The ethics of developing, implementing, and using advanced warehouse technologies

THE ETHICS OF DEVELOPING, IMPLEMENTING, AND USING ADVANCED WAREHOUSE TECHNOLOGIES

Top-Down Principles Versus The Guidance Ethics Approach

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Abstract

Advanced technologies are increasingly being utilised in logistics warehouses, raising ethical concerns about responsible development, implementation, and use. In this study, we follow Verbeek's guidance ethics approach to explore the potential positive and negative effects of advanced technologies on the quality of work and values considered important by key stakeholders. This bottom-up approach led us to conduct 23 interviews with engineers, technology advisors, employees with managerial tasks, and operators who are designing, implementing, and/or using advanced technologies. We identified nine categories of technology effects on society, warehousing companies' business, and operators' work (i.e., economic, health, opportunities for development, job autonomy, technical complexity, employee voice in technology implementation, job (in)security, privacy, and societal effects). However, limitations were observed in relying on this bottom-up approach, as most stakeholders displayed minimal reflection on ethics and did not formulate their responses in terms of values. To address this, we propose a combination of top-down ethical guidelines and this bottom-up approach, which is essential for evaluating and justifying decision-making throughout the development, implementation, and use of advanced technologies. By combining bottom-up stakeholder engagement and top-down ethical considerations, a more holistic approach to the ethical integration of advanced technologies in logistics warehouses can be achieved.

1 INTRODUCTION

Policymakers across the world are looking how to tackle the risks that come with artificial intelligence (AI) and other advanced technologies, which include, among other aspects, automation, tracking technologies, and robotics. Importantly, this extends not only to legal regulation measures, but also to the formulation of ethics guidelines. The EU – the context we focus on in this paper – is sometimes considered a front-runner when it comes to the ethics and regulation of AI and technology more generally, but it can still strive to improve its approach. French president Emmanuel Macron at one point said it should be the aim of Europe to be a world leader in this domain (Thompson, 2018). To this end, the European Commission has published a set of ethics guidelines, which emphasises the human-centric perspective, specifically on AI, as its core principle. This approach 'strives to ensure that human values are central to the way in which AI systems are developed, deployed, used, and monitored, by ensuring respect for fundamental rights…, in which the human being enjoys a unique and inalienable moral status' (European Commission, 2019, p. 37).

In this spirit, we focus on one key sector in which advanced technologies are increasingly being developed, implemented, and used, namely logistics – more specifically, modern logistics warehouses. These warehouses are challenged to pick and pack orders quickly and deliver them on time. Like other sectors, however, logistics has been confronted with a labour force shortage, which has led some companies to implement advanced technologies, such as robots, which work alongside human employees (Alım & Kesen, 2020; Ford, 2022). Other technologies they opt to use to meet customers' (high) expectations include automated picking and packing tools, as well as advanced worker and warehouse management systems. At the same time, there is a need to develop specific industry standards and processes, since there are concerns about the responsible development, implementation, and use of AI and other advanced technologies in work settings. The question is not only how to avoid deeply unethical uses of AI and how to counteract poor working conditions, but also how to deal with them in a responsible and positive manner.

Therefore, the main aim of the current paper is to reflect on how to formulate ethical guidelines for particular contexts in which advanced technologies are developed, implemented, and used – such as modern logistics warehouses – and more specifically to contrast and compare principled 'top-down' approaches with a specific contrasting 'bottom-up' type of approach as competing methods for formulating such guidelines for specific technology contexts. Is one of these approaches better for setting positive ethical standards for advanced technologies, such as technologies for logistics warehouses? Or is it better to use a combination of these two – to try to achieve guidelines that are supported by what might be understood as a wide reflective equilibrium with both top-down and bottom-up elements? In addressing the latter question, we draw on Taebi's (2017) suggestion of using the Rawlsian wide reflective equilibrium approach to merge these two perspectives in technological development and implementation. This method, in Taebi's interpretation, considers and balances both the plurality of stakeholders' opinions and the pre-formulated broad theoretical moral principles and judgments about particular cases, which should ultimately result in an equilibrium. A key premise of this method is that relevant stakeholders, who have various interests and values, may provide useful input on what is best for everyone. Even if the parties involved have divergent points of view, they will nevertheless agree on some aspects they value and hopefully reach a consensus. A keyword is *reasonableness*, which assumes that reasonable individuals will critically reflect on their own and other people's convictions, leading to a reasonable overlapping agreement. For this result to be achieved, both general ethical ideas and judgments about specific cases – informed by real-world experience with the technologies in question – are needed. Following this wide reflective equilibrium analogy, to determine whether there is a consensus regarding the principles for developing, implementing, and using advanced technologies in the warehousing context, it is necessary to consider both moral theories (top level) and the opinions of the stakeholders involved (bottom level). Eventually, the top and bottom level should resonate with the formulation of mid-level principles that can guide the relevant stakeholders in developing, implementing, and using advanced warehouse technologies.

To achieve our main aim, we capture key stakeholders' perspectives on developing, implementing, and using advanced technologies in modern logistics warehouses. However, we also consider the limits of solely relying on stakeholders' perspectives as a method of formulating ethical guidelines for specific contexts. In particular, we explore, but also partly push back against, a particular 'bottom-up' approach offered by Verbeek and Tijink (2020), namely, the *guidance ethics* approach, which is inspired by citizen science approach and positive design. A key feature of this approach is to view ethics as not only guarding against bad behaviour, but also aiming to articulate ethical ideals and guidelines that can set a good example. According to this approach, this positive aspect of ethics should come from the interplay between technology and key stakeholders, so that values that are at stake can be identified and taken into account from a 'bottom-up' perspective, rather than a 'top-down' perspectives, that is, a set of general ethical principles formulated by philosophers or other experts.

To test the guidance ethics approach in practice, we decided to ask key stakeholders from warehouse logistics to reflect on ethical issues related to advanced technologies. Their input could ideally facilitate the development of positive ethical standards for the responsible development, implementation, and use of advanced technologies. In the empirical part of our research, we interviewed representatives of key stakeholder groups in the specific context we are focusing on – that is, modern logistics warehouses where advanced, and sometimes experimental, technologies are being introduced and where such technologies profoundly change the nature of work (Berkers et al., 2022). By performing these interviews with engineers, technology advisors (e.g., those who advise their company on what type of technologies to invest in, what they offer, and how to implement them), warehouse employees with managerial tasks, and operators, we gained some insight into what they see as possible positive and negative effects of these advanced technologies on, among others, the quality of work, and what values they consider important[1].

While these interviews with key stakeholders were informative to some extent, we also found indications that the bottom-up approach that Verbeek and Tijink (2020) advocate as a cornerstone of the guidance ethics approach – which has similarities with so-called value sensitive design (VSD) – is not without its limitations. Briefly put, our tentative conclusion is that talking with key stakeholders is not enough: some of the engineers and technology advisors seem to not have reflected much on ethics, nor are they necessarily particularly interested in doing so. Our results, which we explain in greater detail in what follows, support the conclusion that while this bottom-up approach can be to some extent beneficial in capturing how technologies impact stakeholders' (moral) decisions, actions, and the (ethical) concerns they face in their everyday work, top-down ethical guidelines are also needed for the formulation of

[1] In the context of our study, values can be understood in different ways depending on whether they are derived from a top-down or bottom-up approach. In top-down approaches, values are typically derived from established ethical theories and principles, such as those found in bioethics or normative ethics. These values are often abstract, universal, and rooted in philosophical traditions (Floridi & Cowls, 2019). Conversely, in bottom-up approaches, values could be understood through the lens of stakeholders' lived experiences and everyday practices. These values could be more contextual, practical, and often reflect the specific concerns and priorities of those engaged in the technology's development, implementation, and use (van Wynsberghe, 2016).

domain-specific ethics guidelines that can be used to ethically evaluate and justify decision-making during technology development, implementation, and use.[2]

The remainder of this article is structured as follows: section 2 first provides more background information regarding principles-based technology ethics that is relevant for the present discussion – with a special focus on Floridi and Cowls' (2019) extension of familiar medical ethics principles to the context of AI ethics and Van de Poel's (2016) extension of the same principles to the context of technological experimentation. We also briefly explain how others have translated these kinds of ideas into a set of suggested general guidelines for introducing experimental technologies into workplace settings. Section 3 introduces the main ideas of Verbeek and Tijink's (2020) guidance ethics approach and briefly compares their ideas to Value Sensitive Design (VSD). This section also explains some criticisms Manders-Huits (2011) has raised about VSD, and how Jacobs (2020), Jacobs and Huldtgren (2021), and Van Wynsberghe (2016) have argued that those problems can be solved for those interested in VSD. Section 4 describes the composition of our group of interviewed stakeholders and how we collected our data. Section 5 then describes the main findings from the interviews we conducted with stakeholders. Section 6 explores the implications of our findings for the bottom-up and top-down approaches to technology ethics. Section 7 is a concluding discussion that relates this paper's findings to Taebi's (2017) view on the wide reflective equilibrium in technology ethics.

2 TOP-DOWN APPROACHES: ADOPTING BIOETHICAL PRINCIPLES TO TECHNOLOGY ETHICS

As Halaweh (2013) points out, when an advanced technology is used in a particular context, its 'ethical concerns should be highlighted in the early stages of its lifecycle to use this technology in a way that does not harm societal and human values such as life, health, justice, freedom, happiness, privacy, and security' (p. 111). In line with this, a wide range of ethical principles have recently been proposed and introduced for socially beneficial technology. Most of these principles show similarity or seem to overlap, though they are not always interchangeable (Jobin et al., 2019). Therefore, the question arises as to which principles are most important when assessing the ethical aspects of advanced technologies.

Exploring this question, the philosophers Floridi and Cowls (2019) have developed a unified framework for AI ethics based on a set of widely accepted principles within traditional bioethics. Floridi and Cowls' (2019) reason for drawing on bioethics is that 'it is one of the branches of ethics that fits well with ecological challenges such as new agents, patients and environments that digital ethics has to deal with' (p.5). Accordingly, they have extended the familiar four core bioethical principles – namely, *non-maleficence, beneficence, autonomy*, and *justice* (Beauchamp & Childress, 2019) – specifically to the context of AI ethics, and added a fifth core principle, which is *explicability*. As we see thing, their framework can potentially also be applicable not only to the ethical assessment of AI, but also to a wider range of emerging technologies. This includes advanced warehouse technologies, not all of which can be categorised as forms of AI.

Importantly, Floridi and Cowls (2019) are not the only ones who have thought of translating the principles of bioethics into the area of technology. Notably, Van de Poel's (2016) framework for the ethics of introducing experimental technologies is also based on the widely discussed four principles of bioethics, to which he has added an additional principle, namely *responsibility*. While Van de Poel's discussion revolves around experimenting with new technologies in a broader sense, it is noteworthy that his framework can also be applied to assess the moral

[2] Notably, the engineers and technology advisors do not oppose this kind of assessment, since they already follow laws and regulations when developing, implementing, and using technology.

acceptability of conducting experiments with advanced technologies, specifically in workplace contexts. In a recent paper, Hosseini et al. (2024) have formulated a set of ethical guidelines for introducing new technologies into workplaces in general, and specifically into logistics warehouses, based on Van de Poel's framework.

Briefly summarised, Hosseini et al. (2024) suggest that an ethically acceptable workplace should prevent any harm to employees and their working conditions, such as interfering with their learning skills and privacy in unjustifiable ways (non-maleficence). Ideally, new technologies should do good and provide benefits to employees such as enhancing their mental and physical health, and offering them opportunities to work on their skills (beneficence). Employees should be informed about and involved in technology adoption as much as possible (autonomy). Proper measures to protect vulnerable employees should be taken, and if employees are nevertheless harmed, they must be compensated (justice). Furthermore, employers are required to uphold ethical standards, whereby employees who work with new technologies are made aware of their potential risks, responsibilities are clearly distributed, and employers are ultimately held responsible for what happens in the workplace (responsibility). While Hosseini et al. do not do so in their paper, one could here also add a principle of explicability of the sort advocated by Floridi and Cowls, resulting in a set of six principles to guide experiments with new technologies in workplaces: non-maleficence, beneficence, autonomy, justice, responsibility, and explicability.

Notably, this principles-based general approach – whether it is in the form of the Floridi and Cowls' (2019) principles, Van de Poel's (2016) principles, or the adaptation of Van de Poel's principles by Hosseini et al. (2024), with or without the explicability principle added to it – is a so-called top-down approach to the ethics of technology. That is, general principles are derived from philosophical or academic ethical theories. These principles are subsequently applied or connected to a specific problem or context (e.g., working conditions in an AI-equipped or otherwise technologically advanced logistics warehouse).

This, however, is not the only possible way of implementing technology ethics. We will now consider a contrasting ethical methodology, which takes a bottom-up approach, as exemplified by Verbeek and Tijink's (2020) guidance ethics approach and the Value Sensitive Design approach (Friedman, 2004). Both approaches are presented as alternative ways to approach technology ethics and explore key stakeholders' ideas about technologies, including what values they find important in the development, implementation, and use of advanced technologies.

3 BOTTOM-UP APPROACHES: THE GUIDANCE ETHICS APPROACH AND VALUE SENSITIVE DESIGN APPROACH

According to Verbeek and Tijink (2020), technology ethics should not only be about whether to accept or reject already developed technologies. They should also guide how to develop, implement, and use these technologies. Moreover, ethical reflection should not only be about (possible) problems and risks, but also about opportunities and the positive potential of technologies.

These are the basic starting points for what they call the guidance ethics approach. The emphasis in this approach is both on identifying what values are or could potentially be at stake in relation to technologies and on considering what actions need to be taken to guide them. Importantly, Verbeek and Tijink point out that this is and should be a continuous discussion. To make this more concrete, the guidance ethics approach consists of three proposed stages.

In the *first stage*, the emphasis is on describing what technologies are being used or will be used in the context in question, and what their use exactly means for people in that specific context. It makes little sense, the thought is, to speak about technology without involving human beings and their particular context. Accordingly, in the *second stage*, one makes an inventory of who the relevant stakeholders – the key actors – are, and what the (possible) effects and consequences of technologies are for them, so one can identify what values are at stake. The relevant stakeholders could be technology designers, policymakers, and direct users, among others. By inviting key stakeholders to voice the (ethical) concerns they may have when working with technology and going into dialogue with them (e.g., in a workshop setting, by conducting interviews, or doing literature research), the aim is to clarify how a technology's effects are perceived, as well as what values stakeholders find important. In the *third and final stage*, one is then supposed to translate these values into concrete action options, for example, the use of technology itself, the environment that it is being used in, and its users, such that technology and its use fit well with the environment.

Thus, the guidance ethics approach involves the idea that ethics come from within the context of technology, and not from the outside. The primary goal is to identify what values key stakeholders find important for the technologies they use and thereby generate suggestions regarding how these values should be encouraged in the development, implementation, and continued use of technology. While our main focus here is on the guidance ethics approach, we also point out that the guidance ethics approach shows strong similarities with the more well-known Value Sensitive Design (VSD) approach (Friedman, 2004). Both approaches recommend investigating stakeholders' experience with technologies and taking their input into consideration when (re)designing technologies.

Briefly described, the VSD consists of three investigations – (1) *conceptual*, (2) *empirical* and (3) *technical*. In the *conceptual* phase, one tries to identify the values that are at stake in the design context and the stakeholders that are potentially affected by the design of the technology. The *empirical* phase explores how stakeholders who are or will be affected by technologies might assess and perceive them, what values they find important, and how technologies might potentially conflict with their values. Based on the findings of phases 1 and 2 - in the *technical* phase - designers can incorporate these findings into the (re)design of technologies that complies with values that are considered important by stakeholders (Friedman, 2004). Notably, there is a significant overlap between these three phases of the VSD and the three stages of the guidance ethics of approach.

Given the similarity between the guidance ethics approach and VSD, it is worth noting that VSD has received some critical pushback, which may also apply to the guidance ethics approach. For example, Manders-Huits (2011) has objected to VSD that sometimes, 'interviewing stakeholders seems to be on loose grounds; as a result the values are too abstract and multi-interpretable, ultimately undermining the legitimacy of the empirical component of VSD' (p.279). Manders-Huits (2011) also argues that VSD does not provide a clear methodology on what values stakeholders do find important and what values they should consider as important. The reason for this is that VSD does not engage with one particular ethical theory and therefore lacks a clear normative foundation, and accordingly, VSD remains vague: 'If [an ethical theory] is lacking, the list of values runs the risk of becoming arbitrary, and any value serving the particular interests of designers (including the initiators and potential customers) may become a serious threat for VSD' (Manders-Huits, 2011, p. 282).

In response to such concerns, Manders-Huits (2011) and also other philosophers – such as Jacobs and Huldtgren (2021) and Van Wynsberghe (2016) – argue that those problems can be solved by adding an ethical theory to VSD, to properly identify and justify what values are most important throughout the design process of a technology. Interesting papers by Jacobs and Huldtgren (2021) and Van Wynsberghe (2016) provide two examples in which VSD was complemented with an ethical theory along such lines. One example is the Care Centered Value Sensitive Design (CCVSD) approach (van Wynsberghe, 2013, 2016), which builds on four fundamental care ethics values, and aims to support robot designers, users, regulators, and policy makers to ethically evaluate social robots and specifically care robots. Another example is what Jacobs (2020) calls ‘Capability Sensitive Design’ (CSD), which builds on the ten key human capabilities identified by Nussbaum (2011), which Jacobs thinks can serve as leading values in design processes related to health and wellbeing technologies. Both CSD and CCVSD, as ethical theories, thus provide additional normative grounding to and thereby complement VSD.

The question we will consider here is whether applying the guidance ethics approach in practice in the warehouse logistics context will also reveal a need to add an ethical framework of a top-down sort (i.e., Van de Poel’s) in order to give more substance and normative content to ethical theorising about this context. To this end, let us now discuss the interviews we conducted in more detail, before turning to the findings.

4 METHODOLOGY DESIGN, PARTICIPANTS, AND PROCEDURE

We decided to follow the guidance ethics approach's suggestion of interviewing key stakeholders and invited three different Dutch logistics warehouses and one technology supplier to participate in our study (see Table 1).

The technologies in question in these companies include the following types: grippers, autonomous mobile robots (AMR), AutoStores, shuttle systems, picking workstations, pick-to-light systems, vertical lifts, forklift-, reach-, and high-bay trucks, conveyor belts, and AGVs. One warehouse has recently started working with fully automated sorting and packing machines. The warehouses in our study distribute a wide variety of products (e.g., consumer goods, electronics, and clothing), and the technology supplier delivers logistic process automation to a variety of warehouses.

In every company with which we worked, a contact person was appointed. They were asked to participate themselves and/or to select multiple participants who developed, implemented, or used the above-mentioned warehouse technologies. We also required participants to have proficiency in Dutch or English and relevant experience in working with these technologies (i.e., the users).

The research design was a field study using a semi-structured interview methodology. The interviews, conducted by the first author, aimed to gather insights and perspectives on the development, implementation, and use of advanced warehouse technologies. Structured interview protocols (see Appendices 1 and 2) guided discussions with warehouse employees, covering their perceptions, challenges, and implications of working with advanced technologies. Specifically, the study was guided by the following main research question: how do warehouse employees, engineers, and technology advisors perceive the ethical implications of advanced technologies in their work environment? This question aimed to explore both the positive and negative effects of these technologies, with a specific focus on the values that are important to stakeholders in the context of their work. The motivation for using semi-structured interviews was to capture detailed, context-specific insights that might not emerge in more structured forms of data collection. This approach allowed participants the freedom to express their views on complex issues such as responsibility, safety, and trust, while still adhering to a general framework of inquiry.

Additionally, semi-structured interviews were conducted with four engineers and four technology advisors. This allowed for the exploration of various aspects of warehouse technology development and implementation. Topics ranged from observing technological changes to considering stakeholder implications, assessing potential benefits and harms, incorporating new responsibilities, involving stakeholders, implementing risk mitigation measures, guiding values, and reflecting on ethical issues throughout the process. These interviews provided valuable insights into the decision-making processes preceding the implementation of technology in the workplace. The interviewer assured them, that their participation in the study was voluntary, that they should feel no pressure to participate, and that all responses would be kept confidential.

The total convenience sample (N = 23) consisted of four engineers (17.4%), four technology advisors (17.4%), eight employees with coordinating or managerial tasks (34.8) and seven operators (30.4%). Twenty-six percent of the total sample were women. Participants had been working for 8.72 years (SD = 7.56) on average in their current jobs.

The engineers were involved in the development of new equipment/systems. Two of them were trained to fix technical breakdowns, whereas the others were in consulting positions, focusing on what the design of technologies should look like and what requirements these technologies must meet. Technology advisors assessed what type of technologies their company needed, gathered information on these technologies, and indicated how to implement these in the warehousing companies' work processes. Employees with coordinating tasks or managerial tasks were supervisors, team coordinators, and team leaders, who were all responsible for the planning of their teams. Supervisors, in particular, checked the daily output, kept in touch with the control room, technical service and HR, reported back to the headquarters, and discussed the work process with them (e.g., schedule and targets). They also trained the team coordinators and team leaders. The team coordinators and team leaders, in turn, trained their team of operators to work fast and efficient, informed them of organisational changes and answered any questions they have regarding their tasks. At the end of the day, they checked whether the workstations were clean and all orders were sent, and they also inspected the technologies. The operators were responsible for, among other things, receiving (new) products, order putting/replenishment, order picking, order packing, checking, and inspecting orders, and shipping orders. Two of these operators were also partly responsible for either trouble shooting or planning.

The interviews took place in January and February 2021, and in February and March 2022. They were conducted in English and Dutch, and either face-to-face in the companies or online via Microsoft Teams depending on the Covid-19 regulations that were in place at the time. All interviews were tape-recorded to allow for future transcription, and all participants gave informed consent. Each interview session lasted 1-1.5 hours.

The interviews were transcribed verbatim, and analysed using the software NVivo (1.7.1) in order to answer the questions of what these stakeholders see as positive and negative effects of technologies from their specific perspective (i.e., engineering, advisory role, warehouse employee) and what values they find important.

We started by inductively coding the data, whereby sentences, phrases, and words were highlighted and grouped without an a priori coding list. This initial, data-driven approach allowed us to capture themes directly from participants' responses. As a result of this inductive process, we identified the following codes: tasks (e.g., how does their daily work look like), benefits of technology (e.g., mental, physical), harms of technology (e.g., mental, physical), energy (what drains and gives energy to interviewees in their work), autonomy (e.g., decision-making/involvement in the selection and implementation of technology), justice (e.g., measures to mitigate potential risks of technology), meaningful work (e.g., feedback and support from colleagues/managers), responsibilities (e.g., new/additional responsibilities as a result of using technology), and trust in technology (e.g., performing work in a safe and healthy way). These codes were grounded in the empirical data but were also informed by and resonated with existing theoretical and empirical literature. Specifically, they align with themes discussed in works such as Hosseini et al., (2024), Parker and Grote (2020), Smids et al. (2020), van de Poel

(2016) and Simões et al. (2022). Thus, while the codes emerged from the data, they were also supported and contextualised by established theories in technology ethics and work psychology.

Organisational description	Company	Job title	Duration of working at current organisation	Gender
Global logistics services provider (*revenue* $16 billion; 32,094 employees)	A	Engineer	12 years	M
		Supervisor	7 years	M
		Team leader	20 years	M
		Operator 1	16 years	M
		Operator 2	16 years	F
European logistics service provider (*revenue* $10.2 million; 200 employees)	B	Team leader 1	13,5 years	M
		Team leader 2	1 year	M
		Operator/planner 1	10 years	M
		Operator 2	7 years	M
		Operator 3	4 years	M
Global logistics services provider (*revenue:* $7 billion; 58,000 employees)	C	Technology advisor 1	13 years	M
		Technology advisor 2	5,5 years	M
		Engineer	3 years	M
		Operations Manager	4 years	M
		Team coordinator 1	8 years	F
		Team coordinator 2	4 years	F
		Team leader	7 months	M
		Operator/trouble shooter 1	1,5 years	F
		Operator 2	2 years	M
Global logistics technology supplier (*revenue* €2.4 billion; 9,000 employees)	D	Engineer 1	31 years	M
		Engineer 2	16 years	M
		Technology advisor 1	5 months	F
		Technology advisor 2	5 years	F

Note: organisational description (i.e. revenue and number of employees) reflects the global organisation.

Table 1. Study sample

We then re-read the highlighted codes, which led us to identify nine categories of often-mentioned effects of technologies on society, warehousing companies' business, and operators' work (see Table 2). We then again reviewed collated codes and tried to categorise them in terms of values. However, participants typically did not formulate their responses explicitly in terms of values, so we were not able to identify them in such terms based on the interview transcripts. Repeated discussions were held among the researchers until the interpretation of responses regarding the technological effects was agreed upon. The involvement of the interviewer in the data analysis process is considered desirable to enhance the quality of the interpretation, since it enables consideration of the characteristics of the specific context (Bisogni et al., 2002). This approach—starting with inductive coding and moving towards a thematic interpretation informed by previous literature on the effects of technology in the workplace—allowed us to develop a nuanced understanding of how different stakeholders perceive and prioritise concerns in the context of advanced warehouse technologies.

Categories of effects	Short description
Economic	Refers to organisations' overall financial aspects, for example, productivity and labour costs. These aspects contribute to the overall financial success and viability of organisations.
Health	Refers to warehouse employees' overall physical well-being and safety.
Opportunities for development	Refers to warehouse employees' potential personal and professional growth in their jobs, for example, acquiring new competencies, adapting to changing tasks, and fostering a proactive approach to working alongside advanced technologies.
Job autonomy	Refers to warehouse employees' degree of control over their work processes and tasks, for example, the ability to make choices and determine the order of tasks according to their own judgment and discretion.
Technical complexity	Refers to technologies' complexity and challenges associated with their implementation and use in the warehouse setting, for example, the need for testing and making of adjustments to fit technologies to the specific warehouse.
Employee voice in technology implementation	Refers to warehouse employees' opportunity to express their opinions and suggestions regarding various aspects of technology implementation.
Job (in)security	Refers to warehouse employees' perceived level of confidence or uncertainty regarding the continuity and relevance of their current jobs in the face of technological advancements and changes in their workplace.
Privacy	Refers to warehouse employees' rights over their personal information and work performance without unnecessary surveillance from others in their workplace.
Societal	Refers to warehouse technologies' broader impact or influence on society.

Note: these descriptions of the effects are based on our interpretations of the interview results.

Table 2. Description of the categories of effects of developing, implementing, and using technologies in logistic warehouses

5 RESULTS OF INTERVIEWS WITH KEY STAKEHOLDERS

Below, we discuss nine (categories of) effects of developing, implementing, and/or using technologies on society, warehousing companies' business, and operators' work that were mentioned by the various stakeholders during the interviews. Table 3 displays the main results of the interview. Whether these effects can and should be considered ethically relevant is a matter we will return to below in the discussion. Here, we simply focus on highlighting the effects our interviewees seemed to associate with the technologies that we discussed with them.

Economic

First, the implementation of technologies can have economic effects, both positive and negative. On the positive side, both engineers and technology advisors pointed out that technologies can lead to better integration of software, and tailor-made hardware solutions. They improve the quality of warehouse work in terms of performance (i.e., lower error-ratio), are reliable and efficient, and reduce costs.

The technology advisor in one of the warehousing companies mentioned that their technologies c sort 8,000 items per hour. If the automated sorting machine was not implemented, they would have had to deploy an army of people there and would need a much larger warehouse. Because of this technology, companies can streamline their work processes, and employees can work faster. Thus, customers' expectations regarding delivering orders in time can be met. In case they face any issues regarding their customers' order, companies can inform their customers immediately and modify their expectations by putting on their website that the order will be delivered later than expected. Consequently, they have a much more active communication with their customers.

Engineer 2 from company D added that:

> Warehousing companies get a lot more work done with the same group of people and there is an increase in productivity. Thanks to the technology we offer, they can better guarantee their output and make it more reliable and predictable.

Notably, technology advisors mentioned that one of the hardest challenges this sector is dealing with is workforce shortages, which is part of what leads these companies to automate work tasks. Especially during peak periods such as Christmas and New Year's Eve, warehouses are forced to hire new operators to deal with the increasing number of orders.

Technology advisor 2 from company C said:

> We have to bring in a lot of people who have to do the work, while they have only been employed for a few weeks. Try explaining where someone should stick the price sticker. With a technology screen, you can show a picture with a cross where it should be, then everyone will know.

Therefore, these technologies not only help warehouses streamline their work processes and expand their business, but also visually support new hires in performing specific tasks. Operators also indicated that with the help of various technologies, they can find product locations faster and more easily. However, there can also be negative economic effects, as companies may become highly dependent on these technologies. As soon as the technologies stop working, companies face a big problem.

The engineer from company C said:

> Those machines have been developed in such a way that they can do really large numbers in a short time, so if they stop working for a short time, you lose large number of orders. If a person is sick, we call someone else, but that doesn't work with machines.

Health

Second, there are perceived health effects. Because of legal requirements, engineers take the ergonomic strain on operators into account in the design of technologies. They have to meet Quality, Health, Safety, and Environment (QHSE) guidelines, laws, and regulations, so that technologies are safe when operators are working with them. Consequently, using technologies comes with health benefits for the operators since ergonomic demands are lowered, which may in turn lead to less (risk of) health complaints.

Team coordinator 1 from company C said:

> Our work is less physically demanding, we do not have to walk and move the totes manually to different areas and we do not have to lift totes since we have the conveyors and automatic sorting machines. The issues with our backs and arms have decreased.

The team leader from company A said 'the semi-automated warehouse carts make our tasks physically easier, we do not have to pull and push the carts ourselves. We can operate the carts by using the buttons on the screen'.

However, even though operators receive training and instructions on how to perform their tasks in a safe and healthy way, and most physically demanding tasks are taken over by technologies, there are still some left-over tasks that require constantly looking up (e.g., working in high-bay trucks) and some repetitive tasks that have to be performed manually (e.g., picking and packing of small and fragile items) and are therefore physically straining. In addition, some technologies consist of moving parts and generate (excessive) noise and/or heat, which can be dangerous for operators.

Opportunities for development

Third, there are perceived opportunities for development, specifically for the more 'senior' operators. Because boring and repetitive tasks are slowly being automated, some operators are encouraged to develop themselves in their jobs. These technologies sometimes change their tasks and responsibilities, such as supervising robots, instead of performing the tasks themselves. Since some 'senior' operators are trained to take care of technologies, they are also allowed to solve technical problems. As these technologies require different skills and solutions, these operators need to continuously stay updated on technical changes in order to collaborate successfully with these technologies.

Technology advisor 1 from company D pointed out that getting rid of monotonous tasks is good for the wellbeing of operators:

> How do you make sure that you get people motivated and that they actually see technology as an opportunity instead of something bad? Now we still have human employees because certain tasks cannot be done by a machine, as some products such as clothes might get damaged. Companies only keep people motivated by giving them bonuses for working faster, but I don't think this is the work for the future.

Although technologies bring opportunities for 'senior' operators to develop themselves, even they mention that there is not much left to learn after they have familiarised themselves with the new way of working. 'Junior' operators seem to not benefit from these technologies at all as regards opportunities for development. Team leaders do try to increase variability by rotating these operators over different departments so that they have different tasks to perform. It was not surprising that some operators themselves also mentioned that their work had become simpler, more boring, and monotonous because of the implementation of technologies.

Operator 2 from company C said 'our work is not that dynamic anymore since you have to repeat certain movements such as scanning products and pressing buttons, which can be boring over time'.

Job autonomy

Fourth, all stakeholders mentioned that with these advanced technologies, operators have less autonomy over their jobs. In some departments, operators still have some room to decide on the order of their tasks, but in most departments their work is standardised. For example, working with automated picking and sorting machines means that one has to follow pre-defined and precise work instructions. Therefore, not all technologies are immediately embraced, as operators are resistant to them due to the loss of autonomy. As work processes become simplified with technologies instructing operators on what to do, operators find it challenging to remain engaged and alert since they are no longer required to think independently, and instead blindly have to follow the technologies' instructions. Additionally, technology advisors have noticed that some operators choose to seek employment elsewhere, while those who remain may find it difficult to collaborate with the technologies, which sometimes leads to resistance, particularly when technologies do not function seamlessly from the outset.

One of the engineers mentioned that for ergonomic aspects, such as physical load, there are European legislations they have to adhere to, and guidelines on how to test and validate technologies; however, there is less attention to operators' autonomy.

Technology advisor 2 from company D said:

> There is a prevailing notion that operators do not need autonomy, that they are content with performing simple tasks. However, that is not necessarily the case. They still need to have autonomy and be able to make decisions for themselves. Unfortunately, there is less attention given to this aspect by product developers and warehouse companies, as it is not considered a crucial factor in such workplaces. There is generally not enough discussion about whether people enjoy their jobs or are satisfied with them, as the focus tends to be primarily on costs.

Technical complexity

Fifth, there are perceived technical complexity effects, since some technologies are not easy to implement. 'One size fits all' does not apply to warehousing technologies. Most of the technologies developed have to be tested and adjusted to a specific (warehousing) context. In fact, employees mention that software updates do not immediately succeed and that they face technical breakdowns.

Team coordinator 2 from company C said 'the system breaks down and is unable to function, which impacts almost all departments in the warehouse. Sometimes it gets too complex to solve the problem immediately, which means that we have to change our planning'.

Engineers from the technology supplier mentioned that they need more skilled people to develop these technologies. In fact, current engineers should be trained to keep up with new technical challenges. In warehouses, first-line maintenance and troubleshooting are performed by specialised technical service staff and sometimes senior operators, since they have the required knowledge and experience. For reasons of safety, technology's high costs, and lack of knowledge, junior operators are not allowed to solve (complex) technical problems by themselves.

Employee voice in technology implementation

Sixth, it is surprising that operators are not directly involved in the development process of advanced technologies. In rare cases, technology advisors do some mock-ups with a few operators to receive feedback. Engineers and technology advisors were under the impression that most operators are not interested in being directly involved in the design process of advanced technologies or that they find other aspects important, such as being able to chat with their colleagues.

The engineer from company A said:

> It is very difficult to get them along with changes because their general comment is "that's how we've been doing it for years, so we'll continue to do it that way" and you really notice that some people thrive when you ask for input and others actually don't want to change. If you ask people for their input, you are obliged to do something with it, but this is not always feasible. That is a difficult process.

Operators from all three companies said that they get informed during meetings and that sometimes their opinions are being asked when advanced technologies are being developed and implemented. Their impression is that the management is open to listen to their suggestions and feedback. However, they are nevertheless only indirectly involved in these two phases, which some of them consider a pity.

Operator 3 from company B said 'I have been informed that a new technology will be implemented soon, but I am not directly involved. If I encounters any errors in the technology after the implementation, I can report them to the team leader or supervisor'.

Job (in)security

Seventh, operators who work with advanced technologies receive higher salaries, and most of them are not afraid of losing their job, since they see that many tasks are still performed manually.

Operator 2 from company A said 'I am not afraid of losing my job. Companies like mine will continue to need people for manual work'.

Nevertheless, some operators expressed concerns about the future relevance of their current tasks. They harboured doubts about whether their roles will still be necessary in ten to twenty years, given the advancements in warehousing technologies.

Privacy

Eight, when it comes to privacy, all stakeholders – including the operators – mentioned that they are aware that everything they do can be tracked. Management is able to micro-manage them and check what and how many items they process. Operators stated that if managers are not satisfied with their performance, they approach the operators immediately or address the concerns during annual reviews.

Speaking rather bluntly, technology advisor 1 from company C said:

> In terms of privacy, it is difficult because we would like to see how someone performs, how much time it takes to perform certain tasks, and how many mistakes (s)he makes. It is almost inevitable because everyone has to log in under an ID, so that you know who did what. Is that ethical? Yes, it is part of your job and everyone has to cooperate.

Societal

Ninth, there are perceived societal effects. Warehouse technologies (indirectly) enable the creation of (high quality) jobs for older people and people with a disability, which contributes to an inclusive labour market.

To conclude, the stakeholders who were interviewed for this paper (e.g., engineers, technology advisors, employees with managerial tasks and operators) mentioned nine advantageous and disadvantageous effects of developing, implementing, and/or using technologies in logistics warehousing. However, they rarely expressed themselves in terms of 'ethical values'. Therefore, we do not have an overview of the ethical values that they consider relevant to their specific work contexts.

Economic

- Technologies help to better integrate software and tailor-made solutions for warehousing companies.
- Technologies improve performance, are reliable and cost less money (less human employees needed for certain tasks).
- However, technical breakdowns lead to less output.

Health

- Engineers and technology advisors have to meet Quality, Health, Safety and Environment (QHSE) guidelines, law and regulations.
- Operators pointed out that technologies decrease ergonomic and physical demands (e.g., less heavy lifting).
- However, some tasks can still be physically straining, and some technologies can be physically dangerous for operators.

Opportunities for development

- Technologies mostly automate boring and repetitive tasks, and push (senior) operators to develop their skills. Instead of picking and packing orders themselves, they can supervise robots that perform their tasks.
- However, even after technologies are implemented, operators still feel that their jobs are getting standardised.

Job autonomy

- Less space for operators to decide which tasks they want to perform and in what order as technologies provide operators with precise work instructions.

Technical complexity

- 'One size fits all' does not apply to warehousing technologies.
- Need for skilled people to develop advanced technologies.

Employee voice in technology implementation

- Although operators get informed and their opinions are asked sometimes, they are not directly involved in the development process of advanced technologies.

Job (in)security

- Although most operators are not afraid of losing their jobs, there are some who have doubts about the relevance of their roles in the future.

Privacy

- Operators' tasks can all be monitored and tracked by supervisors.

Societal

- More job opportunities for older people and people with a disability.

Notes: technologies included grippers, autonomous mobile robots (AMR), AutoStores, shuttle systems, picking workstations, pick-to-light system, vertical lift, several types of trucks, AGV's, conveyors, and automated picking and packing machines.

Table 3. Summary of the effects of technologies from stakeholders' perspectives

6 IMPLICATIONS FOR THE GUIDANCE ETHICS APPROACH AND PRINCIPLES-BASED ETHICAL GUIDELINES

6.1 IMPLICATIONS FOR GUIDANCE ETHICS APPROACH

Let us now return to the theoretical inspiration behind our interviews: the guidance ethics approach suggested by Verbeek and Tijink (2020). As noted above, the major objective of the guidance ethics approach is to direct technology design by prioritising values that are regarded as vital by the relevant stakeholders. In other words, this approach suggests that in order to develop technologies that are ethically sensitive, one should engage in discourse with relevant stakeholders to identify their potential social implications and the essential values that are at risks. After exploring how the guidance ethics approach could be applied in the logistics warehousing context, we concluded that it could not fully reach its potential within that context, at least not by conducting the kinds of interviews we did with our research participants. Specifically, in the case of our participants, we found that ethical values were neither explicitly considered nor reflected upon throughout the development phase of technologies, with the exception of larger firms' corporate codes of conduct and design principles, which serve as a guide for engineers' behaviour and functioning. Moreover, some of the points the interviewees brought up when asked to comment on what they saw as effects related to advanced technologies were considerations that cannot easily be recognised as ethical values. For example, several interviewees brought up considerations concerning economic factors and technological complexity related to advanced technologies. However, such considerations might be hard to recognise as ethical values that are relevant to the formulation of ethics guidelines. In addition, we found that there was no ethical conversation among the stakeholders regarding the use of technologies in participants' workplaces. They even stated that they had never considered what values they found crucial in relation to technologies in their work.

Furthermore, the guidance ethics approach adopts the optimistic perspective that stakeholders are able and motivated to discuss ethical values. Our interviews with key stakeholders in the logistics context dampen such optimism. As we see, Manders-Huits' (2011) criticism of VSD also applies to the guidance ethics approach, which discusses whether the relevant stakeholders are able to assess technology, and whether or not they have a common understanding of a certain value. Since our participants typically did not formulate their responses explicitly in terms of values, we were not able to identify what ethical values were at stake from their point of view.

However, we did observe that each stakeholder accords different levels of importance to various components of technology, and that each effect is viewed in a different way by different stakeholders based on their respective responsibilities and interests. For instance, while technology advisors view the positive health effects of technologies as a means to reduce absenteeism, operators see them as a way to avoid the need to manually transfer or hoist totes to various locations. Similar considerations apply to which aspects are found to be important by stakeholders when advanced technologies are implemented in their workplace. Operators expressed a preference for being able to talk to their colleagues while doing their tasks. However, engineers and technology advisors tend to prioritise economic factors such as productivity and low error ratio

Another aspect of the guidance ethics technique as spelled out by Verbeek and Tijink (2020) is that this approach should preferably be conducted in a workshop setting – similar to the focus group method – attended by all relevant stakeholders and guided by a skilled moderator. This method could capture productive tensions, dilemmas, and value conflicts among stakeholders. In practice, however, unless one is dealing with an organisation that is unusually motivated to be ethical, this can be difficult and time-consuming. The interviews for this paper were conducted anonymously and individually. We suspect that whenever there is a clear power disbalance, some stakeholders – particularly those at the bottom of the hierarchy like operators – may not feel comfortable speaking openly about the less favourable effects of technologies on their jobs. Additionally, the moderator must be unbiased and sufficiently knowledgeable about the technology and the context in which it is utilised.

Thus, our findings indicated a general absence of ethical dialogue among stakeholders, which might suggest that ethical issues were not a priority or were not recognised within the specific context of warehouse technology. While this could be seen as a limitation of the bottom-up approach, it is also possible that the framing of our questions and the workshop format did not sufficiently guide participants toward considering ethical aspects. This underscores an important point: the success of a bottom-up approach in eliciting ethical concerns may depend heavily on both the context and the way in which stakeholders are engaged.

Importantly, the absence of identified ethical issues does not necessarily indicate that the method is flawed or that ethical problems are absent. Instead, they reflect the perspectives and priorities of the stakeholders involved, shaped by their roles and the specific context in which they operate. For example, technical employees might prioritise different aspects of technology than their financially oriented counterparts, leading to variations in how ethical concerns are identified and emphasised. This suggests that while the ethical guidance approach has significant potential, its effectiveness and outcomes are shaped by the composition of the participant group.

We also acknowledge that by opting for individual interviews, we may have missed the opportunity to explore productive tensions and value conflicts that could emerge in a more interactive setting. Methods such as participatory design, dilemma-driven design, and speculative critical design are specifically geared toward revealing these conflicts (Ozkaramanli et al., 2024), which can be crucial for developing a deeper understanding of the ethical complexities of technology implementation. While interviews provide a safe space for individual expression, future research could benefit from incorporating these more dynamic methods to capture the full spectrum of stakeholder perspectives and the ethical dilemmas they encounter.

Given these factors, while the ethical guidance approach is valuable, it may need to be supplemented by other approaches to ensure a comprehensive ethical analysis. Future research should explore these dynamics further, particularly by differentiating between types of employees and the arguments they present, to better understand how to maximise the approach's potential in diverse organisational settings.

Another limitation of our study is the exclusion of consumer perspectives from our interview process. Our research focused specifically on stakeholders directly involved in the development, implementation, and operation of advanced technologies in logistics and warehousing environments. This approach allowed us to capture the concerns and experiences of those who interact with these technologies on a practical and daily basis, such as operators, managers, and other relevant organisational stakeholders. However, we acknowledge that the perspectives of consumers, who are the end recipients of the services enabled by these technologies, are also crucial for a comprehensive understanding of the ethical landscape. Consumers' expectations regarding timely delivery and their awareness (or lack thereof) of the warehouse dynamics that enable these shipments could provide valuable insights into the broader social implications of these technologies. Including consumer perspectives might reveal additional concerns, such as the potential disconnect between consumer demands for rapid delivery and the pressures this places on warehouse workers and technology systems. Future research should consider integrating consumer interviews to explore these dimensions, offering a more holistic view of the ethical challenges and expectations within the logistics ecosystem.

On a more encouraging note, our interview findings support the tentative conclusion that if operators were included in the development and implementation of advanced technologies, this approach could be a useful tool to establish positive ethical standards for responsible development, implementation, and use of advanced technologies, while ensuring that they meet operators' requirements. As operators are the ones who will ultimately be using these technologies, it is crucial that they perceive their work with them as valuable and meaningful.

6.2 IMPLICATIONS FOR PRINCIPLES-BASED ETHICAL GUIDELINES

We will now reflect on the relations between our interview findings, bottom-up approaches, and top-down approaches. One question that can be raised here is whether a top-down approach like Floridi and Cowls' (2019) framework, or Van de Poel's (2016) ethical framework – or the Hosseini et al. (2024) version of the Van de Poel framework – should, perhaps not be preferred to bottom-up approaches such as the guidance ethics framework, but rather be added as a supplement. That is, perhaps one can and should approach the guidance ethics approach in the way that Jacobs and Huldtgren (2021) and Van Wynsberghe (2013) have approached VSD, that is, by adding a substantive ethical framework to it. Van de Poel's (2016) moral principles, for example, are well-suited for this, since they were developed from a technology development assessment point of view with the general aim of giving direction to how to evaluate the introduction of such technologies into society. However, these principles – just like those of Floridi and Cowls (2019) – are very general in nature, thus requiring specific knowledge of how such technologies work within the contexts in which they are developed to operate, and focus less on whether and under what conditions direct users consider such technologies ethically responsible for executing their tasks. Bottom-up approaches such as the guidance ethics approach could potentially be used to collect at least some of this missing information.

With respect to the relation between our interviews and top-down approaches such as those of Van de Poel or Cowls and Floridi, we found that the nine categories of effects of technologies that came out of our interviews could partially be associated with the general contents of the top-down ethical principles. Most clearly, some of the interview findings are related to considerations such as avoiding specific forms of harms (e.g., decreasing ergonomic and physical demands). Additionally, there were also considerations that could be related to the principle of beneficence, such as ideas related to promoting opportunities for developing (new) skills (e.g., supervising robots). However, many of our interview findings were such that it is fairly hard to relate them to the principles in the ethical frameworks we are considering in this paper in any straightforward way.

Moreover, while Verbeek and Tijink are surely right that input from all key stakeholders is of ethical relevance in relation to the formulation of ethics guidelines, it must not be forgotten that in many companies and organisations (especially of the types we are considering here), not all stakeholders will be able to implement such guidelines if they are formulated. The principle of respect for justice, for instance, outlines how responsibilities and benefits should be allocated. Yet, one must have the ability to act with authority within an organisation in order to implement this principle. While this may apply to some of the stakeholders, such as engineers and technology advisors, it does not to warehouse employees without any decision-making power or managerial tasks.

While our case study on warehouse technology offers valuable insights into the ethical implications of advanced technologies, it is important to recognise that the specific context of logistics warehousing may limit the generalisability of our findings to other sectors. Warehouses often have a unique organisational structure in which decision-making authority is centralised among a few key stakeholders. This structure may not fully capture the broader range of contexts in which ethical guidelines need to be developed and implemented, potentially leading to different outcomes if applied in other sectors.

In sectors where stakeholders have more distributed decision-making power or where there is a stronger emphasis on participatory governance, the challenges we observed—such as the difficulty in translating stakeholder input into actionable ethical guidelines—might manifest differently. For example, in industries like healthcare or education, where ethical considerations are more ingrained in daily operations and stakeholders often have a more direct influence on decision-making, the bottom-up approach could yield different results. These sectors might show a more effective integration of ethical guidelines due to the inherent involvement of a broader range of stakeholders in the decision-making process.

Additionally, the ability of stakeholders to implement ethical guidelines varies significantly across different sectors. In warehouse settings, as noted, employees without managerial or decision-making roles may find it challenging to influence the implementation of ethical principles. However, in other sectors—such as technology development or public service—stakeholders at various levels might have more autonomy and a greater ability to shape ethical practices. This variation could lead to a more effective application of the guidelines developed through either bottom-up or top-down approaches in those sectors.

Given these considerations, it is crucial for future research to test and adapt our proposed approach in diverse contexts. This should include sectors where stakeholder engagement and ethical considerations are more explicitly integrated into the operational culture. Comparative studies across different industries could help identify how varying organisational structures, stakeholder dynamics, and sector-specific ethical concerns might influence the effectiveness and applicability of the guidance ethics approach. Such research would provide a more comprehensive understanding of how to develop and implement ethical guidelines that are both theoretically robust and practically applicable across different sectors.

Importantly, the development and implementation of technologies is an evolving process that requires constant adjustments. For instance, when new information is acquired, one must make adjustments to the interpretation of the specific application of the general principles of beneficence and non-maleficence. Only when new technology is put into use, will we progressively learn about its possible benefits, harms, and other ethical issues. Unwanted effects may be reduced through ongoing technological development and comprehensive testing of (new) technologies. Before new technologies are put to use, however, it can be hard to predict what concerns might arise.

Furthermore, the six moral principles in the top-down frameworks considered in this paper are not necessarily exhaustive with respect to what general concerns might be seen as ethically relevant in the particular context of warehouse logistics. There may be additional principles that are also worth considering, such as *corporate social responsibility* (Preuss, 2013) towards society. Moreover, it is plausible to hold that sustainability – that is, protecting the environment – should also be prioritised when introducing advanced technology in the warehousing sector.[3]

[3] According to Sroka and Szántó (2018) companies that prioritise ethical behaviour and corporate social responsibility could become desirable employers that attract a larger pool of individuals who want to work for them, and ensure that employees will stay committed with them, leading to lower labour turnover rates while increasing employee productivity. Thus, while these technologies bring economic advantages to companies, they also indirectly provide more opportunities for labour participation of certain groups of people (e.g., elderly and people with a disability), which may not have been the primary goal of companies. We believe that companies who are developing, implementing, and/or using advanced technologies should also incorporate elements of this principle, since corporate social responsibility may boost their reputation and make them more appealing to different stakeholders (e.g., investors and customers) to do business with them or buy products from them. In essence, companies are compelled to balance profitability with responsible behaviour.

Van de Poel (2016) makes a related point, stating that the general principle he discusses 'are to be seen as prima facie moral obligations that are open to further specification for specific technologies and to revision in the light of new experiences' (p. 684).

As noted before, in our findings, there was a general absence of ethical dialogue among stakeholders regarding the use of technology, which made it difficult to identify and categorise values consistently through an inductive approach. This lack of discussion has contributed to challenges in defining clear and actionable ethical values. While inductive coding served as a valuable starting point, it proved challenging to apply effectively due to the limited engagement of participants with ethical values. There is a gap here that needs to be filled. Here is where traditional top-down ethical theories can help. We suggest, therefore, that approaches such as Verbeek and Tijink's (2020) bottom-up and Van de Poel's (2016) top-down approach could be merged to create a mixed method that can be defended using the wide reflective equilibrium approach (Taebi, 2017).

This approach could allow for the incorporation of both general ethical principles and specific inputs from key stakeholders into the formulation of ethics guidelines for specific domains. Specifically, this reflective equilibrium analogy could help evaluate whether existing moral principles, such as those proposed by Van de Poel (2016), adequately encompass the consequences of advanced technologies and reflect stakeholders' opinions. Given these observations, we suggest that a small, core set of values could serve as a guiding framework, with the flexibility to incorporate additional values identified through bottom-up methods. This approach could ensure that key ethical principles are not overlooked while allowing for the integration of context-specific values. Future research should explore different interviewing techniques and workshop formats that might better facilitate the explicit identification of ethical values in practice.

However, the integration of top-down and bottom-up approaches poses significant epistemological challenges. One key issue is the potential tension between the abstract, universal values derived from top-down approaches and the concrete, context-specific values emphasised in bottom-up approaches. This tension can complicate the process of developing ethical guidelines that are both theoretically rigorous and practically applicable.

Besides this, the differing epistemologies underlying these approaches may lead to conflicts when attempting to align theoretical principles with stakeholders' experiential knowledge. For instance, a principle derived from a top-down ethical framework may not resonate with the values expressed by stakeholders in a bottom-up process, leading to potential disconnects or the need for negotiation and adaptation. To address these challenges, a wide reflective equilibrium approach could be employed, where both top-down and bottom-up values are iteratively adjusted until a coherent and mutually supportive set of guidelines is achieved. This process requires careful consideration of both theoretical and practical insights to ensure that the resulting ethical framework is both philosophically sound and contextually relevant.

Van de Poel's (2016) framework is particularly relevant here because it not only draws on the four widely discussed principles of bioethics (respect for autonomy, non-maleficence, beneficence, and justice) but also introduces an additional principle, responsibility. This principle of responsibility is central to making Van de Poel's framework highly compatible with Verbeek and Tijink's (2020) approach, which prioritises ethical guidance that is both context-sensitive and action-oriented. Both approaches are concerned with the moral implications of actions within specific contexts, particularly in the experimentation and implementation of new, advanced technologies.

On top of that, Van de Poel's approach is well-suited for integration with Verbeek and Tijink's because both approaches are grounded in the practical realities of technological development and implementation. Van de Poel's principles provide a structured, principle-based method for assessing the moral acceptability of technological experiments, while Verbeek and Tijink's offer a complementary perspective that emphasises the need for actionable ethical guidance for decision-makers. The convergence of these approaches highlights the importance of involving stakeholders and ensuring that ethical guidelines are not only theoretically sound but also practically applicable in specific contexts, such as logistics warehouses. The compatibility of these approaches was further demonstrated by Hosseini et al. (2024), who formulated ethical guidelines for introducing new technologies into workplaces, specifically logistics warehouses, based on Van de Poel's framework. This adaptation illustrates that Van de Poel's principles can be effectively applied to specific domains while maintaining their broad ethical relevance—a flexibility that aligns closely with the objectives of the guidance ethics framework.

7 CONCLUDING REMARKS

In general, both top-down and bottom-up approaches have limitations and practical implications when it comes to formulating ethical guidelines for specific contexts involving advanced technologies. Taebi's (2017) wide reflective equilibrium analogy aligned with our approach in this paper, in which we have looked at whether existing moral principles, such as those that Van de Poel (2016) has proposed, sufficiently encompass the consequences that come with advanced technologies and whether they adequately reflect stakeholders' opinions. We have also invited all relevant stakeholders and asked them to reflect on the existing principles and allowed them to answer questions regarding possible effects of advanced technologies. According to Taebi (2017), the latter is a crucial component of this methodology, since it shows that not all parties need to share the same moral principles in order to establish a consensus. However, the ability to evaluate their individual perspectives as well as those of others is more crucial.

Thus, we have in part sought to follow the guidance ethics approach by engaging in dialogue with the key stakeholders involved in the development, implementation, and use of advanced warehouse technologies. We found that different stakeholders have different interests, tasks, roles, and responsibilities, and experience different effects of these advanced technologies. The engineers mainly focus on the development of technologies, and technology advisors whose criteria these technologies should meet in order to be implemented in the warehouses. The warehouse employees with managerial tasks are the ones that manage and guide the operators, and the operators are the ones who directly work with those technologies. Since these stakeholders have their individual roles, they experience different effects of these technologies in their work. Accordingly, while the input from these kinds of stakeholders is valuable and crucial in the search for a wide reflective equilibrium in reflections on the ethics of technologies in specific contexts – such as the logistics warehousing context – more general principles are also needed.

Data Access Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to restrictions as they contain information that could compromise the privacy of research participants

Contributor Statement

Ziagul Hosseini: formal analysis, investigation, writing – original draft, visualisation

Sven Nyholm: funding acquisition, supervision, conceptualization, writing – review & editing, visualisation

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No potential conflict of interest was reported by the authors.

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APPENDIX 1: INTERVIEW PROTOCOL WAREHOUSE EMPLOYEES

1. How long have you been working at your current company?
2. What technology(ies) do you use in your daily work?
3. What benefits do you experience from working with these technologies?
4. What challenges do you encounter when working with these technologies?
5. Have you been given any new/additional responsibilities as a result of using these technologies? If yes, what are these tasks?
6. Were you involved in the selection and/or implementation of these technologies?
7. What measures has your employer taken to reduce (potential) risks associated with these technologies?
8. Do you trust that you can perform your work in a safe and healthy way with these technologies?

APPENDIX 2: INTERVIEW PROTOCOL ENGINEERS AND TECHNOLOGY ADVISORS

1. What significant technological changes within logistics warehousing have you noticed in recent years?
2. Before developing/implementing a technology, do you consider its implications for stakeholders (i.e., warehouse employees, customers, the company, and society)? If yes, what factors do you take into account?
3. What are the potential beneficial effects of the technologies you develop/implement?
4. What are the potential harmful effects of the technologies you develop/implement?
5. To what extent are new and/or additional responsibilities considered during the development/implementation of these technologies? If yes, what are these responsibilities?
6. To what extent do you involve stakeholders (i.e., warehouse employees, customers, the company, and society) in the development/implementation of the technologies?
7. What measures are taken during the development/implementation to mitigate (potential) risks associated with these technologies?
8. What values do you consider important in your role when developing/implementing technologies? Can you provide an example?
9. Is there a designated moment for reflecting on ethical issues that may arise during the development/implementation process of these technologies? If yes, when does this occur, and what is discussed?