]
3. García-Alcaraz, J.L.; Díaz Reza, J.R.; Sánchez Ramírez, C.; Limón Romero, J.; Jiménez Macías, E.; Lardies, C.J.; Rodríguez Medina, M.A. Lean Manufacturing Tools Applied to Material Flow and Their Impact on Economic Sustainability. *Sustainability* **2021**, *13*, 10599. [CrossRef]
4. Manzouri, M.; Ab-Rahman, M.N.; Zain, C.R.C.M.; Jamsari, E.A. Increasing Production and Eliminating Waste through Lean Tools and Techniques for Halal Food Companies. *Sustainability* **2014**, *6*, 9179–9204. [CrossRef]
5. Antosz, K.; Pasko, L.; Gola, A. The Use of Intelligent Systems to Support the Decision-Making Process in Lean Maintenance Management. *IFAC-Pap.* **2019**, *52*, 148–153. [CrossRef]
6. Ribeiro, I.M.; Godina, R.; Pimentel, C.; Silva, F.J.G.; Matias, J.C.O. Implementing TPM supported by 5S to improve the availability of an automotive production line. *Procedia Manuf.* **2019**, *38*, 1574–1581. [CrossRef]
7. Pinto, G.F.L.; Silva, F.J.G.; Campilho, R.D.S.G.; Casais, R.B.; Fernandes, A.J.; Baptista, A. Continuous improvement in maintenance: A case study in the automotive industry involving Lean tools. *Procedia Manuf.* **2019**, *38*, 1582–1591. [CrossRef]
8. Singh, C.; Singh, D.; Khamba, J.S. Exploring an alignment of lean practices on the health and safety of workers in manufacturing industries. *Mater. Today Proc.* **2021**, *47*, 6696–6700. [CrossRef]
9. Gietaneh, W.; Molla, M.; Alene, M.; Shitu, D. Magnitude of work related injury, associated factors and its disparity across selected occupations in Ethiopia: Systematic review and meta-analysis. *Dialogues Health* **2023**, *2*, 100093. [CrossRef]
10. Gonçalves, I.; Sá, J.C.; Santos, G.; Gonçalves, M. Safety stream mapping—A new tool applied to the textile company as a case study. *Stud. Syst. Decis. Control* **2019**, *202*, 71–79. [CrossRef]
11. Veisi, H.; Choobineh, A.; Ghaem, H.; Shafiee, Z. The effect of hand tools' handle shape on upper extremity comfort and postural discomfort among hand-woven shoemaking workers. *Int. J. Ind. Ergon.* **2019**, *74*, 102833. [CrossRef]
12. Babur, F.; Cevikcan, E.; Durmusoglu, M.B. Axiomatic Design for Lean-oriented Occupational Health and Safety systems: An application in shipbuilding industry. *Comput. Ind. Eng.* **2016**, *100*, 88–109. [CrossRef]
13. Ahmed, I.; Faheem, A. How Effectively Safety Incentives Work? A Randomized Experimental Investigation. *Saf. Health Work* **2021**, *12*, 20–27. [CrossRef] [PubMed]
14. Bae, H.; Simmons, D.R.; Polmear, M. Promoting the Quarry Workers' Hazard Identification Through Formal and Informal Safety Training. *Saf. Health Work* **2021**, *12*, 317–323. [CrossRef] [PubMed]
15. Lee, H.; Ahn, H.; Park, C.G.; Kim, S.J.; Moon, S.H. Psychosocial Factors and Work-related Musculoskeletal Disorders among Southeastern Asian Female Workers Living in Korea. *Saf. Health Work* **2011**, *2*, 183–193. [CrossRef]

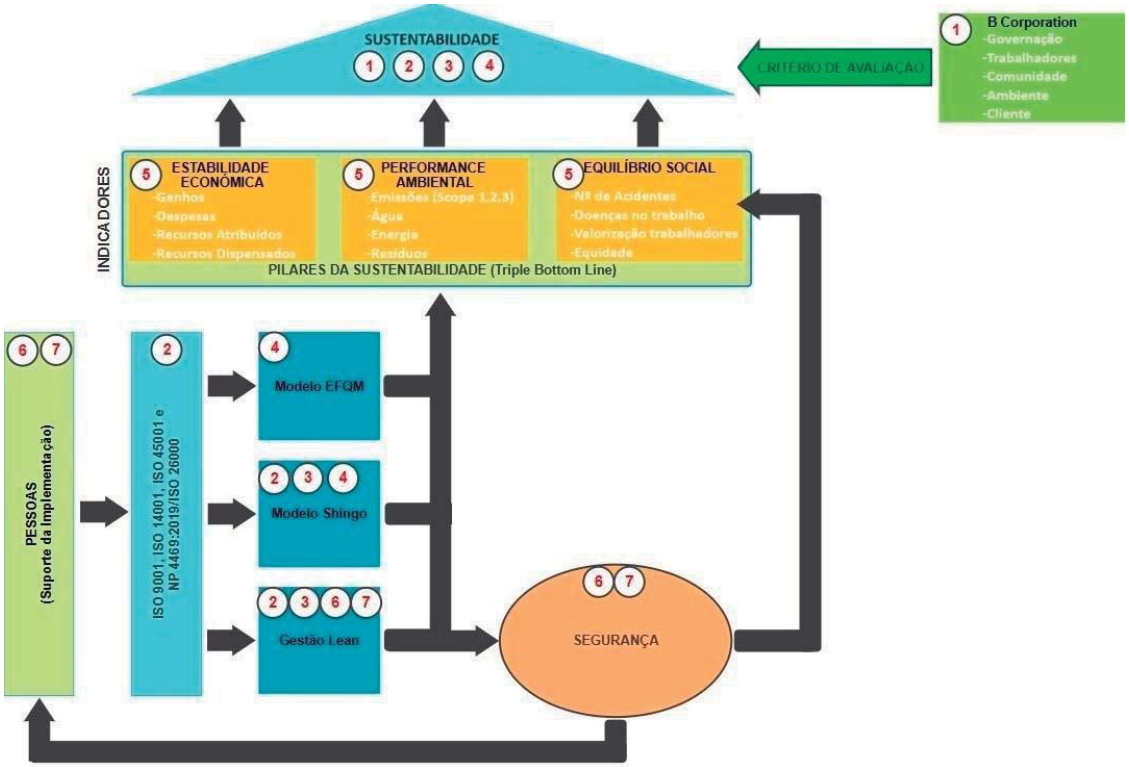
16. Marques Filho, J.P.T. Melhoria do Processo Produtivo e da Segurança Através da Aplicação das Ferramentas Lean Numa Empresa Metalomecânica (in Portuguese). Master's Dissertation, Engineering and Industrial Management, Department of Mechanical Engineering, Polytechnic Institute of Porto, School of Engineering, Porto, Portugal, 2020. Available online: https://recipp.ipp.pt/handle/10400.22/16926 (accessed on 2 January 2023).
17. Brito, M.F.; Ramos, A.L.; Carneiro, P.; Gonçalves, M.A. A continuous improvement assessment tool, considering lean, safety and ergonomics. *Int. J. Lean Six. Sigma* **2019**, *11*, 879–902. [CrossRef]
18. Aqlan, F.; Lam, S.S.; Ramakrishnan, S.; Boldrin, W. Integrating lean and ergonomics to improve internal transportation in a manufacturing environment. In Proceedings of the IIE Annual Conferencee, Montreal, Canada, 31 May–3 June 2014; Available online: https://www.researchgate.net/publication/284724181_Integrating_Lean_and_Ergonomics_to_Improve_Internal_Transportation_in_a_Manufacturing_Environment (accessed on 4 September 2023).
19. Pereira, A.C.; Alves, A.C.; Arezes, P. Augmented Reality in a Lean Workplace at Smart Factories: A Case Study. *Appl. Sci.* **2023**, *13*, 9120. [CrossRef]
20. Crema, M.; Verbano, C. How to combine lean and safety management in health care processes: A case from Spain. *Safe. Sci.* **2015**, *79*, 63–71. [CrossRef]
21. Ammavasi, P.P.; Arumugam, K.; Sundram, A.M. Integrated Lean Safety Model to Develop Organizational Safety Culture. In *Six Sigma and Quality Management*; Pereira, P., Xavier, S., Eds.; IntechOpen: London, UK, 2022; pp. 1–13. [CrossRef]
22. Ateekh-ur-Rehman, L.U.R. Safety management in a manufacturing company: Six Sigma approach. *Engineering* **2012**, *4*, 400–407. [CrossRef]
23. Rhodes, J.; Lok, P.; Diamond, A.; Bhatia, N. The Six Sigma approach in performance management to reduce injury rate at work. *Int. J. Six. Sigma Comp. Adva.* **2008**, *1*, 188–209. [CrossRef]
24. Radin Umar, R.Z.; Tiong, J.Y.; Ahmad, N.; Dahalan, J. Development of framework integrating ergonomics in Lean's Muda, Muri, and Mura concepts. *Product. Plan. Control* **2023**, 1–9. [CrossRef]
25. Abu Aisheh, Y.I.; Tayeh, B.A.; Alaloul, W.S.; Almalki, A. Health and safety improvement in construction projects: A lean construction approach. *Int. J. Occup. Saf. Erg.* **2021**, *28*, 1981–1993. [CrossRef]
26. Nikolou-Walker, E.; Lavery, K. A work-based research assessment of the impact of 'lean manufacturing' on health and safety education within an SME. *Res. Post-Compuls. Educ.* **2009**, *14*, 441–458. [CrossRef]
27. Moldovan, F.; Moldovan, L.; Bataga, T. Assessment of Labor Practices in Healthcare Using an Innovatory Framework for Sustainability. *Medicina* **2023**, *59*, 796. [CrossRef]
28. Mutaza, M.S.R.; Che Ani, M.N.; Hassan, A. Investigation the Impact of 5S Implementation Toward Accident-Free Manufacturing Industries. *Adv. Struct. Mater.* **2020**, *131*, 199–204. [CrossRef]
29. James, J.; Ikuma, L.H.; Nahmens, I.; Aghazadeh, F. The impact of Kaizen on safety in modular home manufacturing. *Int. J. Adv. Manuf. Technol.* **2014**, *70*, 725–734. [CrossRef]
30. Lee, E.; Grooms, R.; Mamidala, S.; Nagy, P. Six Easy Steps on How to Create a Lean Sigma Value Stream Map for a Multidisciplinary Clinical Operation. *J. Am. Coll. Radiol.* **2014**, *11*, 1144–1149. [CrossRef] [PubMed]
31. Arey, D.; Le, C.H.; Gao, J. Lean industry 4.0: A digital value stream approach to process improvement. *Procedia Manuf.* **2021**, *54*, 19–24. [CrossRef]
32. Li, C.; Chang, Q. Hybrid feedback and reinforcement learning-based control of machine cycle time for a multi-stage production system. *J. Manuf. Syst.* **2022**, *65*, 351–361. [CrossRef]
33. Olakotan, O.O.; Yusof, M.M. Evaluating the alert appropriateness of clinical decision support systems in supporting clinical workflow. *J. Biomed. Inform.* **2020**, *106*, 103453. [CrossRef] [PubMed]
34. Arifin, A.; Mohd-Yusof, M. Error evaluation in the laboratory testing process and laboratory information systems. *J. Med. Biochem.* **2022**, *41*, 21–31. [CrossRef]
35. Glegg, S.M.N.; Ryce, A.; Brownlee, K. A visual management tool for program planning, project management and evaluation in paediatric health care. *Eval. Program. Plann.* **2019**, *72*, 16–23. [CrossRef]
36. Jaca, C.; Viles, E.; Jurburg, D.; Tanco, M. Do companies with greater deployment of participation systems use Visual Management more extensively? An exploratory study. *Int. J. Prod. Res.* **2014**, *52*, 1755–1770. [CrossRef]
37. Sá, J.C.; Manuel, V.; Silva, F.J.G.; Santos, G.; Ferreira, L.P.; Pereira, T. Lean Safety—Assessment of the impact of 5S and Visual Management on safety. *IOP Conf. Ser. Mater. Sci. Eng.* **2021**, *1193*, 012049. [CrossRef]
38. Machikita, T.; Tsuji, M.; Ueki, Y. Does Kaizen create backward knowledge transfer to Southeast Asian firms? *J. Bus. Res.* **2016**, *69*, 1556–1561. [CrossRef]
39. Fernando, L.; Evans, S. Competencies to Move beyond Eco-efficiency. *Procedia CIRP* **2016**, *40*, 365–371. [CrossRef]
40. Suryaprakash, M.; Prabha, M.G.; Yuvaraja, M.; Revanth, R.V.R. Improvement of overall equipment effectiveness of machining centre using TPM. *Mater. Today Proc.* **2021**, *46*, 9348–9353. [CrossRef]
41. Dieste, M.; Baseggio, A.; Panizzolo, R.; Biazzo, M. Lean Thinking and Workplace Safety: Insights from two improvement projects. In Proceedings of the International Conference on Industrial Engineering and Operations Management, Dubai, UAE, 10–12 March 2020; Available online: www.ieomsociety.org/ieom2020/papers/695.pdf (accessed on 24 August 2023).
42. Sá, J.C.; Jorge, J.P.; Santos, G.; Félix, M.J.; Barreto, L.; Jiménez-Delgado, G. Assessing the Impact of Lean Tools on Production and Safety by a Multicriteria Decision-Making Model and Statistical Analysis: A Case Study in Textile Sector. In Proceedings of the

HCI International 2021—Late Breaking Papers: HCI Applications in Health, Transport, and Industry, Virtual Event, 24–29 July 2021; pp. 616–638. [CrossRef]
43. Powell, D.; Coughlan, P. Corporate Lean Programs: Practical Insights and Implications for Learning and Continuous Improvement. *Procedia CIRP* **2020**, *93*, 820–825. [CrossRef]
44. Pereira, A.; Abreu, M.F.; Silva, D.; Alves, A.C.; Oliveira, J.A.; Lopes, I. Reconfigurable Standardized Work in a Lean Company—A Case Study. *Procedia CIRP* **2016**, *52*, 239–244. [CrossRef]
45. MÍlkva, M.; Prajová, V.; Yakimovich, B.; Korshunov, A.; Tyurin, I. Standardization—One of the Tools of Continuous Improvement. *Procedia Eng.* **2016**, *149*, 329–332. [CrossRef]
46. Morgado, L.; Silva, F.J.G.; Fonseca, L.M. Mapping Occupational Health and Safety Management Systems in Portugal: Outlook for ISO 45001:2018 adoption. *Procedia Manuf.* **2019**, *38*, 755–764. [CrossRef]
47. Mello, C.H.P.; Turrioni, J.B.; Xavier, A.F.; Campos, D.F. Pesquisa-ação na engenharia de produção: Proposta de estruturação para sua condução. *Producão* **2012**, *22*, 1–13. [CrossRef]
48. Marinho, P.; Pimentel, D.; Casais, R.; Silva, F.J.G.; Sá, J.C.; Ferreira, L.P. Selecting the best tools and framework to evaluate equipment malfunctions and improve the OEE in the cork industry. *Int. J. Ind. Eng. Manag.* **2021**, *12*, 286. [CrossRef]
49. Mourato, J.; Ferreira, L.P.; Sá, J.C.; Silva, F.J.G.; Dieguez, T.; Tjahjono, B. Improving internal logistics of abus manufacturing using the lean techniques. *Int. J. Product. Perform. Manag.* **2020**, *70*, 1930–1951. [CrossRef]
50. Martins, R.; Pereira, M.T.; Ferreira, L.P.; Sá, J.C.; Silva, F.J.G. Warehouse operations logistics improvement in a cork stopper factory. *Procedia Manuf.* **2020**, *51*, 1723–1729. [CrossRef]
51. Bulhões, N.P. Identificação de Perigos e Avaliação de Riscos na Indústria Alimentar (in Portuguese). Master's Thesis, Master's Degree in Environment, Health and Safety, Department of Biology, University of Azores, Azores, Portugal, 2015. Available online: https://repositorio.uac.pt/bitstream/10400.3/3332/2/DissertMestradoNicolePimentelBulhoes2015.pdf (accessed on 16 August 2023).
52. Rahani, A.R.; Al-Ashraf, M. Production Flow Analysis through Value Stream Mapping: A Lean Manufacturing Process Case Study. *Procedia Eng.* **2012**, *41*, 1727–1734. [CrossRef]
53. Monteiro, C.; Ferreira, L.P.; Fernandes, N.O.; Silva, F.J.G. Amaral, Improving the Machining Process of the Metalworking Industry by Upgrading Operative Sequences, Standard Manufacturing Times and Production Procedure Changes. *Procedia Manuf.* **2019**, *38*, 1713–1722. [CrossRef]
54. Ahmad, A.A.; Rashid, A.A.; Wong, F.R.; Iqbal, M. Worker Safety Improvement at Paper Pleating Production Line Using Poka-Yoke Concept—A Case Study in Automotive Industry. *J. Mech. Eng.* **2017**, *4*, 183–196. Available online: https://ir.uitm.edu.my/id/eprint/39346/1/39346.pdf (accessed on 16 August 2023).

4 CONCLUSÕES E TRABALHO FUTURO

4.1 Discussão

O modelo concetual ***OpEx SafeSustain*** (Figura 23) proposto neste estudo, pretende ser um contributo para a comunidade científica, no que se refere aos contributos que os modelos OpEX podem dar à sustentabilidade e segurança nas organizações.



Legenda:

1 – Artigo com o título *"Sustainability - B Corporation Geo Distribution"*

2 – Artigo com o título *"Development of a conceptual model integrating management systems and the Shingo Model towards operational excellence"*

3 – Artigo com o título *"The Development of an Excellence Model Integrating the Shingo Model and Sustainability"*

4 – Artigo com o título *"A New Conceptual Model for Excellence in Business Towards Sustainable Development"*

5 – Artigo com o título *"Science Based Targets and the factors contributing to the sustainable development of an organisation from a Litera-ture review to a conceptual model"*

6 – Artigo com o título *"The Impact of Lean on Occupational Safety in Organisations"*

7 – Artigo com o título *"Assessment of the Impact of Lean Tools on the Safety of the Shoemaking Industry"*

Figura 23 - Modelo conceptual OpEx SafeSustain suportado pelos artigos

A proposta do modelo concetual ***OpEx SafeSustain***, sugere que a melhor opção para as organizações, será iniciarem o caminho rumo à Excelência Operacional (OpEx) pela adoção dos referenciais normativos ISO 9001, ISO 14001, ISO 45001 e NP 4460 (ISO 26000) (Carvalho et al., 2023), dado estes referenciais terem critérios iniciais que permitem às organizações estarem mais bem preparadas, para avançarem para níveis mais avançados de gestão, rumo à excelência.

O modelo conceitual ***OpEx SafeSustain*** destaca a importância da adoção dos modelos Excelência Operacional (OpEx), como o Modelo de Shingo, Modelo EFQM e a filosofia *Lean*, para a melhoria da sustentabilidade nas organizações (Sá et al., 2022; Sá et al, 2023). O impacto destes modelos OpEx pode ser avaliado internamente pelas organizações, através da adoção de uma versão alargada dos *Science Based Targets* (SBT) (Sá et al., 2023), ou através de uma avaliação externa para um reconhecimento externo *B Corporation* (Sá et al., 2024).

Por outro lado, o modelo concetual ***OpEx SafeSustain***, evidencia também que a adoção da filosofia *Lean*, tem um impacto positivo na melhoria das condições de segurança dos trabalhadores (*Lean Safety*) (Sá et al, 2022; Sá et al., 2023), contribuindo desta forma, para o seu bem-estar, e um melhor desempenho dos trabalhadores. O modelo também identifica outro impacto positivo da filosofia *Lean* na segurança (*Lean Safety*), que se refere ao seu impacto direto no pilar social da sustentabilidade.

4.2 Conclusões

A importância da sustentabilidade é atualmente uma das principais preocupações da sociedade. Nesse sentido as empresas e os mercados, tornaram esse tema como prioritário e estratégico. O aparecimento do modelo de certificação *B Corporation*, apesar de ser uma certificação ainda em desenvolvimento, tem ajudado as organizações que optaram por esta certificação, a tomarem conhecimento do estado em que se encontram, ao nível da sustentabilidade. Por vezes os clientes têm exigido aos seus fornecedores esta certificação, dado terem nas suas preocupações estratégicas, a sustentabilidade. Desta forma pretendem impor níveis de sustentabilidade interessantes nas três dimensões, aos seus fornecedores, criando desta forma cadeias de empresas sustentáveis. A distribuição geográfica de empresas com certificação *B Corporation*, demonstra que apesar de existir um maior número de cerificações em alguns países, esta certificação já se encontra bastante disseminada por todo o globo. Este facto permite-nos constatar, que por todo o planeta a sustentabilidade, passou a integrar as preocupações das empresas.

Os modelos de excelência como o Modelo de Shingo e o Modelo EFQM, são opções que as empresas têm adotado como modelos de gestão, dado estes modelos contribuírem de forma positiva para a sustentabilidade das empresas, como é demonstrado pela literatura. Neste processo de transformação, a literatura chama a atenção da importância dos recursos humanos das empresas. Nesse sentido será importante uma clara aposta na capacitação e na satisfação dos seus recursos humanos, dado que apenas trabalhadores empenhados e motivados serão capazes de ajudar a empresa a alcançar resultados sustentáveis.

No que se refere especificamente ao Modelo de Shingo, e através do desenvolvimento de um modelo concetual foi possível concluir que as empresas que tenham previamente implementado um Sistema Integrado de Gestão de Qualidade (ISO 9001), Ambiente (ISO 14001), Segurança (ISO 45001) e Responsabilidade Social (NP 4469), que terão estarão mais bem preparadas para adotarem o Modelo de Shingo. Isto resulta das empresas nestas situações, terem já implementados um conjunto de requisitos normativos destes quatro sistemas referências normativas, que estão alinhados com os princípios orientadores do Modelo de Shingo.

A emissão de gases com efeito estufa, é um dos fatores que mais tem contribuído para as alterações climáticas e ao aparecimento das catástrofes naturais. Os *Science Based Targets* (SBT) atualmente são um excelente meio de apoio na tomada de decisão, por parte da gestão, dado que indicam qual o caminho que as empresas deverão adotar, por forma a reduzirem as suas emissões de gases com efeito estufa, contribuindo de forma positiva para a sustentabilidade ambiental. Através da literatura foi possível verificar aspetos positivos e algumas dificuldades dos SBT, bem como a possibilidade de integração da filosofia *Lean*, com os conceitos do Green e ainda KPI no seu modelo. A dificuldade detetada, está relacionado com o facto de as empresas utilizarem diferentes KPIs, o que se torna num problema para a gestão, devido a falta de normalização, o que dificulta comparações entre as empresas. Outro aspeto observado na literatura, está relacionado com aumentar exponencial ao longo dos últimos anos, de indicadores ambientais, com especial destaque para os indicadores relacionados com os gases com efeitos estufa.

No que se refere a segurança, podemos afirmar que os modelos de excelência operacional, como o Modelo de Shingo, a filosofia *Lean*, o Modelo EFQM e o *Toyota Way*, são modelos de gestão que contribuem de forma positiva para a segurança dos trabalhadores. No que se refere ao Modelo de Shingo, os valores culturais que suportam o modelo, promove o bem-estar e a segurança dos trabalhadores. A filosofia *Lean* tem como foco a eliminação dos desperdícios em todas as

atividades dos processos. Esta situação permite melhorar a eficiência, reduzindo desta forma a pressão sobre os trabalhadores, para que estes produzissem a um ritmo insustentável. O Modelo EFQM promove a excelência em todas as áreas da organização, incluindo a segurança dos trabalhadores. Ao avaliar e melhorar constantemente a excelência operacional, as organizações que adotam o Modelo EFQM têm maior probabilidade de identificar e mitigar os riscos ocupacionais. Acresce ainda o facto deste modelo valorizar fortemente o envolvimento e a responsabilidade de todos os trabalhadores, a todos os níveis da organização, o que fortalece a cultura de segurança da empresa. O Toyota Way por seu lado, também tem o seu foco na melhoria contínua e na eliminação de desperdícios em todas as suas atividades. A cultura da *Toyota* sempre teve uma abordagem com foco na segurança dos seus trabalhadores e na eliminação de riscos ocupacionais nos processos produtivos. Além disso, promove o respeito pelos funcionários e valoriza sua contribuição na identificação de riscos e na melhoria da segurança. Os trabalhos apresentados, comprovam que as práticas *Lean* melhoram as condições de segurança dos trabalhadores, aqui que se tem designado por *"Lean Safety"*.

4.3 Oportunidades para Investigações Futuras

Como recomendações de investigação futura, recomenda-se os seguintes trabalhos de investigação:

- Investigar de forma mais aprofundada os processos de certificação de *empresas B Corp*, e encontrar áreas de melhoria, e de que forma podem contribuir para a melhoria da sustentabilidade das empresas;
- Identificar outras ferramentas com impacto na área social e ambiental dado serem os pilares que apresentam o menor volume de ferramentas no modelo concetual apresentado no artigo "*The Development of an Excellence Model Integrating the Shingo Model and Sustainability*", determinando uma metodologia para quantificar os efeitos destas ferramentas através de indicadores-chave de desempenho de forma a direcioná-las para objetivos mais específicos;
- Investigar e colmatar as lacunas relativas à falta de estudos práticos sobre a nova versão do modelo EFQM e o modelo Shingo com a sustentabilidade;
- Investigar de que forma o modelo concetual apresentado no artigo *"Development of a Conceptual Model Integrating Management Systems and the Shingo Model Towards"* poderá ser melhorado, através da sua aplicação em outros ambientes empresariais, e medir o impacto que o modelo e poderá ter;

- Testar a validade do modelo concetual apresentado no artigo *"Science Based Targets and the Factors Contributing to the Sustainable Development of an Organisation From"*, através de um questionário às empresas, ou através da implementação em empresas;
- Aplicar o *Safety Value Stream Mapping*, apresentado no artigo *"Assessment of the Impact of Lean Tools on the Safety of the Shoemaking Industry"*, em outros tipos de atividades industriais, para consolidar o *Lean Safety*, ou seja, investigar qual o real impacto do *Lean* da segurança.

Referências Bibliográficas

Adamek, P. (2018). An investigation of interconnection between business excellence models and corporate sustainability approach. European Journal of Sustainable Development, 7(1), 381-381. doi: 10.14207/ejsd.2018.v7n1p381

Andersen, I., Ishii, N., Brooks, T., Cummis, C., Fonseca, G., Hillers, A., Macfarlane, N., Nakicenovic, N., Moss, K., Rockström, J., Steer, A., Waughray, D., & Zimm, C. (2021). Defining 'science-based targets'. *National Science Review*, 8(7), nwaa186. doi:10.1093/nsr/nwaa186

B Corporation. (2021). *Certified B Corporation*. https://bcorporation.net/

Bastos, A., Sá, J., Silva, O., & Fernandes, M. C. (2014). A study on the reality of Portuguese companies about work health and safety. *Occupational Safety and Hygiene II*, 1, 687-691.

Bebbington, J., & Unerman, J. (2018). Achieving the United Nations Sustainable Development Goals: an enabling role for accounting research. Accounting. *Auditing & Accountability Journal*, 31(1), 2-24. doi:10.1108/AAAJ-05-2017-2929.

Bendig, D., Wagner, A., & Lau, K. (2023). Does it pay to be science-based green? The impact of science-based emission-reduction targets on corporate financial performance. *Journal of Industrial Ecology*, 27(1), 125-140. doi: 10.1111/jiec.13341

Bjørn, A., Matthews, H. D., Hadziosmanovic, M., Desmoitier, N., Addas, A., & Lloyd, S. M. (2023). Increased transparency is needed for corporate science-based targets to be effective. *Nature Climate Change*, 13(8), 756-759. doi:10.1038/s41558-023-01727-z

Burton, I. (1987). Report on reports: Our common future: The world commission on environment and development. *Environment: Science and Policy for Sustainable Development*, 29(5), 25-29. doi:10.1080/00139157.1987.9928891

Carvalho, J. D. (2023). *Continuous Improvement in Organizations*. CRC Press.

Carvalho, M., Sá, J. C., Marques, P. A., Santos, G., & Pereira, A. M. (2023). Development of a conceptual model integrating management systems and the Shingo Model towards operational excellence. *Total Quality Management & Business Excellence*, 34(3-4), 397-420. doi: 10.1080/14783363.2022.2060810.

Ciannella, S., & Santos, L. C. (2022). Exploring the influence of lean manufacturing practices on employee social sustainability. *Social Responsibility Journal*. 18(8), 1677-1691. doi:10.1108/SRJ 062021 0229.

Cordeiro, P., Sá, J. C., Pata, A., Gonçalves, M., Santos, G., & Silva, F. J. G. (2020). The impact of lean tools on safety-case study. *Occupational and Environmental Safety and Health II.* 151-159. doi:10.1007/978-3-030-41486-3_17.

de Menezes, L. M., Escrig-Tena, A. B., & Bou-Llusar, J. C. (2022). Sustainability and Quality Management: has EFQM fostered a Sustainability Orientation that delivers to stakeholders?. *International Journal of Operations & Production Management*, 42(13), 155-184. doi:10.1108/IJOPM-10-2021-0634.

Dehdasht, G., Zin, R. M., Keyvanfar, A., & Muhammad, N. Z. (2018). A model development for lean safety planning in design phase of construction. *Advanced Science Letters*, 24(6), 4166-4171. doi: 10.1166/asl.2018.11564

Dinis-Carvalho, J. & Macedo, H. (2021). Toyota Inspired Excellence Models. Learning in the Digital Era: 7th European Lean Educator Conference, ELEC 2021, Trondheim, Norway, October 25–27, 2021, Proceedings 7, 235-246. Springer International Publishing. doi:10.1007/978-3-030-92934-3_24.

EFQM (2019). *EFQM Model Brochure*. European Foundation for Quality Management.

Elkington, J. (1998). Partnerships from cannibals with forks: The triple bottom line of 21st-Century Business. *Environmental Quality Management*. 8(1), 37-51. doi:10.1002/tqem.3310080106.

Ferreira, C. D. S., Poltronieri, C. F., & Gerolamo, M. C. (2019). ISO 14001: 2015 and ISO 9001: 2015: analyse the relationship between these management systems standards and corporate sustainability. *Gestão & Produção*, 26, e3906. doi:10.1590/0104-530X3906-19

Gao, S., & Low, S. P. (2014). The Toyota Way model: an alternative framework for lean construction. *Total Quality Management & Business Excellence*, 25(5-6), 664-682. doi:10.1080/14783363.2013.820022.

Gimenez, C., Sierra, V., & Rodon, J. (2012). Sustainable operations: Their impact on the triple bottom line. *International journal of production economics*, 140(1), 149-159. doi:10.1016/j.ijpe.2012.01.035

Hafey, R. B. (2010). *Lean safety: Transforming Your Safety Culture with Lean Management*. CRC Press.

Heinrich, H.W., Peterson, D., & Roos, N. (1980). *Industrial Accident Prevention*. New York, NY, USA: McGraw-Hill.

Helleno, A. L., de Moraes, A. J. I., & Simon, A. T. (2017). Integrating sustainability indicators and Lean Manufacturing to assess manufacturing processes: Application case studies in Brazilian industry. *Journal of Cleaner Production*, 153, 405-416. doi:10.1016/j.jclepro.2016.12.072.

Henderson, B., Larco, J. & Martin, S. (2003). *Lean Transformation: How to Change Your Business into a Lean Enterprise*. The Oaklea Press.

Jankal, R., & Jankalova, M. (2016). The application of the EFQM excellence model by the evaluation of corporate social responsibility activities of companies. *Procedia Economics and Finance*, 39, 660-667. doi: 10.1016/S2212-5671(16)30313-6

Juran, J. M. (1999). Juran's quality handbook.

Kavouras, S., Vardopoulos, I., Mitoula, R., Zorpas, A. A., & Kaldis, P. (2022). Occupational health and safety scope significance in achieving sustainability. *Sustainability*, 14(4), 2424. doi:10.3390/su14042424

Kelly, S., & Hines, P. (2019). Discreetly embedding the Shingo principles of enterprise excellence at Abbott Diagnostics manufacturing facility in Longford Ireland. *Total Quality Management & Business Excellence*, 30(11-12), 1235-1256. doi:10.1080/14783363.2017.1363645.

Krafcik, J. F. (1988). Triumph of the lean production system. *Sloan management review*, 30(1), 41-52.

Kwon, Y. G., & Park, H. J. (2002). Factor analysis of safety for visitors to a mega-event. *International Journal of Occupational Safety and Ergonomics*, 8(3), 365-375. doi:10.1080/10803548.2002.11076536.

L. Ateekh-ur-Rehman, L. (2012). Safety Management in a Manufacturing Company: Six Sigma Approach. *Engineering*, 4(7), 400-407. doi:10.4236/eng.2012.47053.

Liker, J.K. (2004). *The Toyota way: 14 management principles from the world's greatest manufacturer*. New York: McGraw-Hill, 1st Edition.

Marien, M. (1992). Environmental problems and sustainable futures: Major literature from WCED to UNCED. *Futures*, 24(8), 731-757. doi: 10.1016/0016-3287(92)90104-N

Marques, J. P., Sá, J. C., Silva, F. J. G., Pereira, T., Ferreira, L. P., & Santos, G. (2021). Safety efficiency value stream mapping (SEVSM)-A new tool to support the implementation of Lean Safety. *IOP Conference Series: Materials Science and Engineering*, 1193(1), 012124). doi:10.1088/1757-899X/1193/1/012124.

McIntoshFletcher, D., Little, J.C., Magers, J. (1997). The power of combining research data and the wisdom of people. AQP'S 19TH Annual Spring Conference and Resource Mart, 1997 Proceedings "The Spirit of Working Together", 456-466.

Moroz, P. W., Branzei, O., Parker, S. C., & Gamble, E. N. (2018). Imprinting with purpose: Prosocial opportunities and B Corp certification. Journal of Business Venturing, 33(2), 117-129. doi: 10.1016/j.jbusvent.2018.01.003

Nawaz, W., Linke, P., & Koç, M. (2019). Safety and sustainability nexus: A review and appraisal. *Journal of Cleaner Production*, 216, 74-87. doi: 10.1016/j.jclepro.2019.01.167

Ohno, T. (1988). *Toyota production system: beyond large-scale production*. Productivity press.

Paelman, V., Van Cauwenberge, P., & Vander Bauwhede, H. (2020). Effect of B Corp certification on short-term growth: European evidence. *Sustainability*, 12(20), 8459. doi: 10.3390/su12208459.

Plenert, G. (2021). *Driving the Enterprise to Sustainable Excellence—A Shingo Process Overview* (1st ed.). Taylor and Francis.

Pramjeeth, S., & Mutambara, E. (2022). Achieving Organisational Deliverables During the Covid-19 Pandemic Using the Shingo Guiding Principles at Eskom South Africa. *Journal of Public Administration*, 57(4), 770-787. https://hdl.handle.net/10520/ejc-jpad_v57_n4_a3

Quintero-Garzón, M. L., Carrión-García, A., Jordá-Rodríguez, M. A., & Rodríguez-Córdoba, M. (2015). Corporate Social Responsibility and the EFQM excellence model as a frame work for integration of management systems in organizations. *Ingeniería y competitividad*, 17(1), 9-22.

Robertson, J. (2000). The three Rs of action research methodology: reciprocity, reflexivity and reflection-on-reality. *Educational action research*, 8(2), 307-326. doi: 10.1080/09650790000200124

Ronalter, L. M., Bernardo, M., & Romaní, J. M. (2023). Quality and environmental management systems as business tools to enhance ESG performance: a cross-regional empirical study. Environment. *Development and Sustainability*, 25(9), 9067-9109. doi: 10.1007/s10668-022-02425-0

Rother, M., & Shook, J. (2003). *Learning to see: value stream mapping to add value and eliminate muda*. Lean enterprise institute.

Sá, J. C., Carvalho, A., Fonseca, L., Santos, G., & Dinis-Carvalho, J. (2023). Science Based Targets and the factors contributing to the sustainable development of an organisation from a Literature review to a conceptual model. Production Engineering Archives, 29(3), 241-253. doi:10.30657/pea.2023.29.28

Sá, J. C., Dinis-Carvalho, J., Fraga, H., Lima, V., Silva, F. J., & Bastos, J. (2022, November). The Impact of Lean on Occupational Safety in Organisations. *In European Lean Educator Conference* (pp. 184-192). Cham: Springer International Publishing. doi: 10.1007/978-3-031-25741-4_16

Sá, J. C., Manuel, V., Silva, F. J. G., Santos, G., Ferreira, L. P., Pereira, T., & Carvalho, M. (2021, October). Lean Safety-assessment of the impact of 5S and Visual Management on safety. *In IOP Conference Series: Materials Science and Engineering*, 1193(1), p. 012049). IOP Publishing. doi: 10.1088/1757-899X/1193/1/012049

Sá, J. C., Oliveira, A. R., Carvalho, J. D., Santos, G., & Silva, F. (2023). A New Conceptual Model for Excellence in Business Towards Sustainable Development. *Quality Innovation Prosperity*, 27(2), 33-60. doi: 10.12776/qip.v27i2.1866

Sá, J. C., Reis, M., Dinis-Carvalho, J., Silva, F. J., Santos, G., Ferreira, L. P., & Lima, V. (2022). The development of an excellence model integrating the Shingo model and sustainability. *Sustainability*, 14(15), 9472. doi: 10.3390/su14159472.

Sá, J. C., Silva, V., Fonseca, L., Lima, V., & Dinis-Carvalho, J. (2023, June). Sustainability-B Corporation Geo Distribution. *In International Conference on Flexible Automation and Intelligent Manufacturing*, 928-937. Cham: Springer Nature Switzerland. doi: 10.1007/978-3-031-38165-2_107

Sá, J. C., Soares, L., Dinis-Carvalho, J., Silva, F. J., & Santos, G. (2023). Assessment of the Impact of Lean Tools on the Safety of the Shoemaking Industry. Safety, 9(4), 70. doi:10.3390/safety9040070

Saunders, M., Lewis, P., & Thornhill, A. (2009). *Research methods for business students*. Pearson education.

Shiba, S., Graham, A., & Walden, D. (1997). *TQM: quatro revoluções na gestão da qualidade*. Bookman.

Singo Institute (2023). *Shingo Model booklet*. Shingo Institute, 15th Edition.

Steingard, D., & Gilbert, J. C. (2016). The benefit corporation: A legal tool to align the interests of business with those of society; An interview with Jay Coen Gilbert, co-founder, B Lab. *Business & Professional Ethics Journal*, 5-15.

Stubbs, W. (2017). Sustainable entrepreneurship and B corps. *Business Strategy and the Environment*, 26(3), 331-344. doi: 10.1002/bse.1920

Teixeira, P., Coelho, A., Fontoura, P., Sá, J. C., Silva, F. J., Santos, G., & Ferreira, L. P. (2022). Combining lean and green practices to achieve a superior performance: The contribution for a sustainable development and competitiveness—An empirical study on the Portuguese context. *Corporate social responsibility and environmental management*, 29(4), 887-903. doi: 10.1002/csr.2242.

Tran, T., Kim, S., Son, B. G., & Ramkumar, M. (2023). Paradoxical Association Between Lean Manufacturing, Sustainability Practices and Triple Bottom Line Performance. *IEEE Transactions on Engineering Management*. 1-13. doi:10.1109/TEM.2023.3290724.

Tsalis, T. A., Malamateniou, K. E., Koulouriotis, D., & Nikolaou, I. E. (2020). New challenges for corporate sustainability reporting: United Nations' 2030 Agenda for sustainable development and the sustainable development goals. *Corporate Social Responsibility and Environmental Management*, 27(4), 1617-1629. doi:10.1002/csr.1910.

Van Ham, K. J. (1992). Total Quality Management in Europe and EFQM, Fellenoord 47A, Eindhoven, The Netherlands. Total Quality in the Chemical Industry, 104, 13.

Wilson, L. (2010). *How To Implement Lean Manufacturing*. McGraw-Hill.