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Article

Industrial Performance: An Evolution Incorporating Ethics in the Context of Industry 4.0

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Abstract: This article addresses the issue of the industrial performance model and its evolution to cope with the context of Industry 4.0. With its digitalisation, intelligent/autonomous systems and wealth of data, Industry 4.0 offers opportunities that can achieve objectives better. It also presents risks and uncertainties that question the autonomy of the systems, their interaction with humans and the use of available data. The hypothesis put forward in this work is that the efficiency–effectiveness–relevance performance triangle can no longer guarantee long-term performance under these conditions and needs to be associated with an ethical dimension that allows for the risks and uncertainties relating to Industry 4.0 to be considered. Ethics is therefore considered to extend the triangle to a tetrahedron. A brief analysis of current performance management will first show the limits of the current practice in the context of Industry 4.0. The frameworks that could overcome these limits in light of new needs are then recalled and discussed, leading to the choice of ethics, whose main definitions and use in the engineering field are also introduced. The proposed (efficiency–effectiveness–relevance–ethics tetrahedron-based methodology is illustrated through a case study related to an aeronautical supplier, regarding the consequences of the implementation of a MES (Manufacturing Execution System) in terms of product traceability and operator autonomy. The discussion and prospects finally conclude this study.

Keywords: industrial performance; Industry 4.0; (efficiency, effectiveness, relevance) triangle; ethics



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1. Introduction

Companies look for profitability [1] and have always identified performance with the financial benefits it brings them. In its turn, performance deals with the notion of optimality and has been associated with the efficiency–effectiveness–relevance triangle. This triangle was seen as encompassing all the conditions for performance, in the sense that satisfying efficiency in the use of equipment, effectiveness in achieving objectives and relevance in setting objectives was sufficient to ensure performance. However, basing performance on these conditions alone subscribes to a vision that only focuses on the direct and positive impacts. It does not consider the short- or long-term risks associated with achieving the objectives set and using the means available. Such a vision was valid until the industrial systems became well-controlled and the risks attached to their operation mostly known and taken into account. Due to its technological revolution, Industry 4.0 has brought about changes that can question this performance model to do with new risks and uncertainties and the guarantee of long-term profitability (Figure 1). Indeed, the intelligence of systems and the wealth of data that characterise Industry 4.0 imply short and long-term risks, first regarding the intelligent systems' ability to increase performance, which pushes the limits of what can be achieved. Such intelligence can also lead the autonomous systems to make decisions that may not be completely beneficial. Moreover, as Artificial Intelligence (AI) could be a substitute for humans at all levels, redefining or even restricting their role could

lead to added pressure and demotivation. Another major risk is an inappropriate use of data, again for the purpose of optimising results. By neglecting these risks, the guarantee that every 4.0 technological development is useful for both companies and the society from a general point of view will decrease, leading in particular to unsustainability and therefore non-performance.

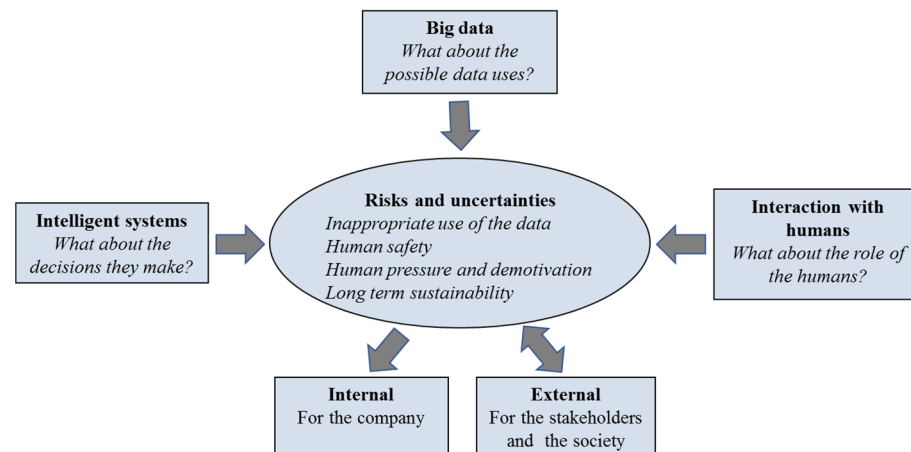


Figure 1. Industry 4.0's risks and uncertainties.

Therefore, the submitted research question in this paper concerns the way the efficiency–effectiveness–relevance performance triangle can be enriched in order to cope with the Industry 4.0 consequences mentioned above. The hypothesis put forward in this study is to associate an ethical dimension to this triangle in order to ensure that both the objectives set and the means used subscribe to the sustainability of the companies and humans involved. From our perspective, not integrating a dimension such as ethics into the performance model will lead to overruns that will be associated with unjust or immoral behaviours and will have an immediate impact on a company's profitability. These overruns may be due to human demotivation or pressure as well as to the consequences of an ill-adapted or poorly controlled use of AI. In this sense, ethics, which in essence places any intention or action in a perspective of justice and equity, is one of the avenues to reconsider this triangle and handle risks and uncertainties. Indeed, since this triangle involves both the parameters of performance (objectives, results, means) and its conditions (efficiency, effectiveness, relevance), associating an ethical vision of each of these points will make it possible to adjust all the actions carried out and avoid “unethical” behaviour while guaranteeing performance. Ethics is a concept that has been studied for centuries by philosophers and it is not the objective of the authors to discuss all the facets of such a complex concept. However, we have chosen a general but simple definition to set the discourse. Ethics is defined in this work as the search for “a good life, with and for others, in fair institutions” [2]. Today, ethics in companies is seen mainly as part of the CSR (Corporate Social Responsibility) policies of companies [3], dealing primarily with complying to fair and equitable financial policies. Within its different paradigms, ethics offers a framework for subscribing to all the objectives set and actions handled to reach the sustainability of the company, i.e., its profitability in both the short and long term while taking into account human working conditions.

Therefore, seeking the evolution of the industrial performance model, this article is placed in the context of Industry 4.0. Its aim is to show to what extent ethics could be considered as a possible and natural new element to be integrated into the traditional performance triangle. The main contribution concerns a performance model enriched on the basis of considering ethics as well as an associated methodology for implementing it. In order to illustrate the idea of using ethics as a way for evolving the current model, the key concepts of performance are presented in Section 2, as well as a brief analysis of the evolution of this notion and its limits regarding Industry 4.0 risks and uncertainties. This

presentation will make it possible to draw a trajectory along which principles relevant to performance management can naturally evolve towards the integration of the concept of ethics for adapting to the context of 4.0. Therefore, general frameworks that could cope with the Industry 4.0 risks and uncertainties for industrial systems are introduced and discussed in Section 3. A proposal for a tetrahedron by integrating ethics into the efficiency–effectiveness–relevance triangle is then described in Section 4. To illustrate this proposal, a case related to an aeronautical supplier is considered in Section 5. The consequences of the implementation of a MES (Manufacturing Execution System) in terms of product traceability and operator autonomy are studied using the proposed tetrahedron. Lastly, the discussion and prospects to the proposal conclude this study.

2. Industrial Performance Issues

2.1. Definitions

In its general sense, performance “refers to an exceptional, outstanding, optimal result. It involves expectations that can be translated into objectives” [4]. Conveying thus the notion of optimality, company performance has been associated with this optimality regarding its profitability and the objectives that contribute to it. Since profitability has in turn been identified with the company’s purpose, it has become associated with what is understood as its sustainability. Therefore, performance, profitability and sustainability have become synonymous in industry. In this sense, the performance purpose is reached through a procedure consisting of setting objectives, launching actions and measuring the results obtained. The “reached results” can then be quantified regarding the expected “optimal results”. However, if such a procedure is quasi-intuitive, the success of its implementation depends on the way it is handled. In this sense, three conditions have been associated throughout the context of evolution, progressively constituting the efficiency–effectiveness–relevance triangle.

2.2. From a Historical to a Modern Vision of Performance

During the thirty glorious years, optimising profitability was achieved through increasing production rate and decreasing production cost. Industrial performance was expressed in terms of equipment efficiency and Direct Labour productivity [5], which underlied the direct link between performance, cost and efficiency. The so-called performance indicators were introduced, with regards to the Taylorian standardised ratios, notably the famous “productivity indicator” [6]. Therefore, the task of performance management was to guarantee the conditions relating to the efficient use of the machines by the operators, without considering the limits of the humans who were production resources like any other. At the same time, industry was characterised by a kind of acceleration and performance took on the specificity of short-term results. Progressively, competitiveness and customer satisfaction led to a subsequent extension of the structural cost criterion. Consequently, performance was not only deployed regarding the production system but also throughout the company, from production to business levels and extending productivity to all production factors [7,8]. New objectives were set that related to the introduction of added value to products: variety, quality and delivery [9–11], which therefore raised the question of effectiveness in their achievement. In the spirit of acceleration, performance management strategy looked for both effectiveness (achieving the objectives) and efficiency (reducing costs): “Effectiveness concerns how well a system tracks against its purpose or normative behaviour”, when “efficiency describes how well a system uses resources” [12]. Providing quality products at the lowest cost and in the shortest time was the strategy and continuous improvement philosophies were adopted [13,14]. The Taylorian performance indicators were extended since financial calculations alone were no longer sufficient [15], as well as performance measurement systems and operational management scorecards [16–18]. Moreover, aside from the pre-established control rules, others allowing priori reaction to events were integrated into the previous Taylorian posteriori verifications, which meant that

decision support was needed to determine adequate solutions in a context characterised by a growing uncertainty that still remained totally human-controlled.

Later, relevance was added as a third condition to efficiency and effectiveness to handle the consistency of the objectives with regards to the allocated means (operators and equipment) [19,20]. Indeed, as objectives became more diverse it was necessary to analyse the ability of the production systems to meet them [17,21]. At this time, performance was associated with the efficiency–effectiveness–relevance triangle [19]. Several variants of relevance have been proposed: comparing objectives to means [22], achieving objectives to overall goals or matching the objectives with the intention that preceded them [23]. This being the case, the practice of relevance led to an interpretation that consisted of acting on the means to achieve the objectives, without going back on them. In fact, relevance took the direction of optimising the achievement of objectives, insofar as it stemmed from the sole objective of short-term profitability. As a result, optimising effectiveness and efficiency has been the subject of many developments, both in management and performance evaluation models [24–26]. This is the meaning of Lean Manufacturing for instance [27], which can be described by the transition from a logic of efficiency: “Maximum gain with minimal capital investment” to a logic of optimising both effectiveness and efficiency: “Maximum added value with a minimal use of all resources”. In accordance with this pre-established model, performance has at all times implicitly become synonymous with continuous performance.

Lastly, the so-called new technologies of the fourth industrial revolution [28] led to the rise of the concepts of smart manufacturing and Cyber-Physical Systems (CPSs) that are “systems of collaborating computational entities which are in intensive connection with the surrounding physical world and its on-going processes, providing and using, at the same time, data-accessing and data-processing services available on the internet” [29]. CPSs in Industry 4.0 involve “the Internet of Things, the Big Data-driven Decision-Making Processes and the digitized mass production” [30]. Although digitalisation is often considered as an extension of the previous automation, it remains specific [31–33], and the concept has not been mastered in terms of the scope of the opportunities and risks it presents [34]. On the one hand, data wealth and intelligence allows operation management to be more accurate [35]. It also makes equipment more autonomous and able to perform beyond human limits to achieve previously unattainable objectives. In particular, Industry 4.0 highlights the servitisation [36,37] and allows innovation [38] and in particular open innovation, by facilitating exchanges and networking [39]. More reactivity is possible because of increased traceability, available information in real time and at any time, and the reduction of reporting errors due to their automation which makes it more efficient and effective [40]. As a result, a better response to customer specifications and a reconsideration of the human role in such an industry have been observed. On the other hand, the inherently digital and complex production systems sometimes behave and react to change which is unpredictable and potentially risky [41]. Such risks are mainly related to the limited reliability of human interactions with intelligent systems, the potential sacrifice of their welfare, i.e., the threat felt by operators towards AI that can track all their operations and may also replace them in their tasks for the sake of increased productivity, and the loss of competence as a result of this replacement. As the opportunities and risks of Industry 4.0 are still not fully understood, the question of the relevance of the current performance management methods arises, along with the welfare of humans.

Currently, the performance 4.0 model is felt to have been revisited regarding the “performance 3.0” model, according to the occurring deep and radical changes. However, although “performance 4.0” management has been widely handled in recent literature, there is still no clarity in the definition of the paradigm or its evolution. Frameworks dealing with the digitalisation contribution to the global performance have been proposed [42–45]. Performance 4.0 is either considered through the impact of the use of the technologies on the global performance: “Firms’ performance is measured in terms of the absolute number of opportunities perceived by firms when adopting Industry 4.0 technologies” [46] or the

maturity of the system to integrate those technologies [47]. However, the lines reinforce the efficiency and effectiveness, without revisiting the relevance.

2.3. Limits of Current Performance Management Approaches

Since the beginning of industrialisation, performance management has focused on short-term results and actions on factors whose impact on performance was direct and known. Optimising profitability meant maximising the achievement of the objectives associated with these factors, while ensuring that resources are used efficiently. The only considerations beforehand were related to analysing the capacity of these resources to achieve the objectives when they became diversified. Therefore, performance was based on the postulate that three conditions had to be verified:

- The efficiency of the means regarding the achievement of the objectives;
- The effectiveness of the system to achieve the objectives;
- The relevance of the objectives regarding the means available.

With these conditions, performance has been and is still defined as follows: effectiveness in achieving objectives (appropriateness of O (objectives) with R (results)), in an efficient use of available means (appropriateness of M (means) with R (results)), subject to the relevance of these objectives for the system, in terms of the means used (appropriateness of O (objectives) with M (means)).

Although at the end of the Industry 3.0 period there were signs that this model had some limits, with the advent of Industry 4.0, the upheavals are such that these doubts have been confirmed. It has become urgent to revisit such a model for the sustainability of both companies and humans. Apart from the rehabilitation of humans in the system, the risks and uncertainties mentioned above, linked to the integration of AI, create a context in which control is not totally guaranteed. The need to deal with emergencies, changes, opportunities and uncertainties in the environment has sometimes led to a kind of identification of the notion of responsiveness to immediate responses whose repercussions cannot always be taken into account. This observation is exacerbated in the case of the non-systematically predictable functioning of Industry 4.0 systems. In such cases, short-term improvements of direct performance drivers may not guarantee overall, long-term performance. The aim of revisiting the performance model is related to the handling of all the accumulated risks and uncertainties, particularly those of the Industry 4.0, and how to best consider the humans involved in the system. Indeed, as seen before, even if works and studies have been concerned with the key issues that appeared at the end of Industry 3.0, namely, human welfare [48] and the environment and its resources protection, these issues persist and now require even more action.

Clearly, focusing on a permanent short-term improvement of the cost–quality–delivery triptych for a search for efficiency–effectiveness–relevance is questionable. The need goes beyond technical updates to become a performance model that guarantees profitability while taking care of humans, environmental protection and integrating the data related to introducing new technologies. It is then a question of defining the objectives and actions, and therefore the means that will contribute to profitability with this vision. One way of doing this, which is the investigated hypothesis in this article, is to start again from the efficiency–effectiveness–relevance performance triangle and enrich it by a dimension that could cope with all the risks and uncertainties that have been highlighted.

Adding relevance to the triangle could meet this demand. As mentioned above, although performance has integrated efficiency and effectiveness, considering relevance has essentially been part of a vision to adapt the means to the objectives. Putting performance under a relevance constraint which, strictly speaking, leads to ensuring that the means of the system are directed to the objectives, may only provide partial guarantees. This condition could in fact only be sufficient if the behaviour of the means is determined and controlled. Moreover, even though the question of only considering the objectives in relation to the means had been raised [23], as established, the purpose of relevance was to continue to convey the company's strategy and objectives as focusing on direct profitability

drivers. Today, this condition has reached its limits, particularly in view of the restrictions linked to the problems of limited resources, the logic of associating new objectives with new systems, and the human role in such systems. Therefore, relevance must be posed in terms of joint objectives and means. Performance must go beyond the criteria that directly and immediately impact profitability. Besides this, if relevance only deals with objectives and means, it does not involve the aspect of results which also impacts the way performance is managed.

The performance triangle vision must therefore be enriched in order to cope with risks and uncertainties in human-based industrial systems merged into human society and to contribute to their sustainability (Figure 2). This need, which advocates a fair and global vision, can be echoed in some proposed approaches that are described in the following sections.

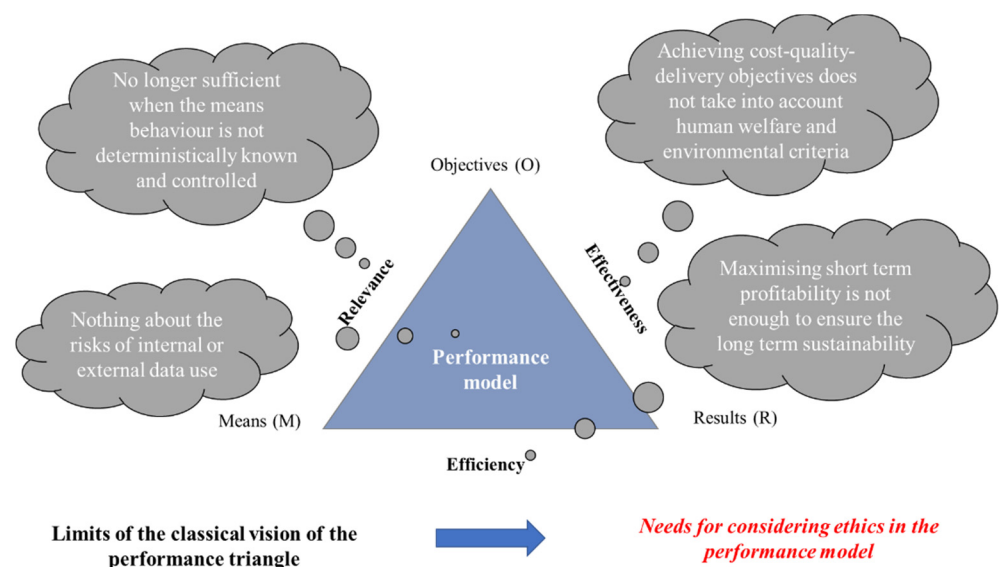


Figure 2. Towards the consideration of ethics in the performance model.

3. Towards the Consideration of Ethics in Performance

3.1. General Frameworks

According to the performance limits model highlighted before, the aim of this section is to briefly analyse both the CSR and the GDPR frameworks, before turning to a more generic ethics framework that could encompass all the risks that might be encountered. Indeed, taking into account the previously mentioned Industry 4.0 risks and uncertainties in the performance management models is a challenge for companies. Some approaches have already been implemented concerning human welfare in general that advocate the “global performance” vision which integrates societal and environmental facets. These include the Sustainable Development framework, the CSR framework with its ISO 26000 principles [49], which is used in companies and the global governance strategy [3,50–52]. In coherence with these global performance visions, companies have had to revisit their way of producing, by introducing paradigms such as reverse production [53] or circular economy [52,54], which is defined as “an economic model wherein planning, resourcing, procurement, production, and reprocessing are designed and managed, as both process and output, to maximize ecosystem functioning and human wellbeing” [55]. In this way, a recent bibliographic analysis underlines that the most cited topics in circular economy are still consumption challenges, waste management and sustainability, ethics is an emerging theme in this area [56].

To be more precise, the CSR framework defines moral and ethical obligations for companies with regards to the employees, the stakeholders, the environment, the competitors and more generally the society [57]. A deontological vision has been adopted for the CSR companies’ deployment on the basis of the ISO 26000 standard [3], which

gives the norms and rules to put in place. The finality of these obligations is to reduce the negative consequences of companies functioning on the environment and the society. These obligations mainly focus on marketing and financial activities, and concern strategic decisions rather than production activity and its operational decisions [58]. Although this framework could be enriched to address the risks associated with data and systems intelligence, its purpose remains remote for the moment.

Moreover, the famous Global Data Protection Regulation (GDPR) framework that focuses on the specific 4.0 data use risks has also been implemented. This is a European legal framework which “imposes obligations to organizations anywhere, so long as they target or collect data related to people in the European Union” [59]. The GDPR framework is currently adopted in many countries outside the European Union. It works on the principle that personal data may not be used and processed without a legal basis to do so. Its aim is to enhance the requirements on security and individual data protection in order to protect the rights and freedom of citizens in every aspect of their life (health, education, business . . .). The purpose of the GDPR is that: “Every organization that deals with personal data has to comply with the GDPR to protect these rights and to be accountable while improving business models” [60]. The GPDR framework thus allows companies to comply with the following data protection principles: “Lawfulness, fairness and transparency; Purpose limitation; Accuracy; Data minimization; Integrity and confidentiality; Accountability” [60]. Hence, this framework is well adapted for Big Data management and is not involved in the other aspects of systems intelligence.

3.2. Ethics

3.2.1. The Ethics Framework

Driven by disciplines such as philosophy, law, and more generally, human and social sciences, ethics has given rise to a good deal of reflection in both the search for its most accurate definition and the means of implementing it. Globally, from a system or societal point of view, the behaviour of an entity is ethical if it conveys equity and morality while being aligned with the values and culture of the system [61]. Several paradigms are available for ethical behaviour, namely, deontology, utilitarianism (including consequentialism), virtue and pragmatism [62,63] (Table 1).

Table 1. Four ethics’ paradigms.

Paradigm	Deontology	Utilitarianism	Virtue	Pragmatism
Vision	Action is imperatively linked to principles and values	Action is viewed through its consequences	Action emphasises moral character	Actions are drawn by practice rather than rules and norm
Keywords	Duty, Rules, Law, Principles, Norms, Fundamental rights	Objective, Impact, Global well-being, Equality of interests	Wisdom, Moral Value, Behaviour, Altruism	Experience, Practice, Recommendations

Deontological ethics, as defined by the German philosopher Immanuel Kant, means the ethics of duty, in which every action is imperatively linked to principles and values that are expressed as a duty, an obligation to do in order to respect the principles and values that are considered as fundamental rights [64]. In this vision, ethics is conceived through following immutable rules, which can be applied to any situation.

Utilitarian (consequentialist) ethics, also known as the ethics of consequences, was defined by the English philosopher Jeremy Bentham [65] at the end of the 18th century. It is primarily concerned with the utility (consequences) of actions on the notion of global well-being. Ethics becomes a set of practices to be carried out to ensure the equality of interests to be maximised and promote well-being, while reducing suffering. This paradigm is more interested in the consequences of the actions than in the actions themselves. The consequentialist paradigm is conceived through studying the consequences of possible actions on ethical values. In coherence with this vision, the so-called “Framework for Making Ethical Decisions”, based on the European school decision-making process [66],

was proposed in the 2010s with an aim to carefully *priori* explore the consequences of the decisions that could potentially be made [67]. The deployment of ethics within this framework is made through the following steps: “Recognise an ethical issue; Consider the parties involved; Gather all the relevant information; Formulate actions and consider alternatives; Make a decision and consider It; Act; Reflect on the outcome” [67]. This consequentialist way is in use today in applications in industry such as ethical business development, which balances the Industry 4.0 benefits between the capital of a company and the welfare of its employees [68].

Inspired by Socrates and Aristotle, the virtue ethics paradigm focuses on human behaviour. The approach is based on the following three iterative questions: “Is it legal? Is it fair? How does it make me feel?” [69]. Virtue aims at individual happiness and seeks answers to the questions: “How should I live?” and “What is the good life?” According to Socrates’ three iterative sieves: “Are you sure that what you are going to tell is true? Will you tell something good or positive? Is it necessary to tell what has to be told?”, people can question themselves about the ethical impact of their actions. With this virtue deployment vision, ethics addresses all the levels of society, individuals and companies, and thus gives a reference way for building ethical behaviours. Hence, virtue ethics emphasises individual virtues and moral character, in contrast to the previous approaches that emphasise both individual and collective duties and rules (deontology) or consequences of actions.

Finally, the pragmatic paradigm of ethics derives its implementation from practice rather than *priori* rules and norms [70]. It is based on experience that allows ethics from non-ethics to be distinguished.

Because of its different paradigms, ethics represents a sufficiently general framework to deal with the different situations and limitations seen above.

3.2.2. Ethics in Industry

Ethics is a concept that is already widely used to adjust actions in organisations. It takes different forms and leads to specificities, depending on the field it covers: individual ethics [71], professional ethics [72], business ethics [73], managerial ethics [74], etc. Current research shows that if we look at the paradigms that are easily appropriated by the technical engineering researcher, it is then possible to identify the two major paradigms of deontology and consequentialism [34]. Indeed, even if the different paradigms mentioned above display certain intersections, both the deontology and consequentialism paradigms show an objective and rational character, in accordance with the Cartesian approach of engineering sciences.

However, ethics in companies and industrial activities in general is mainly deontological and is often associated with the CSR framework [57]. To illustrate this, we can notice the recommendations established within the circular economy philosophy that aims to promote a responsible research and innovation, according to the “3Rs” (Reuse, Remanufacture, Recycle) [75]. Other recommendations have also been developed according to the considered industrial sector, such as the ones developed for the textile industry, for avoiding “overuse of resources, waste generation, environmental pollution and unethical labour condition” [76]. In the same way, the bibliometric analysis of Tseng et al. [77] shows that Industry 4.0 allows the company to avoid such waste but also to ensure “a safe and secure environment that encourages more ethical and moral behaviors that can increase sustainability through mutual cooperation”. However, the authors underline that even if “the socio-ethical features of CPSs . . . is needed”, there is still a lack concerning Industry 4.0’s ability to integrate societal aspects in such systems. For its part, the “integrative framework for evaluating ethical and sustainable business performance of manufacturing organizations” recently proposed by [42] combines case study analysis and multi-criteria decision tools for identifying ethical and sustainable practices in manufacturing. Industry 4.0 cleaner production and circular economy are the considered alternatives for companies. The idea is thus to compare these possible strategies and rank them, according to ethics and sustainability criteria.

With regards to production activity in Industry 4.0, the interest to use ethics has also been highlighted in the literature. The specificity of Industry 4.0 is related to the difficulty, via an aggregation of various digital technologies with a high potential of use, of understanding, predicting and guaranteeing the behaviour of these entities, particularly in terms of ethics. The behaviours of these entities are considered both when they operate autonomously and when they interact with people [78]. For instance, in their analysis of human risks, [48] show the importance of reflecting on the ethics related to the functioning of all the intelligent entities involved, whether human or AI, if they have a certain degree of decision-making autonomy. In this case, considering ethics makes it possible to check and prove that the behaviour of these intelligent systems respects the legal rules [79,80]. The authors advocate the use of the consequentialist paradigm in cases where there is a high degree of uncertainty about their behaviour or where the impact of their operation on the environment is poorly known. In the same vein, studies dealing with technoethics, the ethics of industrial systems [81,82], have been considered for the case of CPSs. Recommendations have been developed focusing on safety and sustainability in their design. Elsewhere, ethics is also taken into account through the integration of human values such as trustworthiness, welfare, autonomy and altruism for the design of the future human-CPS [83]. Other aspects are also considered in this field such as the CPS' contribution to the acceleration of social changes which are currently creating new needs for ethical responsibilities management [84]. A guideline is also currently under development that focuses in particular on addressing ethics in the interactions between human systems and CPS interactions [85].

In this study, the two key concepts, Industry 4.0 and ethics, revolve around the central notion of performance. Industry 4.0 brings great progress in the technicality of products and production processes. It also brings a great change in terms of the intelligence involved in its systems (cf. Section 2.2). It is precisely this change that will need to be bounded by an ethical framework to avoid the risks mentioned above in the paper. Associating ethics with Industry 4.0 thus makes it possible to guarantee the conditions for 4.0 systems to function properly and profitability objectives to be achieved in this context. Conversely, as performance is based on deployment and management processes, the challenge is to integrate this ethical dimension into these processes considered in the 4.0 context. The enrichment of the efficiency–effectiveness–relevance triangle seems to us to be the first step in this direction.

Typically, in the latter cases, no objective can be explicitly associated with the entities under consideration, and they will therefore escape any measure and action to mitigate them, except possibly in terms of minimising risks. In such cases, the three postulates inherent to performance are limited. In line with this early work, the integration of ethics in the performance model would become the means to put humans as the key element, to prevent technological risks while guaranteeing long-term profitability.

4. Towards the Performance Tetrahedron

4.1. The Performance Tetrahedron

The proposal consists of enriching the efficiency–effectiveness–relevance performance triangle by an ethical dimension. Integrating this dimension leads to satisfying additional conditions by respectively objectives, means and results on the one hand and effectiveness, efficiency and relevance on the other hand. Figure 3 represents this completed vision of performance which can be defined in the following synthetic form:

Ethics and effectiveness in achieving ethical objectives, in an efficient and ethical use of available and ethical means, subject to the ethics and relevance of these objectives for the system in terms of the means used and the ethics of the results obtained.

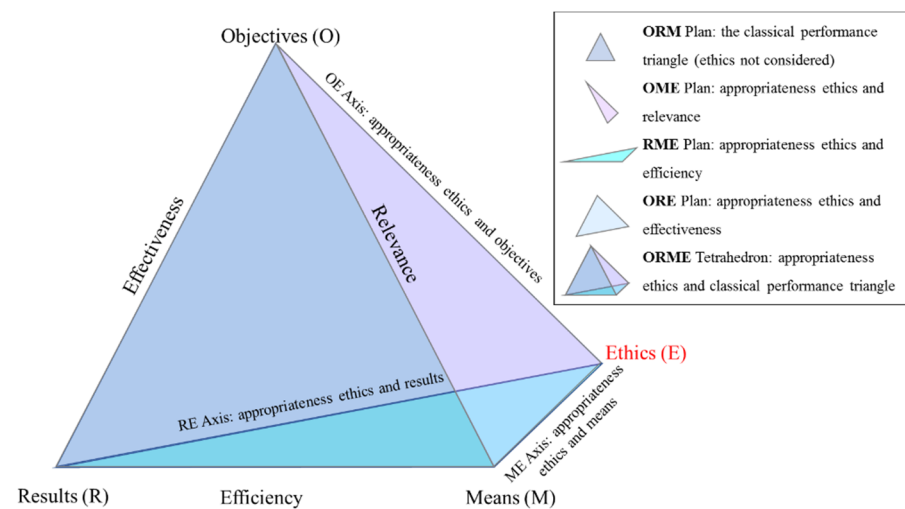


Figure 3. The performance tetrahedron.

The purpose of the tetrahedron is to cover all the elements involved in performance. The conditions gathered in this framework are aimed at sustainability and allow performance to be “ethically” optimised, i.e., both that profitability is guaranteed and ethics is observed. Hence, in addition to dealing with the relationships between objectives, means and results and their relation with humans, ethics also deals with objectives, means and results as such through the three usual conditions of performance (efficiency, effectiveness and relevance). The facets describing the different relationships between ethics and these notions are represented by the different surfaces of the tetrahedron. For instance, regarding the (OE) axis which deals with the relationship between objectives and ethics, the idea is to set ethical objectives knowing the system under consideration. Regarding the (OME) plane which deals with the relationship between relevance and ethics, the idea is to set achievable objectives knowing the means available and also an ethical use of these means. Similar conditions apply to the other three planes. Table 2 contains examples of questions asked to give yes/no answers and illustrations according to the studied relationship between ethics and the different historical concepts of performance.

Table 2. Performance tetrahedron: examples of questions.

Match between Ethics and ...	Examples of Questions	Illustrations
objectives (axis OE)	Are the set objectives ethical?	Imposition of an objective with a negative social impact.
results (axis RE)	Are the results measured or obtained ethically?	Use of human operators’ personal data 4.0.
means (axis ME)	Are the means used or defined in an ethical manner?	Split responsibility for limiting wages.
effectiveness (plan ORE)	Are objectives and results linked in an ethical manner?	Cheating, cyber-espionage or lying about achieving objectives.
efficiency (plan MRE)	Are means and results linked in an ethical manner?	Systematic replacement of human operators by autonomous robots.
relevance (plan OME)	Are means and objectives linked in an ethical manner?	Voluntary imposition of an unattainable objective to push to fault.

The tetrahedron concept provides global ethics thinking. For an operational point of view, the implementation of such a tetrahedron requires a deployment process as well as an information processing methodology that makes it possible to collect data, detect potential risks and suggest corrective values or actions in a systematic and sound way.

4.2. The Tetrahedron-Based Methodology

Managers are looking for solutions or safeguards that will prevent ethical violations. The performance tetrahedron is intended to help the managers who want to integrate ethics when deploying their strategy, setting their objectives, launching their action plans and evaluating performance. The idea is to associate the additional ethical dimension to conventional performance deployment in order to adjust or bound respectively the values of the objectives and the results as well as the capacity of the means. Hence, the tetrahedron-based methodology used in this sense is structured around the following steps (Figure 4).

1. Description of the situation; within the set objectives, the reached results and the used means.
2. Analysis of the consequences of the situation.
3. Determination of the ethics points of interest.
4. Proposal of ethical objectives and actions to carry out.



Figure 4. The steps of the tetrahedron-based methodology.

In more precise terms, the first step consists in the conventional collection of data (O, M, R) that is inherent to performance, without considering ethics. In the second step, the consequences of the actions carried out are analysed, as well as those that have been observed or those that can be imagined. In the third step, a questionnaire is established, according to the listed consequences, on the basis of the different planes and axes of the tetrahedron. The given answers that highlight ethics' points of interest are finally translated into ethical objectives and actions in the fourth step.

In line with the works of [85] previously mentioned, a guideline implementing this ethical risks management process is under development in cooperation with a partner company. Deontological and consequentialist paradigms are first considered. The following case study is a testimony of an initial use of the tetrahedron in a manufacturing digitalisation context.

5. Case Study

5.1. Context

NTN-SNR Bearings is a subsidiary of the NTN Corporation and one of the world's leading designers, developers and manufacturers of rolling bearings. With a turnover of EUR 6 billion in 2019, the company is present in the automotive, rail, renewable energy and aeronautics markets. NTN-SNR employs around 6000 people, mainly in Europe, and has 13 production sites, including 7 in France.

In particular, taking advantage of the opportunities offered by the new technologies of Industry 4.0 to maximise profits and, at the same time, seeking to satisfy its customers' requirements in terms of bearing quality and precision, the site specialising in aeronautics has been benefiting from major investments to digitalise its production since 2015, which has led to the "Digital Manufacturing" project being implemented. It concerns the production system dedicated to the bearings of the new LEAP engine, which is intended for the new generations of medium-haul aircraft such as the Airbus a320neo and the Boeing 737Max. This has given priority to the implementation project of a MES (Manufacturing Execution System) solution in order, on the one hand, to quickly respond to customer expectations in terms of product-process traceability and, on the other hand, to set up the operational dashboards enabling the control of the production workstations and the autonomy of the associated operators [86]. The aim is to make production data available which, combined with commercial, financial and human data, will make it possible to propose new uses

(Augmented Reality, Simulation, Cloud Computing, AI) in a secure environment (Cyber Security). Two main objectives were considered, one related to the traceability which had to be achieved as quickly as possible in less than six months, and the other associated with the autonomy of the workstations management, which had more time to be achieved.

The first results of the MES implementation project have been encouraging. The company found that:

- Product-process traceability was improved significantly and now makes it possible to meet the requirements of equipment manufacturers;
- Control panels were deployed on all the production workstations, leading to operational dashboards that bring together all the considered performance indicators.

At the same time, these objectives of traceability and autonomy were of a sensitive nature, because of the possible consequences their achievement would bring to the humans involved. Traceability could allow control of the operators, while autonomy could put them under pressure due to responsibility and competition. Therefore, as these objectives have been achieved, the management were questioned by the company's ethics committee about the way the project was carried out and the potential risks for humans regarding the consequences of this implementation were handled. Shedding light on the willingness of the company was enabled using the tetrahedron proposed in Section 4. In the following section, the consideration of ethics to achieve the pursued objectives is done through the two situations of traceability and management autonomy.

5.2. Application of the Tetrahedron-Based Methodology

5.2.1. Description of the Situations

The first situation deals with the objective linked to the traceability of the products and processes involved in the production system dedicated to the bearings of the new LEAP engine. The second situation also concerns the LEAP bearings production system and deals with the objective related to the autonomous management of its workstations which is associated with the implementation of operational performance indicators in the same production system. The objectives, results and means that correspond to the two situations are given in Table 3.

Table 3. Description of the traceability and autonomy situations.

Performance Aspect	Traceability Situation	Workstations Management Autonomy Situation
Objective O	Relates to the traceability of the products and processes that is expected to be of 100% for both products and processes involved in the production.	Relates to autonomy that is expected to concern all the workstations.
Result R	Reflects the achievement of O, measured by the ratio of the tracked products and tracked processes involved in the production respectively.	Reflects the achievement of O, measured by the number of implemented operational dashboards.
Means M	Includes information system, equipment and humans that are involved in the production respectively.	Concerns the information system associated with the production system as well as the operators.

5.2.2. Analysis of the Consequences

As previously discussed, achieving the traceability objective led the company to add the MES to its information system. Consequently, data identifying the operators' behaviour, beyond the production activity, and more widely the behaviour of all the humans involved in the support activities and the process management (internal logistics, quality, maintenance, etc.) became available and subject to historisation. Of course, the company has defined some rules about the use of these data in a deontological way, according to the General Data Protection Regulation (GDPR) [59] and the CSR frameworks. However, in essence, these types of generic approaches mainly focus on the external interactions of the company with customers, competitors and partners on the one hand and

the alignment with the missions of the company on the other hand. They do not cover all the indirect effects of this traceability, given the lack of knowledge about the technologies used and the uncertainty about the scope of their use. For instance, operators' feelings and general worry about being threatened by tracking by the management as a pretext for improving performance are examples of the side effects caused by traceability.

As for the first situation, the implementation of the MES has been the way to achieve the objective and many consequences have been observed. By only considering the technical point of view, the responsibilities and increased pressure from production management on the operators at the operational level regarding a strengthening of the autonomy have not been explicitly considered. Moreover, another consequence of this autonomy has been observed, related to the simplification of the management levels, which has created added worry at "middle management" level about its new responsibilities. Finally, it has been noted that performance indicators could be used as a way to compare the efficiency and the effectiveness of the operators, which could induce competition and sometimes irrelevant behaviour.

5.2.3. Determining the Ethics Points of Interest

By systematically questioning all the axes and planes of the tetrahedron according to questions such as those given in the first column of Table 3, the point of interest about considering ethics for the two situations has been highlighted.

5.2.4. Proposal of Ethical Objectives and Actions

As the managers know the revealed questions by the third step, they have proposed actions in order to prevent ethical risks which are presented in the second column of Table 4. At this time the objectives have not been reconsidered.

Table 4. Tetrahedron-based methodology results.

Match between Ethics and ...	Questioning	Actions
Situation 1 results (axis RE)	Is the traceability achieved ethically given the time allocated?	Traceability objective achievement deadline extended regarding the future implementation in the other production systems. Simulation and planning of all the project steps.
Situation 1 efficiency (plan MRE)	Are humans feeling protected and really protected with regards to traceability?	Communication on traceability issues. Humans consulted beforehand about potential uses of data concerning them, either directly or indirectly. Working groups set up on the subject.
Situation 2 objectives (axis OE)	Is it ethical to set an autonomy objective?	Middle management's role specified, defining new responsibilities within a less hierarchical and more coordinated control structure. Missions assigned to the operators rethought and new job descriptions defined regarding the integration of the operational dashboards.
Situation 2 relevance (plan OME)	Is it ethical to set an autonomy objective that is difficult for an operator to achieve?	Training sessions. Definition of a coaching protocol for the operators in addition to the supervisory screens associated with their work. "Customisation" of the MES according to the needs of each workstation.

5.3. Analysis

The feedback carried out in the NTN-SNR Company is discussed in the following section, resulting in more conceptual and methodological reflections.

The managers questioned have already observed advantages in using the proposed tetrahedron-based methodology. They essentially mentioned the potential to explicitly explain what was more or less implicitly considered in terms of ethics and to communicate

about this. Indeed, the company is aware of both the opportunities and risks involved in using the new Industry 4.0 technologies. It feels the need to explicitly increase its traditional short-term vision of performance, where objectives are regularly revised according to the conventional criteria, results are analysed and resources are allocated according to these results. In this sense, the systematic vision of exploring all the elements of performance within the axes and planes of the tetrahedron, as well as integrating a step related to the definition of objectives and actions if any risk is detected, enables an overall and exhaustive analysis of the situations and a more balanced use of modern technologies. Furthermore, having such an approach relieves the personnel of their worries and allows them to participate in managing the changes.

However, with reference to a positioning with the hierarchical approach to performance deployment practiced in the company, as well as measuring the “ethics performance” as such, a question was raised about deploying ethics along with other objectives and performance indicators, the proposal then complements the existing GDPR framework.

As it was also made clear that the deontological way is not entirely adapted to cope with changes linked to digitalisation, whereas the consequentialist way gives opportunities to do this, the question of translating the different actions carried out into deontological rules was raised, as well as identifying the managers that would be in charge of this. However, it has also been observed that the use of the proposed methodology would be improved by associating tools that are well-known by industrialists with each step of it.

The company’s “Digital Manufacturing” project is currently on going with successive deployments of the various pillars of Industry 4.0. This is profoundly transforming the system and its use, and such ethical thinking has allowed the company to prepare its future. By introducing modern technologies (Big Data, IoT, System integration, Cyber-Physical Systems), the company aims to make the production system intelligent, in order to better meet customer needs, analyse and improve performance, develop more economic and sustainable supplies, make the company more flexible, etc. However, as these transformations have been taking place, the company has become aware of how important the human dimension is, which paradoxically appeared essential to master the deployment and use of 4.0 technologies. The questions posed by this transition are numerous and while the opportunities it offers are becoming better known, the associated risks are being gradually revealed.

Finally, this first application of the tetrahedron-based methodology to the MES implementation of the NTN-SNR Company is planned to be applied to other subprojects of the company’s “Digital Manufacturing” project. Indeed, as the four steps of the process described in Figure 4 are generic, they can be applied to deal with performance in any ethical risks context. The specificity will then reside in the questionnaire to collect information, as illustrated in Tables 3 and 4 (columns 2 and 3).

6. Discussion

6.1. Theoretical and Empirical Implications of the Ethical Approach into the Industry 4.0 Performance Model

Let us now come back to the hypothesis of this study, which was to associate the ethical dimension with the efficiency–effectiveness–relevance triangle, in order to ensure that both the objectives set and the means used subscribe to sustainability for the companies and humans involved.

The introduction of ethics into the 4.0 performance model has both theoretical and empirical consequences. From the theoretical point of view, considering ethics does not require the companies to rethink the concept of Industry 4.0 or change the material structures and architecture. The transition to Industry 4.0 is an opportune moment to mainstream the integration of ethics into practices. Involving ethics in industrial management practices from now on means extending what was previously devoted to human resource management. With the advent of Industry 4.0, this involvement extends human resource management to take into account the use of CPSs including AI and its human interactions. In this respect, the proposed tetrahedron has been developed in the continuity of work

initiated around the integration of ethics in production systems [34]. The performance model is not modified in its philosophy of achieving objectives either, which had to be efficient and relevant. It is now efficient, relevant and ethical. Besides, considering ethics from an operational point of view has consequences on the decision-making process (new decision criteria, new data and new data processing, multiple decision-makers), and more generally on the industrial systems management. This last point highlights the central role of humans, advocating the Industry 5.0 era where humans are present compared to the very technological focus of the Industry 4.0. However, at this level of tetrahedron-based methodology, the consequences of this integration of ethics on performance are not directly measurable, especially at short term. Adding the ethics point of view will enable companies to jointly improve efficiency, effectiveness and relevance with the guarantee that no side of the performance triangle is forgotten and that the synergy between these sides is also taken into account. This handling also enables the formalisation of implicit practices that can be made by some managers regarding the ethical aspect of some action plans or in setting objectives. Integrating ethics into the mechanism will increase coherence and effectiveness from a performance management point of view. Hence, the implementation of the tetrahedron vision in performance management must be followed and adapted to the encountered situations. An operational guideline allowing for this implementation is currently being developed in the spirit of the methodology as well as the guideline dealing with the interaction of human systems and CPS [85] presented in Sections 4 and 5. It includes all the questions to be asked, a quantification of the associated risks and ethical uncertainties and a set of recommendations for the managers in charge of achieving the objectives. This tool is designed to be used by the company's engineering managers, in agreement with its ethics committee. Although this study focuses on the AI risks and uncertainties in the industrial systems, the principles underlying the proposal could be applied to any system.

With this in mind, the consistency and genericity of the tetrahedron are being tested on different case studies in industry, information technology and services, healthcare and logistics. Indeed, the proposed methodology could be applied to any sectors and situations at the considered abstraction level. However, the guidelines associated with the methodology should be adapted according to the specific sector risks and uncertainties (health risks and uncertainties for healthcare, financial risks and uncertainties for banks or insurance services, etc.).

6.2. Limitations and Future Research

Considering the performance management from a global point of view, the tetrahedron also has to be strongly associated with developed frameworks regarding the Industry 4.0 performance model, which has to handle ethics to avoid risks but also consider the opportunities that are given by the Industry 4.0 tools. Performance indicators will therefore be defined in this sense to measure the ethics' degree or maturity in the considered systems as well as the impact of the handling of ethics within performance. This point has been identified as an important demand by the industrialists. From a methodological point of view, the implementation of a performance deployment in an Industry 4.0 context, based on the vision and definition proposed above, opens the debate on a number of points. From an industrial point of view, the idea retained is to "bound" both the actions on the means as well as the objectives so as to guarantee ethics. Ethics thus becomes a condition to be met as the production systems are controlled. The satisfaction of this condition would have to be planned in the same way as the other objectives. Naturally, as mentioned earlier, such an integration has to be considered, along with other aspects to integrate into the performance measurement systems that meet digitalisation specifications, such as real time data availability, sharing decision-making with AI, etc. Hence, the deployment of the performance will need to consider the physical/operational and strategic decision-making points of view of the system. Ethics should therefore be associated with the behaviour of all the elements of the system, and its autonomous and intelligent parts in particular. This

association must be carried out in coherence with the company's decision-making model, for example the question of the appropriateness of relevance with ethics could be raised at a strategic level, the appropriateness of efficiency with ethics at a tactical level, and the appropriateness of effectiveness with ethics at an operational level. Answers can then be given about the decision-makers who are in a position to carry out this integration of ethics. How, then, can this be done and how can a company integrate this new ethical dimension in the performance model? As the integration of ethics into the performance model, and industrial management more generally, can be identified with a process involving innovation, it would be interesting to associate the innovation paradigm, and in particular the open innovation paradigm, with this research. Indeed, the open innovation paradigm, which has already been used in similar sustainability ecosystems [39], seems to be an interesting research avenue. In particular, in addition to the innovation aspect, the ethics consideration in the Industry 4.0 performance model involves numerous internal and external stakeholders who could then share their knowledge and practices in order to progressively build the new performance and management models in a consensual way.

Moreover, simulation devices must be used when the consequences of a behaviour are poorly known to make it possible to envisage different scenarios, evaluate the consequences and capitalise on the information obtained. From a technical point of view, given the complexity induced by Industry 4.0, the use of simulation tools would allow different alternatives (decisions) to be made before applying a decision, in order to test the impact on the ethical performance ("what-if?" approach). Advances in developments relating to digital twin technology make this possible, along with the democratisation of serious games, which can simulate different organisations for a company, or even fictive lawsuits where legal or ethical responsibilities can be assigned to either people or artificial and intelligent entities [87]. However, quantifiable performance indicators like measuring and comparing two alternatives or situations from an ethical perspective or diagnosing a situation from an ethics point of view, must be determined in this context, which is certainly one of the most delicate aspects to deal with. The basic concepts of performance have measures (monetary value, time value, etc.) and diagnostic tools, but how can a measure of ethics be constructed or a degree of "ethicality" be established and explained? Although an absolute measure seems difficult in our view, it is reasonable to think that on a case-by-case basis, some indicators may contribute to a more relative and more or less consensual measure depending on the corporate culture or social environment. For example, a measure of social well-being by means of a questionnaire, a measure of wage-labour appropriateness, a survey on the social impact of a company, being able to recruit younger generations who are attentive to societal changes, etc. would allow an evaluation, albeit indirect, of this degree of "ethicality" to be done. It would never be possible to achieve "industrial ethical excellence" on the first attempt and an iterative approach will be necessary [88].

6.3. Policy Recommendations

Conceptually speaking, in our view, the positioning of ethics in relation to the CSR framework currently in place is still insufficient. The NTN-SNR Company confirmed this observation as the managers questioned believed that ethics issues were taken into account by such a framework. Ethics is essentially a financial issue (tax havens, employment of young people and employment conditions, etc.) in a CSR framework and concerns the behaviour of employees but suggests the alignment of their ethics with the search for the company's sustainability (I help my employees to progress, etc.). However, even if the understanding is that the purpose of a company is and will remain to generate profit, it is understandable that the employees' ethics towards the company may not be considered sufficient if societal issues and the world around these companies are taken into account. In this sense, ethics must also integrate Sustainable Development, at the very least through its pillar relating to society. As a result, it is possible to imagine the dilemma of an employee who, in order to be ethical towards society, contravenes his company's quest

for sustainability (for example, a whistle-blower in the environmental or data protection fields). Virtue and pragmatism ethics paradigms could help in these cases, even if these approaches still remain more associated with philosophy than with industry.

Several recommendations can be given in view of integrating ethics into industrial management, in particular in the efficiency–effectiveness–relevance triangle. The first recommendations are general and concern the need to be aware that respecting the rules established by the CSR and GDPR frameworks is not enough for the company to be ethical. In this respect, thinking about ethics requires a more global vision, the starting point of which can be the recommendations of the CSR and GPDR. A possible approach would then be to identify the risks and uncertainties that are not taken into account by these frameworks and consolidate them in order to guarantee ethics everywhere. Moreover, in addition to taking into account the environmental and individual dimensions, integrating ethics will have its own specificities (actors involved, stakes, means required, etc.), depending on the decision-making level concerned and the considered life cycle of the system. It is therefore essential to include people and all stakeholders in the design of systems 4.0. Staff will need to be trained in ethics and introduced to its different paradigms, for implementation in an industrial context. Strategic managers will also need to be aware that long-term human well-being is a necessary condition for the sustainability of the company and therefore for its performance. Indeed, it will be fatal for both companies and the society if human well-being is not treated as a main issue and is dissociated from performance that is kept in its traditional race for short-term efficiency and lets AI autonomously control industrial systems. As developed, the tetrahedron is intended to be an operational vehicle for both these ethical recommendations and warnings in case of non-compliance.

Finally, the recommendations that could be associated with the use of this proposal will mean following the intuitive steps proposed in the methodology summarised in Figure 4. This use is necessarily collective, mobilising both technical and managerial skills, and as mentioned before, requires an operational guideline for the collection and analysis of the data involved. So, starting by being aware that the performance model must evolve by integrating ethics and, beyond this model, the industrial practices as a whole, company strategic decision-makers must work in two main directions in order to proceed in a systemic approach. On the one hand, the human resources management department must be associated when integrating the tetrahedron methodology to the current management practices. In this sense, a starting point could be the CSR and GDPR procedures already implemented. On the other hand, an operational tool that is able to identify and prevent the potential ethical risks induced by Industry 4.0 technologies must be implemented in the same manner as the Failure Mode Effects and Criticality Analysis are used for the Safety policy [89]. As asked by the NTN-SNR Company, such a tool will be developed to be used by all the managers involved in industrial decision-making processes.

7. Conclusions

This paper has addressed the issue of integrating ethics into the industrial performance model. It focuses on the context of Industry 4.0, which goes beyond the constraints of acceleration and short-term results that characterise the industry from its beginning. Indeed, the profusion of data and Artificial Intelligence increasingly question the behaviour of industrial systems as well as the place of humans in them. It was assumed that integrating ethics into Industry 4.0 management methods in general would ensure that people were protected from the risks of integrating AI into systems while maintaining the focus on performance. In line with the work already carried out to introduce ethics into the production systems of Industry 4.0, a tetrahedron-based methodology has been proposed, built on the basis of the efficiency–effectiveness–relevance performance triangle, and systematically linking ethics to the objectives, means and results associated with the system. The methodology for using the tetrahedron was applied to an initial industrial case. Issues of traceability and operator autonomy were raised as a result of implementing a manufacturing digitalisation project.

This work is exploratory and has many research perspectives. Indeed, the general purpose of the study is to create an ethics management system (like the quality management system) that goes beyond mere deontology when the company is involved in change, which is now permanent. In other words, ethics in business are rules when appropriate and a methodology based on the consequentialist paradigm in other cases. In this sense, three global perspectives seem essential to be in line with the preliminary reflections put forward on the subject: the application of the model in other industrial situations, its operationalisation via methodological tools and a software solution and finally the association of a performance measurement system to quantify the “ethicality” of the systems considered.

More precisely, the considered hypothesis in this paper has to be strongly validated before going deeper into the development of the tetrahedron and its associated methodology. Multiple sectors must be considered in order to collect the specificities of each of them with regards to Industry 4.0 risks and uncertainties. Such risks and uncertainties have to be listed and eventually quantified, according to risks analysis and fuzzy theories for instance. The steps of the tetrahedron-based methodology will thus be detailed along with the tools and methods that are used by the engineers associated with their implementation. The proposed framework will become operational by associating its software transcription with simulation tools in order to integrate them into the considered system. Moreover, building such a framework will also need to be based on paradigms such as open innovation in order to both capture the innovation aspect that is associated with it and to make it possible to share all the exchanges that are involved during its lifecycle. Associating ethics and innovation in the Industry 4.0 context will seem quite natural for practitioners.

Apart from the development of the tetrahedron concept, research work on evaluating the notion of ethics is envisaged so that it would become associated with an objective and action plans in order to improve its performance. The precise principle would consist in measuring both the initial performance state when the ethical risks and uncertainty are identified and the performance state reached after the execution of the corrective actions. This would allow consequentialist actions to be considered and translated into deontological rules then added to the existing conventional ones. Naturally, such developments will lead to more general work on the performance measurement systems of Industry 4.0 industrial systems. Integrating the ethical dimension to performance management is a useful research perspective as an alternative to the current short-term vision of it.

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