Key Activity Indicators: critical review and proposal of implementation criteria

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Abstract

Purposes – This paper discusses the concept, definition, and usage of Key Activity Indicators (KAIs) and their integration within a Performance Measurement and Management system (PMM).

Design/methodology/approach – The actual definition and application areas of the KAIs are determined through a systematic literature review. Successively, a thorough definition of Key Activity Indicators is provided, along with a set of criteria for their deployment. Lastly, a case involving a Large Scale Retail Trade (LSRT) company is reported to report an example for guiding KAIs adoption.

Findings – This research shows that the scientific background concerning KAIs is still not mature. Moreover, the paper defines the role of KAIs for measuring operational activities and their possible connection with Key Performance Indicators (KPIs).

Research limitations/implications – Although KAIs have been introduced and discussed in the scientific literature, there is no evidence of criteria to deploy these indicators, leaving organizations without any guidance for their operational implementation.

Practical implications – From an academic standpoint, the study provides an overview of the usage of KAIs within the present scientific contributions, showing the advancements of this research field. From an industrial standpoint, the research proposes a set of criteria for the organizational deployment of KAIs.

Originality – The study investigates the concept of KAIs that, besides being originally conceived within World Class Manufacturing (WCM), has not received much attention in the scientific literature.

Keywords: Key Activity Indicators, Key Performance Indicators, Performance measurement and management, Operational Excellence Models, People Development, Human Factor

1 Introduction

Performance Measurement and Management (PMM) systems play a central role in monitoring and driving the achievement of long-term organizational objectives (Franco-Santos *et al.*, 2012; Giordani da Silveira *et al.*, 2016). PMMs provide organizations with relevant tools to identify and evaluate which activities need to be pursued and improved for achieving the planned strategic objectives (Parmenter, 2007). For this reason, the research field concerning the strategic role of indicators has been widely explored in the last decades (Neely, 2005; Neely *et al.*, 1995).

Despite the wide use of performance measurement systems within organizations, many times PMMs fail to guide the achievement of strategic goals (Tangen, 2005). The main causes are related to an improper alignment between PMMs and Critical Success Factors (CSFs), leading management to measure activities that are not in line with corporate strategic goals (Di Luozzo *et al.*, 2021). Indeed, CSFs make it possible to identify the factors that are critical to business success (Villalba-Diez, 2017) and should be considered for the design of an organization's measurement system as they point out its main objectives and areas of improvement.

Hence, starting from the definition of a CSF – e.g., "continuous improvement as a core value" or "zero late deliveries to customers" – an organization should be able to cascade a system of Key Results Indicator (KRIs) and Key Performance Indicators (KPIs). While KRIs measure the overall result of the organizational activities and typically represent financial measures, KPIs have a predictive nature and focus on the aspects of performance most critical to organizational success (Parmenter, 2007). As an example for a corporation that operates in the financial industry, the "overall annual company sales volume" may be defined as a KRI, while the "customer loyalty rate" could be considered as a KPI.

As a further clarification, an automotive company with the strategic goal of increasing profitability and reducing CO_2 after sales emissions may adopt the following CSFs: "reducing costs through Kaizen projects" and "increasing sales of electric vehicles". Therefore, the main

KRIs to be monitored would be the “percentage of cost reduction” and the “number of electric vehicles sales per quarter”; differently, the KPIs to be monitored would be the “number of initiative to increase quality rate/machines availability” and “percentage of response to marketing initiatives promoting electric cars” (Lascu & Severin, 2021).

However, having said that, PMMs are typically focused on high-medium level performance, and lower attention is paid to the alignment between strategic critical success factors and operational performance (Di Luozzo et al., 2021; Tangen, 2004). This shortcoming hinders the organization's strategy deployment since no clear direction is provided on how to align strategic goals with day-to-day activities (Villalba-Diez, 2017). Indeed, the focus of PMM research has often been paid on the definition of more consistent Key Performance Indicators (KPIs) rather than on the interface between those indicators and shop-floor activities.

From these considerations, the concept of Key Activity Indicators (KAIs) originated (Murata and Katayama, 2009). KAIs are specific indicators that have been introduced in different Operational Excellence (OpEx) models based on the Lean philosophy, such as World Class Manufacturing (Amadio, 2017; Antognazza and Moretti, 2016) and Toyota Production System (Murata and Katayama, 2009). The purpose of these indicators is to track and evaluate shop-floor activities concerning the human factor by focusing primarily on intangible elements for aligning the employees' daily/weekly objectives with the organizational strategy (De Felice & Petrillo, 2015). In this sense, the indicators directly relate to managers/leaders/supervisors activities since they are included within the managers’ standard work, and can be adopted as a reference for the standard work templates development (Chiarini and Brunetti, 2019). They also allow for a direct focus on the “soft side of operations” (Brennan *et al.*, 2015), recognized as one of the key objectives for the contemporary lean manufacturing challenges. Examples of their implementation are described in the context of continuous improvement activities (De Felice *et al.*, 2015) and competences management (Sardi *et al.*, 2019), though KAIs have not been explicitly mentioned in the latter.

Although several authors explicitly or implicitly adopted the KAI concept in their research works, it seems no clear understanding of its definition and industrial application is widespread. This limitation leads organizations without guidelines for integrating KAIs within

daily operational activities. Considering the latter observation, a possible solution for connecting KAIs to upper levels of the indicators hierarchy is by using intermediate metrics such as Result Indicators (RIs) and Performance Indicators (PIs), as defined by the paper of Di Luozzo *et al.* (2021) and of Tangen (2004). Indeed, while the RIs summarize the activity of more than one team and are helpful in getting an overview of how teams are working together (e.g., potential examples in the service industry may be the "number of initiatives implemented from the staff survey" or the "number of employees' suggestions implemented in the past 30 days"), the PIs are those non-financial indicators that can be traced back to an individual team (e.g., potential examples in the service industry may be the "late deliveries to customers" or the "number of planned abandonments of reports, meetings, processes that are no longer functioning"). However, this potential connection and related implementation guidelines have not been deeply investigated in the scientific literature, hindering the potential benefits of performance management on the organizational effectiveness (Wadongo and Abdel-Kader, 2014).

In order to contribute to filling this research gap, this paper aims to develop a comprehensive definition of Key Activity Indicators and provide clear implementation criteria for effective organizational deployment. Hence, the following research questions are addressed:

RQ1: What are the main characteristics and application areas of the Key Activity Indicators? Is it possible to derive a comprehensive and standardized definition of Key Activity Indicators?

RQ2: How can the Key Activity Indicators be effectively integrated within an organization's Performance Measurement and Management system?

To address these questions, this paper performs a critical review of the present scientific contributions that either directly or indirectly have cited the KAIs, proposing a comprehensive definition for these indicators, along with a set of criteria and a sample case for their implementation.

The research work is organized as follows. Section 2 describes the methodology to select and analyse the bibliographic portfolio, while Section 3 performs the content analysis of the selected scientific portfolio on KAIs. Successively, the paper formalizes the concept of KAIs along with implementation criteria (Section 4), and shows an application of KAIs concerning

the industrial sample case of a LSRT company (Section 5). Lastly, Section 6 summarizes the conclusions, future research opportunities, and limitations of this work.

2 Methodology: bibliographic portfolio selection and analysis

This research provides a systematic review of the scientific background on Key Activity Indicators for gaining insights concerning their definition, design, and implementation. Leveraging the scientific literature review, this paper formalizes the concept of Key Activity Indicators and proposes several criteria for their deployment.

The first step of the research approach is to select the bibliographic portfolio to be analysed. Specifically, the research employed the following search string on the major scientific databases (e.g., ISI Web of Science, Scopus, etc.):

Research String: [("Key Activity") OR ("Organizational Performance") OR ("Intangible Performance") OR ("Employees") OR ("Human Resource") OR ("Shop floor" OR "Shop-floor") OR ("Continuous Improvement") OR ("Kaizen") OR ("People") OR ("Training" OR "Coaching" OR "Mentoring")] AND [("Indicators") OR ("Metrics") OR ("Index") OR ("Measurement")]

In addition, only those papers discussing and/or adopting the concept of Key Activity Indicators, either explicitly or implicitly, have been analyzed. More specifically, were included in the analysis only those papers meeting at least one of the following criteria:

- The paper includes a reference about the measurement practices related to operational activities concerning the human factor;
- The paper includes a reference about the deployment of strategic objectives into operational activities through the development of specific metrics.

By adopting these criteria, 44 scientific papers have been selected within the bibliographic portfolio, which are reported as in Table A.I. Successively, the obtained bibliographic portfolio allowed to identify several main topics discussed by the scientific landscape. The research areas have been clustered into five macro-topics, described as follows:

1. Industry 4.0;
2. Operational Excellence models (OpEx);
3. People development, involvement, and abilities (PDIA);

4. Performance Measurement and Management (PMM);
5. Shop-Floor Management (SFM).

Figure 1 summarizes the identified topics and clusters, along with a graphical representation of their relative importance in terms of frequency of occurrence in the selected bibliographic portfolio.

Figure 1: Clusters and topics relevance from the literature review

In addition, a trend analysis has been performed to identify the research interest related to the different topics. For this reason, Figure 2 shows the number of relevant yearly articles that have been published and considered within the analysis, while Figure 3 reports the number of relevant articles published in different countries. From the graphs, it can be observed that there is an increasing trend of scientific contributions implementing the concept of KAIs, and that the European countries seem to be the most promising in terms of KAIs diffusion, followed by USA, Japan and India. This result may be explained by the growing attention of organizations towards the human factor and related operational practices (Aloini *et al.*, 2021; Fera *et al.*, 2020), and by the establishment of Lean implementations within the European context.

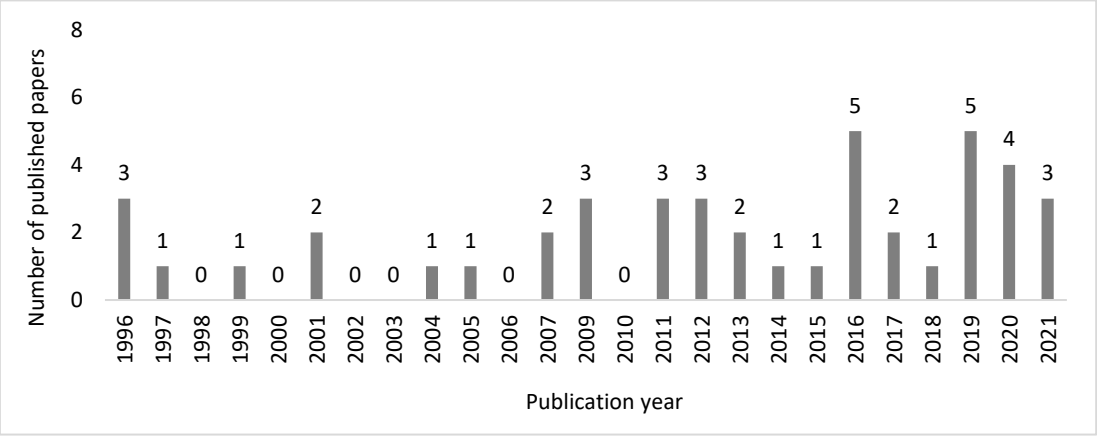

Figure 2: Number of relevant publications per year

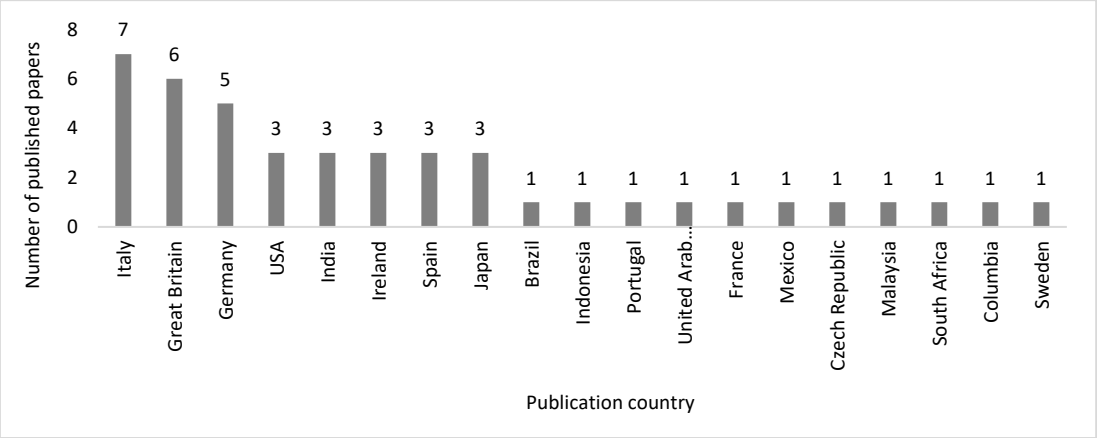

Figure 3: Number of relevant publications per country

Lastly, it is possible to observe that considering the selected bibliographic portfolio, the journals emerging as the leading outlets for this current scientific debate are the "International Journal of Productivity and Performance Management" (IJPPM) and "International Journal of Operations and Production Management" (IJOPM), which have the highest number of papers published in this area (respectively 7 and 4 articles).

3 Key Activity Indicators (KAIs) background

3.1 KAIs definition: perceptions from the literature

According to the contribution of Amadio (2017), the main indicators adopted to measure the progress and performance of Continuous Improvement (CI) projects are Key Activity Indicators and Key Performance Indicators. Through the regular engagement of the

organization's associates into relatively small improvement projects, CI activities are considered one of the key elements to obtain a people-centric management system (Yan and Makinde, 2011). For this reason, while KPIs show how well the company or individual function is moving towards the expected results (Parmenter, 2007), KAIs have a greater focus on the evaluation of operational activities and of their alignment with strategic choices (Antognazza and Moretti, 2016). This allows considering that KAIs must be linked with transparent cause-effect relationships with one or more KPI, which in turn must be aligned to the organizational strategic objectives (Bourne *et al.*, 2018; Di Luozzo *et al.*, 2021). Indeed, KAIs should be seen as a way of focusing people on doing the right things, that will in turn deliver the right operational outcomes and performances. This reasoning is directly linked and derived from the first principle of Toyota ("Good Thinking: Good products"), stating that a long-term philosophy drives the organization towards good results (Wee and Wu, 2009). KAIs are thus considered a tool for translating long-term thinking into practical actions, leading the organization toward operational excellence.

Key Activity Indicators are often associated with people's shop-floor activities: one of their earliest definitions could be found within World Class Manufacturing (WCM), where they have been used as progress activity indicators for process improvement and Kaizen projects (De Felice and Petrillo, 2015; Petrillo *et al.*, 2019). According to the Lean Philosophy pillars, KAIs should always be available at zero cost without requiring long data extraction or processing times. To achieve this objective, it is necessary to identify the connections between the results of improvement projects and the day-to-day actions. Additionally, during the project execution phase, KAIs must be managed dynamically: any inconsistency in activities/results should be followed by a re-planning to achieve previously planned objectives (Amadio, 2017). The paper of Murata and Katayama (2009) introduces KAIs following the previous theory: in their view, KAIs represent a "*process to achieve a purpose of project improvement*".

In the latter contribution, KAIs also find application in Total Productive Maintenance (TPM), originally theorized in the Toyota Production System (TPS). Within TPM, Key Activity Indicators are associated with the pillars of autonomous maintenance and are used according to its principles (Murata and Katayama, 2009). This definition follows the one proposed in the research by Katayama *et al.* (2019), which describes KAIs as the interface between

performance indicators and shop-floor activities. Indeed, when extended to the definition of managers/leaders/supervisors' standard work (Chiarini and Brunetti, 2019), KAIs can support mid to long term objective attainment through the deployment of operational actions (e.g., coaching and mentoring of people), and through ensuring that leaders engage as they should, dedicating time for strategic thought. In this sense, the adoption of KAIs can be seen as an approach towards the achievement of a greater involvement of people within organizational management activities, which is recognized as one of the main expectations of TPM programs implementation (Singh and Singh, 2020).

Table I reports the definitions of KAIs introduced by the present scientific literature.

Citation	**Definition of KAI**
(Katayama *et al.*, 2019)	KAIs are indicators related to operational input and have a physical/monetary dimension
(Petrillo *et al.*, 2019)	KAIs represent a process to achieve the purpose of project improvement. The choice of indicators of activity is different for each pillar, according to what may be the most significant
(Amadio, 2017)	KAIs are indicators of progress in process improvement activities and must monitor all company improvement activities
(Antognazza and Moretti, 2016)	KAIs focus on operational activity and are used to verify if the company's operations are in line with what has been defined at the strategic level
(De Felice and Petrillo, 2015)	KAIs as a system for measuring Kaizen activities and Continuous Improvement
(Murata and Katayama, 2009)	KAIs represent a process for achieving a purpose of an improvement project

Table I: Common definition of Key Activity Indicators

It is also possible to observe that several scientific contributions seem to have implicitly introduced the concept of Key Activity Indicators, without an explicit mention. For instance, the contribution of Bjerke and Renger (2017) considers staff involvement and step-by-step procedures crucial for the successful implementation of a PMM system, while the research of Sardi *et al.* (2019) discusses the adoption of Enterprise Social Networking to define metrics for measuring and managing individual competences. Differently, other scientific contributions focused on the negative impacts of misalignments between objectives and

operational activities (Bessant *et al.*, 2001; Jurburg *et al.*, 2016; Masron *et al.*, 2012; Ng and Kee, 2011). Besides highlighting the widespread adoption of this class of indicators, these works allow understanding the critical role of KAIs as the interface between the tactical and shop-floor levels of the organizations.

3.2 Main application areas of KAIs

This subsection reports the main application areas of KAIs that have been explicitly considered in the scientific literature. A first example of Key Activity Indicators implementation is provided by De Felice and Petrillo (2015) paper, which describes the use of WCM in process re-engineering to increase customer satisfaction in an automotive industrial setting. To achieve this goal, the authors describe the application of a Continuous Improvement initiative, along with its main objectives: reduction of inventories, synchronization of production, and minimization of material handling operations. In this context, Key Activity Indicators have been used as metrics to evaluate operational activities linked to the human factor since they directly stem from shop-floor data.

Examples of adopted KAIs are the "*number of CI projects*" and "*% Staff involved"*. Note that these indicators are directly associated with the day-to-day associates' tasks since they represent the main actors of Kaizen projects. In addition, "*number of flow analysis*" and "*% classified of materials*" highlight the connections with shop-floor data. This implementation of KAIs confirms the perception that KAIs are directly associated with human actions (Antognazza and Moretti, 2016; Katayama *et al.*, 2019).

Another significant contribution is provided by Murata and Katayama (2009), which shows the KAIs implementation in a TPM context. In their research, the authors also highlight the critical role of KAIs in the achievement of factory performance objectives. From this case, three critical aspects can be derived:

1. Key Activity Indicators measure strategic operational activities and impact critical success factors in medium-long term;
2. Key Activity Indicators focus on human activities since TPM focuses on improvement activities and autonomous maintenance acted by people;
3. Key Activity Indicators are strongly connected to critical success factors since people's CI activities directly impact the factory performance.

In conclusion, Table II summarizes some of the main implementations of KAIs that emerged from the critical literature review.

Citation	Usage of KAI
(Katayama *et al.*, 2019)	KAIs are in an intermediate level between KPI and shop-floor data, and are used to measure operational activities
(Petrillo *et al.*, 2019)	Some examples of introduced KAIs are: "number of people involved in a specific project", “number of Kaizen projects” and “number of flow analysis”
(Amadio, 2017)	KAIs are used to assess the achievement of objectives within Kaizen projects
(Antognazza and Moretti, 2016)	KAIs are used to measure the performance of operational activities
(De Felice and Petrillo, 2015)	Some examples of introduced KAIs are: “number of projects”, “number of flow analysis”
(Murata and Katayama, 2009)	A total number of education times for employees who tackle performance improvement projects. Accumulative number of Kaizen cases.

Table II: Common implementation of Key Activity Indicators

3.3 Shortcomings of the scientific literature

According to the literature review, Key Activity indicators connect operational activities with strategic goals. Moreover, to align performance objectives with day-to-day activities, it seems crucial to identify cause-effect relationships between KAIs and KPIs, where the improvement of communication between the different organizational levels plays a central role (Villalba-Diez, 2017). The core idea is to define proper Key Activity Indicators and standardize business communication between people who manage KPIs and KAIs to define a comprehensive PMM system.

However, many organizations do not have a communication standard that allows for exchanging information between managers and team leaders at the shop floor level. In fact, the identification of KAIs must be aligned with business objectives. In this context, the lack of standardized criteria to help organizations identify the activities to be measured by Key Activity Indicators and properly implement KAIs within a PMM system appears relevant. Moreover, no standard definition criteria to connect KPIs with KAIs are present and scarce

attention has been paid in the scientific literature to this specific topic. Lastly, a lack of operational and practical criteria for connecting KAIs to upper levels of the indicators hierarchy through using intermediate indicators (such as Performance Indicators and Result Indicators) is highlighted.

Considering this background, being KAIs a human-centric system for measuring the performance of operational activities (Murata and Katayama, 2009), one of its main advantages is the possibility of constantly evaluating the alignment of shop-floor activities with performance goals. Henceforth, for the success of their implementation, a proper definition of Key Activity Indicators and their scope should be provided, as well as the information provided to the shop-floor level. Indeed, through KAIs and their relationships with KPIs, the management should steer the organization towards the alignment between strategic goals and operational activities (Di Luozzo *et al.*, 2021). For this reason, the absence of an operational framework enabling the KAIs introduction seems to be a significant barrier to their implementation, along with the absence of a clear definition that is recognized to be as a common shortcoming of the performance management field (Tangen, 2005). Note that this organizational framework should be specifically able to: provide guidelines to implement Key Activity Indicators within organizations; define criteria for measuring and updating Key Activity Indicators according to the organizational strategic objectives; maintain a constant interaction between Key Activity Indicators and Key Performance Indicators. This paper addresses the above-mentioned shortcomings by formalizing a comprehensive definition of KAIs, along with relevant implementation criteria and a sample case for their industrial adoption.

4 Formalizing the concept of Key Activity Indicators (KAIs)

As previously discussed, Key Activity Indicators are a typology of indicators theorized in literature and adopted in several industrial settings. Still, it seems that no formalized definition has been proposed. Moreover, although several authors – as reported in Table II – mentioned some possible usage of KAIs within organizations, it seems that there is a shortcoming of contributions proposing standard implementation criteria. For this reason, this section aims to provide a comprehensive definition of Key Activity Indicators and formalize the key attributes that characterize this class of indicators. To achieve this

objective, the research leverages the systematic review and the selected bibliographic portfolio reported as in Table A.I.

4.1 Proposal of a comprehensive KAIs definition

In the current literature, several authors have contributed to formalizing the main characteristics of KAIs and their role within organizations. Indeed, the review highlights the essential role of KAIs in connecting people's shop-floor activities and the achievement of key performance objectives. Thus, this subsection introduces an accurate and comprehensive definition of the Key Activity Indicators.

The term *"Key Activity Indicators"* reflects the concept that organizations should measure essential – tangible and intangible (Aloini *et al.*, 2021; Cumming, 2005) – activities for value creation. Specifically, the actions that KAIs should measure are those performed at the shop-floor level. In fact, the contribution of Antognazza and Moretti (2016) and Katayama *et al.* (2019) highlight that KAIs focus on operational activities. Thus, it is reasonable to characterize KAIs as indicators formed by a single fundamental element: people's actions. Measuring these activities helps monitor the achievement of daily/weekly goals that could impact the expected level of performance in the medium-long term.

Parmenter (2007) introduced two different types of indicators that could be adopted to measure teams' achievement of goals: Results Indicators (RIs) and Performance Indicators (PIs). RIs and PIs, unlike KAIs, reflect the summation of more than one team input. RIs summarize the activity of more than one team and provides an overview of how teams are working together, while PIs help teams to align their performance with their organizational strategy. PIs and RIs are the results of different actions performed by different teams. Contrarily, KAIs measure only the individual activities performed by associates, contributing to achieving the planned RIs and PIs, as shown in Figure 4.

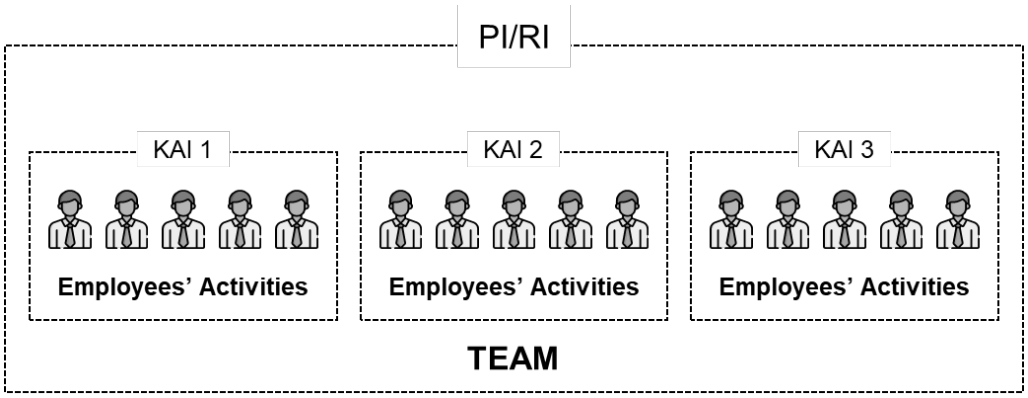

Figure 1: Connection between Key Activity Indicators and Performance Indicators/Results Indicators

Following this point of view, several authors adopted KAIs to measure and evaluate Continuous Improvement initiatives (Amadio, 2017; De Felice and Petrillo, 2015; Petrillo *et al.*, 2019). In this context, the role of KAIs is to drive workers to execute improvement projects to improve the organization's KPIs, and reach strategic objectives in the long run. In particular, the objective is to define which Kaizen initiatives are critical to increasing performance and what critical activities need to be performed for successful Kaizen projects. To achieve the strategic objectives, it is necessary to provide a PMM system that connects KPIs with the results of Kaizen projects.

Moreover, Murata and Katayama (2009) define employee training activities as critical to maintaining a high level of plant performance. The importance of these actions is also reinforced by the paper of Ribeiro *et al.* (2021), which observe that associates' individual performances are impacted by the managerial coaching skills of their superiors, and by the paper of Sardi *et al.* (2019), that underlines the role of competences in a holistic PMM system. Once again, the tasks mentioned above have two mutual features: are intangible and concern the human factor. Hence, the cited applications areas are examples of activities that Key Activity Indicators should measure.

Following this reasoning, it seems reasonable to state a first definition of Key Activity Indicators (D1):

D1: Key Activity Indicators represent a class of indicators that measure activities related to the human factor at the operational level

Another essential piece of evidence is given by the contribution of Antognazza and Moretti (2016), which highlights that a sound system of KAIs should be easy to understand for all the

operational staff. Indeed, those indicators should be used by the associates to align their activities with organization's strategy. Thus, for a successful implementation of KAIs, all employees should fully understand these indicators, not just by middle and upper managers. Indeed, their usage should allow to instantly identify which activities have an impact on the overall team's performance and results. In this way, immediate actions can be taken if teams are not on track to meet the planned objectives. To achieve this goal, KAIs should be as simple and immediate as possible and should ideally be available at no cost at any time (Bjerke and Renger, 2017; Jurburg *et al.*, 2016), meaning that they must require quick data extraction or processing times.

Antognazza and Moretti (2016) also point out that, to obtain an effective implementation, one or more KAIs should be linked to improving a KPI in the medium-long term. Clear cause-effect relationships should link KPIs and KAIs: the improvement of a KAI should also cause the improvement of at least one KPI. This connection would facilitate the alignment between the organizational strategic objectives and the operational level, which is crucial to attaining superior business performances (Giordani da Silveira *et al.*, 2016; Di Luozzo *et al.*, 2021). Indeed, while Key Performance Indicators measure organizational performance and are not actionable in the short term, Key Activity Indicators should be actionable on a daily/weekly basis.

Lastly, in the contribution of Katayama *et al.* (2019), KAIs are considered as intermediate indicators between shop-floor activities and KPIs. This highlights that Key Activity Indicators are measured at a lower level than Key Performance Indicators and reinforces the perception that they should be linked to KPIs. Following this reasoning, it seems reasonable to state a second definition of Key Activity Indicators (D2):

D2: The improvement of one or more Key Activity Indicators should cause in the medium-long term the improvement of at least one Key Performance Indicator

At this point, it is possible to summarize the reported contributions (D1 and D2) and to provide a comprehensive definition of Key Activity Indicators (D):

D: Key Activity Indicators represent a class of indicators that measure activities related to the human factor at the operational level, and the improvement of one or more Key Activity Indicators should cause in the medium-long term the improvement of at least one Key Performance Indicator

Table III shows the main adopted contributions to propose a comprehensive definition of KAIs.

Definition	Reference	Insight
Key Activity Indicators represent a class of indicators that measure activities related to the human factor at the operational level (D1)	(Antognazza and Moretti, 2016; Katayama *et al.*, 2019)	KAIs are indicators focused on operational activities
	(Amadio, 2017; De Felice and Petrillo, 2015; Petrillo *et al.*, 2019)	KAIs are indicators used to measure specific activities performed by employees (e.g., Continuous Improvement initiatives)
	(Murata and Katayama, 2009)	KAIs are used to measure activities related to the human factor, and they are critical to maintaining a high level of performance
The improvement of one or more Key Activity Indicators should cause in the medium-long term the improvement of at least one Key Performance Indicator (D2)	(Antognazza and Moretti, 2016; Katayama *et al.*, 2019)	One or more KAIs should be linked to improving a KPI in the medium-long term. KPIs and KAIs should not be linked by precise mathematical laws but by clear cause-effect relationships

Table III: Main contributions and insights on Key Activity Indicators

4.2 Criteria for KAIs implementation

From the proposed definition of Key Activity Indicators, it is necessary to identify the main characteristics that shape this class of indicators. To achieve this goal, content analysis has been performed, which allowed identifying several macro-clusters for the KAIs application, as shown in Figure 1. Successively, five main features that shape the Key Activity Indicators have been identified:

1. Focused on operational activities linked to the human factor;
2. Simply measurable and understandable;
3. Dynamically managed;
4. Frequently measured;
5. Linked by cause-effect relationships with KPIs.

4.2.1 Focused on operational activities linked to the human factor

As already described, Key Activity Indicators should have a specific focus on operational activities linked to the human factor (Antognazza and Moretti, 2016; Katayama *et al.*, 2019), which are essential measures to evaluate operations (Tangen, 2004) in the current industrial settings. Several authors have contributed to formalizing the connection between KAIs and the human factor, such as Sànchez and Pérez (2001). In their research, several indicators are identified for measuring Continuous Improvement activities performed directly by employees. By describing the indicators, the authors show that the connection with human activities is critical to improving performances and immediately acting and driving operations.

4.2.2 Simply measurable and understandable

Key Activity Indicators should guide managers and associates to determine the actions to be carried out to achieve organizational goals. Specifically, all staff should understand the activity being measured and what corrective action is required if undesired performance levels are measured. Hence, these indicators should be as simple and immediate as possible, with ideally very short extracting/processing times. Following this reasoning, Jurburg et al. (2016) 's contribution highlights the need to define easily understandable indicators, Bjerke and Renger (2017) focus on the importance of defining SMART objectives when measuring human activities.

4.2.3 Dynamically managed

One of the key advantages of using Key Activity Indicators is that, being very flexible, allows the organization to quickly adapt its activities to achieve strategic objectives in the medium-long term. This feature, however, should be supported by dynamic management of the indicators (Amadio, 2017), meaning that any result inconsistency should lead to an action re-planning (De Felice and Petrillo, 2015). For this reason, KAIs may vary constantly and dynamically according to the organization's objectives.

4.2.4 Frequently measured

To obtain a clear overview of how activities are performed, Key Activity Indicators should be measured frequently, according to the operational specificities of the considered tasks (Amadio, 2017). Indeed, the significant advantage of having indicators for measuring shop-floor activities is the ability to drive their execution quickly and effectively. However, timely

and flawless execution requires coordination (Villalba-Diez, 2017) and measurement (Alblooshi and Shamsuzzaman, 2020; Kumar *et al.*, 2014). For this reason, the adoption of criteria to measure these indicators with specific time intervals is a crucial enabler to orient performance through KAIs. Note also that this criterion is directly linked with the visualization of the indicators' value: as theorized by the Lean philosophy, visual management is a crucial element to ensure indicators are measured and analysed with the right frequency (Schläfke et al., 2013) that they are effectively implemented within the organization. Indeed, it is possible to observe that visual management is a crucial simplification technique for achieving process improvement (Siaudzionis Filho *et al.*, 2018).

4.2.5 Linked by cause-effect relationships with KPIs

Key Activity Indicators play a central role in improving and orienting business performance; hence, those indicators that do not directly or indirectly impact Key Performance Indicators could not be classified as KAIs. Metzmacher *et al.* (2019) and Hellebrandt *et al.* (2019) show that one of the most predominant organizational aspects for obtaining superior performance is the connection between operational level indicators and KPIs. Since the purpose of KAIs is to align long-term goals with people's activities (Katayama *et al.*, 2019), without identifying cause-effect relationships with KPIs, they would not be actionable and serve any strategic purpose.

4.3 A standard sheet for defining Key Activity Indicators

To obtain complete awareness of their usage when defining indicators, it is necessary to identify a representative sheet to illustrate how these should be managed. Indeed, taking the cue from the ISO22400 standard "KPIs for manufacturing operations management" (ISO, 2014) a full KAI description should be provided through a standard sheet. Specifically, the main elements of the sheet recall the characteristics of the Key Activity Indicators reported as in subsections 4.1 and 4.2. and are illustrated as follows:

1. Key Activity Indicator label: it is a concise title that describes the KAI;
2. Description: provides an overview of the activity measured by the KAI. Indeed, the KAI's owner must have maximum awareness concerning how to measure and manage the activities;
3. Measurement frequency: it represents a critical specification for defining the time bucket in which data should be collected reported;

4. Dynamic review period: since KAIs must be dynamically managed, it is necessary to define a specific review period between staff and team managers to review how the KAI is performing;
5. Connection with Performance Indicators and Key Performance Indicators: the identification of a relationship between KPIs-PIs and KAIs is essential to drive associates in aligning their daily objectives with the organizational ones;
6. Cause-effect relationship: once the relationships with KPIs-PIs have been specified, it is necessary to identify how the KAI impacts PI and KPI (e.g., the improvement of a KAI may cause the improvement of a KPI).

According to the above-mentioned specifications, Table IV illustrates the Key Activity Indicators standard definition sheet.

Key Activity Indicator label	
Description	Report here a brief description of what is measured by the Key Activity Indicator
Measurement frequency	Report here the period in which the Key Activity Indicators should be measured (e.g., daily, weekly, monthly, etc.)
Dynamically review period	Report here the period in which the Key Activity Indicator should be reviewed (e.g., weekly, monthly, quarterly, etc.)
Connections with Performance Indicators	Report here the Performance Indicators impacted by the specific Key Activity Indicator
Connections with Key Performance Indicators	Report here the Key Performance Indicators impacted by the specific Key Activity Indicator
Cause-effect relationship	Report here the nature of the cause-effect relationships between Key Performance Indicators-Performance Indicators and the specific Key Activity Indicator

Table IV: Key Activity Indicators standard definition sheet

4.4 How to build a structured system of KAIs

This section aims to define how Key Activity Indicators can be implemented in the organization and how they can be integrated into a Performance Measurement and Management system.

According to Parmenter (2007), Key Result Indicators (KRIs) provide a clear view of whether the organization is achieving strategic goals aligned with its mission and vision through usually measuring financial aspects such as profitability or return on capital. Considering their nature, the Chief Executive Officer (CEO) is ultimately responsible for the KRIs achievement. However, according to Garvin (1988), one of the most complex goals is to identify the main day-to-day actions impacting these indicators in a medium-long period. For this reason, the connection between KRIs and KAIs should go through other indicators at a different level than those in which KRIs operate: Key Performance Indicators (KPIs), Results Indicators (RIs) and Performance Indicators (PIs).

In this context, Performance Indicators and Result Indicators play a central role as intermediate indicators between KPIs-KRIs and KAIs. The great advantage of using RIs and PIs depends on two critical aspects (Di Luozzo *et al.*, 2021; Parmenter, 2007):

- Employee motivation and engagement: RIs and PIs measure how the team achieves planned goals, operating at a higher level than KAIs but lower than KPIs. In this way, associates can have a clearer view of how their actions are performing in achieving the team's goals;
- Stronger connection with KPIs: RIs and PIs are indicators that are closely tied to the team's KAIs, hence justifying more easily the improvement of a KPI. This makes it easier for management to understand what actions need to be taken at the team level by connecting PIs/RIs with KPIs.

Table V summarizes the main characteristics of the indicators hierarchy, specifying their principal functionalities owners to whom the indicators are addressed.

Indicators	**Main Characteristics**	**Owners**
Key Result Indicators	KRIs help top management define a company's long-term strategy	CEO and Top Management
Key Performance Indicators	KPIs describe what areas need to be improved for customer satisfaction. They help area managers make decisions	Area manager

Indicators	Main Characteristics	Owners
Performance Indicators – Result Indicators	PIs/RIs give a summary of the collective efforts of several teams on a specific area	Team Manager
Key Activity Indicators	KAIs guide people at the operational level to align their actions to achieve teams' performance goals	Associates

Table V: Main characteristics and owners of organizational indicators

In order to better understand how KAIs can be integrated into the PMM, the previously mentioned case of the automotive industry (see Introduction section) is here discussed again. In particular, with the aim of improving the KPI “number of initiatives to increase quality rate/machines availability”, it is possible to identify first the activities at the shop-floor level that can be streamlined. Successively, it is possible to associate RIs (e.g., “number of continuous improvement initiatives implemented by staff” or “electric car sales made in a specific day”) and PIs (e.g., “number of innovations implemented by each team/division” or “number of delays due to maintenance activities”). Finally, some Key Activity Indicators can be interconnected with these the mentioned metrics: “number of Kaizen projects in which employees are involved”, “number of employees involved in trainings on Lean methodology” or “number of initiatives promoted by employees in the marketing area (advertising, etc.)”.

Figure 5 summarizes the interconnections within the PMM system, while Table VI reports the main definitions and few examples concerning the metrics and indicators that have been described so far.

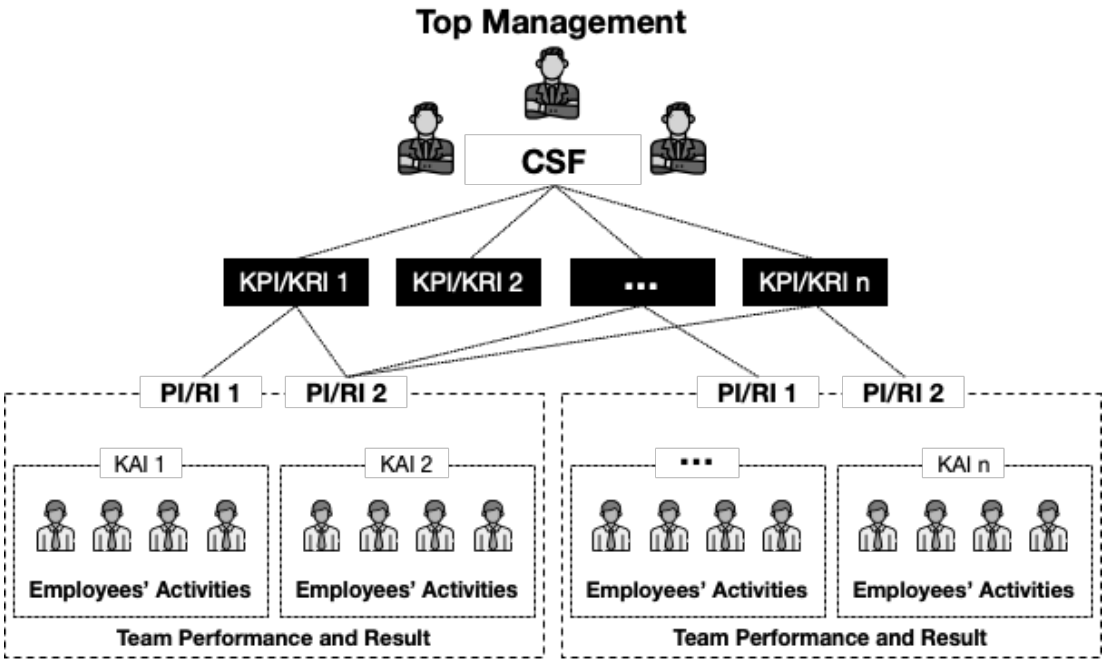

Figure 2: Overall representation of the indicators hierarchy

Element	Definitions	Example
Critical Success Factors	The essential elements for the success of an organization. These factors may be developed as a result of an external analysis that examines the competitive system and proposes a forecast of the future scenario by identifying the variables that can best explain success	*Financial industry* - Adoption of remote and flexible work as a must for the organization - Zero late deliveries to customers - Continuous improvement as a core value *Automotive industry* - Reducing costs through Kaizen projects - Increasing sales of electric vehicles
Key Result Indicators	KRIs evaluates the overall results of many activities managed through a series of performance measures. These indicators typically represent financial measures	*Financial industry* - Customer satisfaction - Net profit margin *Automotive industry* - Percentage of cost reduction - Number of electric vehicles sales per quarter
Key Performance Indicators	KPIs are those indicators that focus on the aspects of performance most critical to organizational success. These indicators are always non-financial measures	*Financial industry* - Customer loyalty rate - The Increase of SKUs portfolio in the past year *Automotive industry* - Number of initiative to increase quality rate/machines availability

Element	Definitions	Example
		- Percentage of response to marketing initiatives promoting electric cars
Result Indicators	RIs summarize the activity of more than one team, and they are useful for getting an overview of how teams work together	*Financial industry* - Number of initiatives implemented from the staff survey - Number of employees' suggestions implemented in the past 30 days *Automotive industry* - Number of continuous improvement initiatives implemented by staff - Electric car sales made in a specific day
Performance Indicators	PIs are those non-financial indicators that can be traced back to a team	*Financial industry* - Late deliveries to customers - Planned abandonments of reports, meetings *Automotive industry* - Number of innovations implemented by each team/division - Number of delays due to maintenance activities
Key Activity Indicators	KAIs guide people at the operational level to align their actions to achieve teams' performance goals	*Financial industry* - Number of continuous improvement initiatives implemented by employees - Number of analyses performed to evaluate customer satisfaction *Automotive industry* - Number of Kaizen projects in which employees are involved - Number of employees involved in trainings on Lean methodology - Number of initiatives promoted by employees in the marketing area (advertising, etc.)

Table VI: Main definitions and examples of the PMM elements

4.5 A proposed procedure for implementing KAIs

Once the key features of a Key Activity Indicator have been described, this sub-section aims to identify a methodology for implementing and managing these indicators.

Indeed, following the analysis provided in the contribution of Duque and Cadavid (2007), a relevant feature for implementing this type of indicator is the ability of the team manager to

align the critical success factors with shop-floor activities related to the human factor. Consequently, it seems reasonable to state that a proper KAIs implementation requires the definition of a procedure for their standardized usage. Hence, a possible procedure for implementing and managing these indicators is defined as follows:

1. Identify critical Key Performance Indicators to improve operational performance: the first step for team leaders is to identify which performance objectives should be improved;
2. Connect Performance Indicators and Result Indicators with KPIs: a crucial aspect of implementing KAIs is the ability of team leaders to identify which PIs/RIs could cause at least one KPI to improve;
3. Establish a cause-effect relationship between people's activities and PIs/RIs: to identify KAIs, it is necessary to define the possible cause-effect relationships between associates' activities and team performance. In this way, all employees have a greater awareness of the actions they individually need to perform;
4. Use a stepwise approach to engage associates in the definition of Key Activities Indicators: the step-by-step approach is a crucial feature for the achievement of KAIs target values since these indicators must be built with the engagement of the staff;
5. Establish a culture of Continuous Improvement: the final step is establishing a culture geared towards improvement. Since KAIs are indicators that must be managed dynamically, people must adopt and use KAIs to continuously improve operations.

Note that to obtain a proper alignment between the different indicators and a coherent Performance Measurement and Management system, Key Activity Indicators may be integrated within the methodology for measuring PMM's coherence proposed by the contribution of Di Luozzo *et al.* (2021). Moreover, Table VII reports the references that can be adopted to implement the procedure's steps.

Criterion	**Reference**
Identify critical Key Performance Indicators to improve operational performance	(Amadio, 2017; Witcher and Chau, 2007)
Connect Performance Indicators and Result Indicators with KPIs	(Hellebrandt *et al.*, 2019; Karlsson and Åhlström, 1996)

Criterion	Reference
Establish a cause-effect relationship between people's activities and PIs/RIs	(De Felice and Petrillo, 2015; Karlsson and Åhlström, 1996; Murata and Katayama, 2009; Petrillo *et al.*, 2019)
Use a stepwise approach to engage associates in the definition of Key Activities Indicators	(Amadio, 2017; Coughlan *et al.*, 2016; Karlsson and Åhlström, 1996)
Establish a culture of Continuous Improvement	(García *et al.*, 2013; Parmenter, 2007)

Table VII: Main references for the implementation of Key Activity Indicators

Recalling the automotive industry example again, the research intends to go through the operational steps that can be practically applied for the procedure implementation.

The first step is the recognition of KPIs-KRIs that management needs to improve. For this reason, the Team Leader must implement a series of meetings to align with top management regarding the key activities to be improved. In this way, KPIs and data analytics – being a fundamental practices in the productivity and performance management area (Schläfke et al., 2013) – guide Team Leaders towards improving operations. In our example the Team Leader is aware that KPIs to be improved to achieve planned performances are the "number of initiatives to increase quality rate/machines availability" and the "percentage of response to marketing initiatives promoting electric cars".

The second and third steps are critical to identifying which PIs and RIs the team needs to improve to connect team performance with KPIs. Thus, the Team Leader could monitor the Result Indicator "number of continuous improvement initiatives implemented by staff" and the Performance Indicator "number of delays due to maintenance activities", since their optimization may cause the improvement of at least a KPI-KRI.

Finally, with the engagement of all the operational staff, the Team Leader identifies the main KAIs interconnected with PIs and RIs, such as the "number of Kaizen projects in which employees are involved" and "number of employees involved in trainings on Lean methodology".

4.6 Critical success factors for the integration of KAIs within the organization

Effective implementation of Key Activity Indicators requires the definition of several critical success factors, which should be followed to deploy these metrics. Different scientific

contributions discussed success factors for the introduction of indicators. For instance, the contribution of Hirzel *et al.* (2017) shows several attributes for a successful indicators deployment, such as the ability of team managers to hand their staff the control over the activities to be performed. Indeed, recent work conducted by Orgambídez-Ramos and Borrego-Alés (2014) confirmed that if associates are not correctly empowered, their work becomes ineffective. Thus, it is possible to adapt a structure of critical success factors proposed by Hirzel *et al.* (2017) to ensure a high level of engagement and proper integration of KAIs in the daily people's routine:

- Increase the level of knowledge and skills of employees: the role of team managers is to identify several training courses and activities to increase staff capability in performing their activities. This factor is essential to create a high level of maturity since it raises awareness about the activities that KAIs should measure. This perception is confirmed by the works of Kusnadi (2020), highlighting the growth of employees' knowledge as an essential intangible element for the achievement of strategic objectives, and the researches of Keegan (2016) and Coughlan *et al.* (2016) showing that the increase of awareness and knowledge is an essential element for lean implementation;
- Provide associates the necessary support to perform activities: team managers should provide associates with the support (e.g., financial, time, supplies etc.) for improving their activities. Indeed, Khan et al. (2019) confirm the positive correlation between people's performance and their dedicated financial budget for implementing incremental solutions;
- Make available to associates the relevant information and knowledge: by providing associates the possibility to access information concerning policies and strategic decisions of the organization, they would develop the ability to influence and align their activities with the organizational goals. Specifically, Hellebrandt *et al.* (2019) show how inaccessible information may cause poor performance. Thus, a critical success factor for proper implementation of Key Activity Indicators is the exchange of information between team managers and the operative staff;
- Development of a continuous feedback system: since Key Activity Indicators should be dynamically managed (Amadio, 2017), creating a continuous feedback system is essential for their success. This point of view is reinforced in the contribution of

Mclver *et al.* (2018), which highlights that constant feedback is a key enabler for effective implementation of Human Resource Indicators.

4.7 Key Activity Indicators (KAIs) and Objective and Key Results (OKRs)

The proposal of a practical and comprehensive organizational framework for implementing Key Activity Indicators from the considerations of the leading corporate Critical Success Factors can be easily integrated with the arising "Objective and Key Results" (OKRs) methodology. Indeed, the OKR approach represents a goal setting framework used to establish goals, monitor their progresses, and identify corrective actions if the performances are not in line with the objectives (Steiber and Alänge, 2013), which has been thoroughly investigated yet in the current scientific literature.

As for the KAIs definition, OKRs are characterized by the ability to allow the organization for individualized productivity and performance management by setting and establishing objectives for individuals and teams (Helmold, 2020). However, unlike KAIs, which represent the interface between shop-floor operational activities and human resources of the organizations, OKRs operate at a higher level of the indicators hierarchy (Hoerger, 2020), interplaying between the Critical Success Factors and the Key Performance Indicators/Key Results Indicators. Hence, KAIs can be derived from the application and cascading of the OKR approach from the adoption of specific CSFs, for the development and practical implementation of a dynamic performance measurement system (Nazari-Ghanbarloo, 2022).

5 Sample case study

Intending to guide how to practically deploy the proposed definition and implementation procedure of Key Activity Indicators, this section shows an application to the case of an Italian large-scale retail trade (LSRT) company. The industrial sample case here demonstrates a potential integration of Key Activity Indicators within the PMM system of an organization. Specifically, starting from the operational critical success factors (CSFs) of the LSRT organization, the indicators hierarchy is consequently identified (Parmenter, 2007), up to the definition of specific KAIs.

Hence, the first step of the implementation requires the identification of the organizational critical success factors, which define the company's strategic directions. Table VIII provides an overview of the company's CSFs.

Operational critical success factors (CSFs) of the organization
(1) Always delivery in full on time to key customers, reduce as much as possible the backorders
(2) Distribution centers (DCs) should be safe locations and streamlined in terms of operations
(3) Increase the portfolio width (# of SKUs) to have a wider service for our customers
(4) Continuous Improvement is a key standard for our daily activities
(5) Develop exceptional people and teams who follow our organization's philosophy

Table VIII: Operational critical success factors (CSFs) in the analysed case

To identify Key Activity Indicators and align them with the company's CSFs, it is possible to apply the procedure described in subsection 4.4. Specifically, the first step is to identify critical Key Performance Indicators that directly impact CSFs and establish a relationship between them. Successively, Performance Indicators impacting the achievement of target KPIs level should be introduced. Once again, this sample case leverages the procedure proposed in the contribution of Di Luozzo *et al.* (2021): Table IX reports an extract of the indicators hierarchy (Key Performance Indicators and Performance Indicators) referred to CSF1 (*"Always delivery in full on time to key customers, reduce as much as possible the backorders"*).

Area/Function/Team	Key Performance Indicators (KPIs)	Sub-area	Performance Indicators (PIs)
Logistics	Late deliveries to key customers (number, percentage on total)	Transportation	Average lead time and standard deviation of deliveries, segmented by customers
		Transportation	Teams with the best on-time delivery record

Area/Function/Team	Key Performance Indicators (KPIs)	Sub-area	Performance Indicators (PIs)
		Transportation	Late deliveries to all customers (number, percentage on total)
	Number of complaints from the key customers that have not been resolved within a day (reported to top management)	Transportation	Logistics service level (in-full)
		Operations	Complaints from all customers (number, percentage on total)
Commercial/ Purchasing	Late deliveries of our key suppliers in the past 15 days	Purchasing	Late deliveries of all suppliers (number, percentage)
		Purchasing	Supply service level (in-full)

Table IX: Key Performance Indicators and Performance Indicators for CSF1

Once the indicators hierarchy has been defined, it is possible to apply the procedure to introduce Key Activity Indicators within the PMM system of the organization. Hence, Table X provides relevant Key Activity Indicators for the LSRT company's PMM system, showing the end-to-end approach adopted for the indicators hierarchy.

Key Performance Indicators (KPIs)	Performance Indicators (PIs)	Key Activity Indicators (KAIs)
Late deliveries to key customers (number, percentage on total)	Average lead time and standard deviation of deliveries, segmented by customers	Number of projects for reducing variability and optimizing deliveries
		Training activities concerning statistical methodologies
		Percentage of staff involved in optimization projects
	Teams with the best on-time delivery record	Coaching activities within specific teams
	Late deliveries to all customers (number, percentage on total)	Number of projects for reducing variability and optimizing deliveries
		Percentage of staff involved in optimization projects
Number of complaints from the key customers that have not been resolved within a day (reported to top mng.)	Logistics service level (in-full)	Number of projects to improve service level
		Training activities concerning statistical methodologies
		Percentage of staff involved in optimization projects
	Complaints from all customers (number, percentage on total)	Number of severity analyses per complaint per customer
		Number of projects to reduce complaints
		Percentage of staff involved in optimization projects
Late deliveries of our key suppliers in the past 15 days	Late deliveries of all suppliers (number, percentage)	Number of supplier analyses for process optimization
		Training activities concerning statistical methodologies
	Supply service level (in-full)	Training activities concerning statistical methodologies

Table X: Overall indicators hierarchy with the introduction of Key Activity Indicators

Considering the Key Activity Indicators reported as in Table X, it is now possible to report a KAI standard definition sheet according to the specifications of subsection 4.3. Indeed, the aim is to provide a reference on defining specific Key Activity Indicators and how to communicate their usage in the organization. Table XI reports the standard definition sheet for the Key Activity Indicator labelled as *"Number of projects for reducing variability and optimizing deliveries"*.

Number of projects for reducing variability and optimizing deliveries	
Description	The indicator measures the number of small projects (e.g., Kaizen projects) for reducing variability and optimizing deliveries
Measurement frequency	Monthly
Dynamically review period	Quarterly
Connections with Performance Indicators	Average lead time and standard deviation of deliveries, segmented by customers
Connections with Key Performance Indicators	Late deliveries to key customer (number percentage on total)
Cause-effect relationship	The indicator has a negative correlation with both PI and KPI: as long as the KAI improves (increases), each project aims at improving (reducing) the specific PI-KPI value

Table XI: Key Activity Indicators standard definition sheet example

6 Conclusions and further developments

This paper investigates the scientific and industrial adoption of Key Activity Indicators (KAIs) and proposes a comprehensive definition for this class of indicators, along with criteria for their practical implementation within an organizational Performance Measurement and Management (PMM) system.

Specifically, the research first performs a systematic literature review, identifying the main definitions, application areas and shortcomings of the KAIs among the scientific background. Successively, it formalizes the concept of KAIs through a comprehensive definition and implementation criteria, also providing guidelines for their successful deployment. Lastly, the paper reports an industrial sample case concerning a LSRT company operating in the Italian

territory, showing how to practically integrate Key Activity Indicators within a company's indicators hierarchy.

To our knowledge, this scientific research is the first of its kind to propose a formalization of the Key Activity Indicators concept, through a comprehensive definition and implementation criteria. Hence, it opens a new research field for the effective deployment of this class of indicators in industrial and scientific settings. Moreover, this work paves the way for other applications and studies of the Key Activity Indicators. For instance, it would be interesting to identify how to create quantitative cause-effect relationships between KAIs and KPIs, hence providing a practical methodology to leverage the human resource potential to achieve operational excellence (Di Luozzo *et al.*, n.d.). Additionally, a framework implementation in a real industrial setting is missing. Though useful to understand the potential application of Key Activity Indicators, a sample case study is not sufficient to validate the proposed methodology.

These research areas are not exhaustive, and further applications of these methodologies may be provided in the future. Indeed, the introduction of indicators for leveraging the human factor potential is another step towards defining effective collective and individual human resource management (Aloini *et al.*, 2021) and operational excellence practices, allowing organizations to "count the intangible and make the intangible count" (Cumming, 2005).

Bibliography

Alblooshi, M. and Shamsuzzaman, M. (2020), "Investigating the relationship between Lean Six Sigma's intangible impacts and organisational innovation climate factors", *International Journal of Productivity and Performance Management*, Vol. 69 No. 6, pp. 1247–1270.

Aloini, D., Fronzetti Colladon, A., Gloor, P., Guerrazzi, E. and Stefanini, A. (2021), "Enhancing operations management through smart sensors: measuring and improving well-being, interaction and performance of logistics workers", *The TQM Journal*, Vol. ahead-of-p No. ahead-of-print, available at:https://doi.org/10.1108/tqm-06-2021-0195.

Amadio, A. (2017), *World Class Manufacturing*, Franco Angeli.

Antognazza, A. and Moretti, C. (2016), "KPI e KAI", *Logistica Management*, Vol. 1 No. 1, pp. 2–4.

Barth, K.B. and Formoso, C.T. (2021), "Requirements in performance measurement systems of construction projects from the lean production perspective", *Frontiers of Engineering Management*, Vol. 8 No. 3, pp. 442–455.

Bessant, J., Caffyn, S. and Gallagher, M. (2001), "Evolutionary model of continuous improvement behaviour", *Technovation*, Vol. 21 No. 2, pp. 67–77.

Bjerke, M.B. and Renger, R. (2017), "Being smart about writing SMART objectives", *Evaluation and Program Planning*, Elsevier Ltd, Vol. 61, pp. 125–127.

Bond, T.C. (1999), "The Role of Performance Measurement in Forming Estonian", *International Journal of Operations and Production Management*, Vol. 19 No. 12, pp. 1318–1334.

Bourne, M., Franco-Santos, M., Micheli, P. and Pavlov, A. (2018), "Performance measurement and management: A system of systems perspective", *International Journal of Production Research*, Taylor & Francis, Vol. 56 No. 8, pp. 2788–2799.

Brennan, L., Ferdows, K., Godsell, J., Golini, R., Keegan, R., Kinkel, S., Srai, J.S., *et al.* (2015), "Manufacturing in the world: where next?", *International Journal of Operations and*

Production Management, Vol. 35 No. 9, pp. 1253–1274.

Chiarini, A. and Brunetti, F. (2019), "What really matters for a successful implementation of Lean production? A multiple linear regression model based on European manufacturing companies", *Production Planning and Control*, Taylor & Francis, Vol. 30 No. 13, pp. 1091–1101.

Cortes, H., Daaboul, J., Le Duigou, J. and Eynard, B. (2016), "Strategic Lean Management: Integration of operational Performance Indicators for strategic Lean management", *IFAC-PapersOnLine*, Elsevier B.V., Vol. 49 No. 12, pp. 65–70.

Coughlan, P., Fynes, B., Keegan, R. and Ledwith, A. (2016), *Implementing Lean through a Tiered Response : The Lean Business Offer*, available at: https://www.leanbusinessireland.ie/wp-content/uploads/2017/05/Implementing-lean-through-a-tiered-response-the-Lean-Coughlan-Fynes-Keegan-Ledwith.pdf.

Cumming, J.F. (2005), "Making the intangible count - Counting the intangible: A report on current learning from a UK food retailer", *International Journal of Productivity and Performance Management*, Vol. 54 No. 4, pp. 288–292.

Duque, D.F.M. and Rivera Cadavid, L. (2007), "Lean manufacturing measurement: the relationship between lean activities and lean metrics", *Estudios Gerenciales*, Vol. 23 No. 105, pp. 69–83.

De Felice, F. and Petrillo, A. (2015), "Optimization of manufacturing system through world class manufacturing", *IFAC-PapersOnLine*, Elsevier Ltd., Vol. 28 No. 3, pp. 741–746.

De Felice, F., Petrillo, A. and Monfre, S. (2015), "Improving Operations Performance with World Class Manufacturing Technique: A Case in Automotive Industry", in Schiraldi, M.M. (Ed.), *Operations Management*, IntechOpen, pp. 1–30.

Fera, M., De Padova, V., Di Pasquale, V., Caputo, F., Caterino, M. and Macchiaroli, R. (2020), "Workers' aging management—human fatigue at work: An experimental offices study", *Applied Sciences (Switzerland)*, Vol. 10 No. 21, pp. 1–21.

Forza, C. (1996), "Work organization in lean production and traditional plants: What are the differences?", *International Journal of Operations and Production Management*, Vol. 16 No. 2, pp. 42–62.

Franco-Santos, M., Lucianetti, L. and Bourne, M. (2012), "Contemporary performance measurement systems: A review of their consequences and a framework for research", *Management Accounting Research*, Elsevier Ltd, Vol. 23 No. 2, pp. 79–119.

García, J.L., Rivera, D.G. and Iniesta, A.A. (2013), "Critical success factors for Kaizen implementation in manufacturing industries in Mexico", *International Journal of Advanced Manufacturing Technology*, Vol. 68 No. 1–4, pp. 537–545.

Garvin, D.A. (1988), *Managing Quality The Strategic and Competitive Edge*, The Free Press, New York.

Ghalayini, A.M., Noble, J.S. and Crowe, T.J. (1997), "An integrated dynamic performance measurement system for improving manufacturing competitiveness", *International Journal of Production Economics*, Vol. 48 No. 3, pp. 207–225.

Giordani da Silveira, W., Pinheiro de Lima, E., Deschamps, F. and Gouvea da Costa, S.E. (2016), "Identification of guidelines for Hoshin Kanri initiatives", *International Journal of Productivity and Performance Management*, Vol. 67 No. 1, pp. 85–110.

Gröger, C., Hillmann, M., Hahn, F., Mitschang, B. and Westkämper, E. (2013), "The operational process dashboard for manufacturing", *Procedia CIRP*, Elsevier B.V., Vol. 7, pp. 205–210.

Hellebrandt, T., Ruessmann, M., Heine, I. and Schmitt, R.H. (2019), "Conceptual approach to integrated human-centered performance management on the shop floor", *Advances in Intelligent Systems and Computing*, Vol. 783, pp. 309–321.

Hirzel, A.K., Leyer, M. and Moormann, J. (2017), "The role of employee empowerment in the implementation of continuous improvement: Evidence from a case study of a financial services provider", *International Journal of Operations and Production Management*, Vol. 37 No. 10, pp. 1563–1579.

Iveta, G. (2012), "Human Resources Key Performance Indicators", *Journal of Competitiveness*, Vol. 4 No. 1, pp. 117–128.

Jurburg, D., Viles, E., Tanco, M. and Mateo, R. (2016), "What motivates employees to participate in continuous improvement activities?", *Total Quality Management & Business Excellence*, Vol. 28 No. 13–14, pp. 1469–1488.

Karkoszka, T. and Honorowicz, J. (2009), “Kaizen philosophy a manner of continuous improvement of processes and products Kaizen philosophy a manner of continuous improvement of processes and products Industrial management and organisation”, *Journal of Achievements in Materials and Manufacturing Engineering*, Vol. 35 No. 2, pp. 197–203.

Karlsson, C. and Åhlström, P. (1996), “Assessing changes towards lean production”, *International Journal of Operations & Production Management*, Vol. 16 No. 2, pp. 24–41.

Katayama, H., Murata, K. and Lee, D.J. (2019), “On advanced topics for reinforcing leanized management”, *Procedia Manufacturing*, Elsevier B.V., Vol. 39 No. 1, pp. 599–608.

Keegan, R. (2009), *Becoming Lean: Practical Steps to Build Competitiveness*, *Becoming Lean: Practical Steps to Build Competitiveness*.

Keegan, R. (2016), “Using Lean to drive Operational Effectiveness and Efficiency at a National level–The Irish Lean Business Offer initiative”, *POMS Cuba*, available at: https://www.leanbusinessireland.ie/wp-content/uploads/2017/05/POMS-2016-Driving-Competitiveness-Improvement-at-a-National-Level.pdf.

Khan, S.A., Kaviani, M.A., Galli, B.J. and Ishtiaq, P. (2019), “Application of continuos improvement techniques to improve organization performance: a case study”, *International Journal of Lean Six Sigma*, Vol. 10 No. 2, pp. 524–565.

Kumar, J., Soni, V.K. and Agnihotri, G. (2014), “Impact of TPM implementation on Indian manufacturing industry”, *International Journal of Productivity and Performance Management*, Vol. 63 No. 1, pp. 44–56.

Kusnadi. (2020), “Increased Productivity of Human Resources Based on Key”, *Dinasti International Journal of Digital Business Management (DIJDBM)*, Vol. 1 No. 6, pp. 904–910.

Letmathe, P., Schweitzer, M. and Zielinski, M. (2012), “How to learn new tasks: Shop floor performance effects of knowledge transfer and performance feedback”, *Journal of Operations Management*, Elsevier B.V., Vol. 30 No. 3, pp. 221–236.

Di Luozzo, S., Del Beato, F. and Schiraldi, M.M.M. (2021), “Measuring coherence of

performance measurement indicators in complex and changing environments", *International Journal of Productivity and Performance Management*, available at:https://doi.org/10.1108/IJPPM-03-2021-0176.

Di Luozzo, S., Schiraldi, M.M. and Marino, M. (n.d.). "Human Excellence Maturity Model: leveraging Human Resource Management to achieve operational excellence", *International Journal of Business Excellence*, available at:https://doi.org/10.1504/ijbex.2021.10043827.

Marr, B., Schiuma, G. and Neely, A. (2004), "Intellectual capital – defining key performance indicators for organizational knowledge assets", *Business Process Management Journal*, Vol. 10 No. 5, pp. 551–569.

Masron, T.A., Ahmad, Z. and Rahim, N.B. (2012), "Key Performance Indicators vs Key Intangible Performance Among Academic Staff: A Case Study of a Public University in Malaysia", *Procedia - Social and Behavioral Sciences*, Vol. 56 No. Ictlhe, pp. 494–503.

McIver, D., Lengnick-Hall, M.L. and Lengnick-Hall, C.A. (2018), "A strategic approach to workforce analytics: Integrating science and agility", *Business Horizons*, "Kelley School of Business, Indiana University", Vol. 61 No. 3, pp. 397–407.

Metzmacher, A.I., Hellebrandt, T., Ruessmann, M., Heine, I. and Schmitt, R.H. (2019), *Advances in Production Research*, *Advances in Production Research*, Springer International Publishing, available at:https://doi.org/10.1007/978-3-030-03451-1.

Murata, K. and Katayama, H. (2009), "An evaluation of factory performance utilized KPI/KAI with data envelopment analysis", *Journal of the Operations Research - Society of Japan*, Vol. 52 No. 2, pp. 204–220.

Neely, A. (2005), "The evolution of performance measurement research: Developments in the last decade and a research agenda for the next", *International Journal of Operations and Production Management*, Vol. 25 No. 12, pp. 1264–1277.

Neely, A., Gregory, M. and Platts, K. (1995), "Performance measurement system design: a literature review", *International Journal of Operations & Production Management*, Vol. 15 No. 4, pp. 80–116.

Newitt, D.J.H. (1996), "Beyond BPR and TQM - managing through processes: is Kaizen

enough?", *IEE Colloquium on "Beyond TQM and Re-Engineering - Managing Through Process"*, available at:https://doi.org/10.1049/ic:19960785.

Ng, H.S. and Kee, D.M.H. (2011), "Organisational success: Explaining the role of key intangible performance indicators (KIPS)", *Asian Business and Management Practices: Trends and Global Considerations*, No. January, pp. 120–137.

Ohlig, J., Hellebrandt, T., Metzmacher, A.I., Pötters, P., Heine, I., Schmitt, R.H. and Leyendecker, B. (2020), "Performance management on the shop floor – an investigation of KPI perception among managers and employees", *International Journal of Quality and Service Sciences*, Vol. 12 No. 4, pp. 461–473.

Orgambídez-Ramos, A. and Borrego-Alés, Y. (2014), "Empowering Employees: Structural Empowerment as Antecedent of Job Satisfaction in University Settings", *Psychological Thought*, PsychOpen, a publishing service by Leibniz Institute for Psychology Information (ZPID), Trier, Germany (www.zpid.de)., Vol. 7 No. 1, pp. 28–36.

Palomares-Montero, D. and García-Aracil, A. (2011), "What are the key indicators for evaluating the activities of universities?", *Research Evaluation*, Vol. 20 No. 5, pp. 353–363.

Parmenter, D. (2007), *Key Performance Indicators - Developing, Implementing, and Using Winning KPIs*, First., Wiley, Hoboken.

Petrillo, A., De Felice, F. and Zomparelli, F. (2019), "Performance measurement for world-class manufacturing: a model for the Italian automotive industry", *Total Quality Management & Business Excellence*, Vol. 30 No. 7–8, pp. 908–935.

Ribeiro, N., Nguyen, T., Duarte, A.P., Torres de Oliveira, R. and Faustino, C. (2021), "How managerial coaching promotes employees' affective commitment and individual performance", *International Journal of Productivity and Performance Management*, Vol. 70 No. 8, pp. 2163–2181.

Sânchez, A.M. and Pérez, M.P. (2001), "Lean indicators and manufacturing strategies", *International Journal of Operations and Production Management*, Vol. 21 No. 11, pp. 1433–1451.

Sardi, A., Garengo, P. and Bititci, U. (2019), "Measurement and management of competences

by enterprise social networking", *International Journal of Productivity and Performance Management*, Vol. 68 No. 1, pp. 109–126.

Siaudzionis Filho, F.A.B., Pontes, H.L.J., Albertin, M.R., de Lima, R.L.M. and Moraes, T. de C. (2018), "Application of visual management panel on an airplane assembly station", *International Journal of Productivity and Performance Management*, Vol. 67 No. 6, pp. 1045–1062.

Singh, J. and Singh, H. (2020), "Justification of TPM pillars for enhancing the performance of manufacturing industry of Northern India", *International Journal of Productivity and Performance Management*, Vol. 69 No. 1, pp. 109–133.

Villalba-Diez, J. (2017), *The Hoshin Kanri Forest*, edited by Group, C.P.-T.& F.*The Hoshin Kanri Forest*, available at:https://doi.org/10.1201/9781315155814.

Wee, H.M. and Wu, S. (2009), "Lean supply chain and its effect on product cost and quality: A case study on Ford Motor Company", *Supply Chain Management: An International Journal*, Vol. 14 No. 5, pp. 335–341.

Witcher, B.J. and Chau, V.S. (2007), "Balanced scorecard and hoshin kanri: Dynamic capabilities for managing strategic fit", *Management Decision*, Vol. 45 No. 3, pp. 518–538.

Yan, B. and Makinde, O.D. (2011), "Impact of continuous improvement on new product development within SMEs in the Western Cape, South Africa", *African Journal of Business Management*, Vol. 5 No. 6, pp. 2220–2229.

Tangen, S. (2005), "Demystifying Productivity and Performance", *International Journal of Productivity and Performance Management*, Vol. 54, No. 1 pp. 34-46. https://doi.org/10.1108/17410400510571437

Schläfke, M., Silvi, R. and Möller, K. (2013), "A framework for business analytics in performance management", *International Journal of Productivity and Performance Management*, Vol. 62 No. 1, pp. 110-122. https://doi.org/10.1108/17410401311285327

Tangen, S. (2004), "Performance measurement: from philosophy to practice", *International Journal of Productivity and Performance Management*, Vol. 53 No. 8, pp. 726-737.

https://doi.org/10.1108/17410400410569134

Wadongo, B. and Abdel-Kader, M. (2014), "Contingency theory, performance management and organisational effectiveness in the third sector : A theoretical framework", *International Journal of Productivity and Performance Management*, Vol. 63 No. 6, pp. 680-703. https://doi.org/10.1108/IJPPM-09-2013-0161

Steiber, A. and Alänge, S. (2013), "A corporate system for continuous innovation: the case of Google Inc.", European Journal of Innovation Management, Vol. 16 No. 2, pp. 243-264. https://doi.org/10.1108/14601061311324566

Helmold, M. (2020). "Lean Management KPI and OKR". *In: Lean Management and Kaizen. Management for Professionals*. Springer, Cham. https://doi.org/10.1007/978-3-030-46981-8_12

Michael Hoerger (2020): "Measure What Matters: Lessons for Strategic Implementation in Psychosocial Oncology", *Journal of Psychosocial Oncology*, https://doi.org/10.1080/07347332.2020.1749212

Nazari-Ghanbarloo, V. (2022), "A dynamic performance measurement system for supply chain management", *International Journal of Productivity and Performance Management*, Vol. 71 No. 2, pp. 576-597. https://doi.org/10.1108/IJPPM-01-2020-0023

Appendix A

Citation	Publication year	Publication place
(Barth and Formoso, 2021)	2021	Brazil
(Ribeiro *et al.*, 2021)	2021	Portugal
(Di Luozzo *et al.*, 2021)	2021	Italy
(Kusnadi, 2020)	2020	Indonesia
(Ohlig *et al.*, 2020)	2020	Germany
(Alblooshi and Shamsuzzaman, 2020)	2020	United Arab Emirates
(Singh and Singh, 2020)	2020	India
(Katayama *et al.*, 2019)	2019	Japan
(Metzmacher *et al.*, 2019)	2019	Germany
(Petrillo *et al.*, 2019)	2019	Italy
(Hellebrandt *et al.*, 2019)	2019	Germany
(Sardi *et al.*, 2019)	2019	Italy
(McIver *et al.*, 2018)	2018	India
(Amadio, 2017)	2017	Italy
(Bjerke and Renger, 2017)	2017	USA
(Antognazza and Moretti, 2016)	2016	Italy
(Cortes *et al.*, 2016)	2016	France
(Coughlan *et al.*, 2016)	2016	Ireland
(Jurburg *et al.*, 2016)	2016	Spain
(Keegan, 2016)	2016	Ireland
(De Felice and Petrillo, 2015)	2015	Italy
(Kumar *et al.*, 2014)	2014	India
(García *et al.*, 2013)	2013	Mexico
(Gröger *et al.*, 2013)	2013	Germany
(Iveta, 2012)	2012	Czech Republic
(Letmathe *et al.*, 2012)	2012	Germany

Citation	Publication year	Publication place
(Masron *et al.*, 2012)	2012	Malaysia
(Ng and Kee, 2011)	2011	Japan
(Palomares-Montero and García-Aracil, 2011)	2011	Spain
(Yan and Makinde, 2011)	2011	South Africa
(Keegan, 2009)	2009	Ireland
(Karkoszka and Honorowicz, 2009)	2009	Great Britain
(Murata and Katayama, 2009)	2009	Japan
(Duque and Rivera Cadavid, 2007)	2007	Columbia
(Parmenter, 2007)	2007	USA
(Cumming, 2005)	2005	Great Britain
(Marr *et al.*, 2004)	2004	Great Britain
(Bessant *et al.*, 2001)	2001	Great Britain
(Sânchez and Pérez, 2001)	2001	Spain
(Bond, 1999)	1999	Great Britain
(Ghalayini *et al.*, 1997)	1997	USA
(Forza, 1996)	1996	Italy
(Karlsson and Åhlström, 1996)	1996	Sweden
(Newitt, 1996)	1996	Great Britain

Table A.I: Selected bibliographic portfolio