



## Risk Identification and Classification in Distribution Warehouses

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### ABSTRACT

Distribution warehouses are important components of modern supply chains, playing a central role in the execution of logistics operations. Risk management in these warehouses has become increasingly important due to the growing complexity of operations. This paper aims to analyze the main risks within distribution warehouses and propose mitigation or elimination measures for the identified risk categories. Risks identified in the available literature and practical reports are assessed and ranked using a combination of qualitative and quantitative methods. The Pilz hazard rating method is applied to evaluate risk levels. The data required for the analysis and assessment of the identified risks are collected through a survey of employees working in distribution warehouses. Following the analysis, the risks are categorized according to their significance. Appropriate measures for risk mitigation and elimination are proposed for risks classified as moderate and high. The research indicates that inadequate risk management in distribution warehouses may lead to long-term consequences for employee safety. The results and conclusions of this study can serve as a basis for improving processes in distribution warehouses.

## 1. Introduction

In today's business environment, warehouses have become a key entity in the supply chain (SC). This is a consequence of shifting activities from other entities to warehouses due to geopolitical influences, crises, and other market changes. By examining risks in distribution warehouses, this paper presents and quantifies the risks that most frequently occur and proposes measures for their reduction/elimination.

Risk management in warehouses affects the functioning of the entire warehouse system, both at the operational and strategic levels. It can be divided into several phases: identification, analysis, response, and control. Risk identification plays a key role in the comprehensive understanding of risks, their selection, and analysis. After identification, it is necessary to perform risk selection and divide them into two groups: those that require action and those that can be ignored. Only risks assessed as having a significant impact on warehouse operations and the entire SC are included in the risk analysis process. For these risks, measures must be defined to reduce or eliminate them.

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Decision-making of this kind is complex, as it involves considering both the potential consequences of risks and the required investments to prevent their occurrence or mitigate their effects [1,2].

The consequences of risk realization are most often categorized as accidents. This is because, in addition to economic consequences, risk realization can also affect the environment and employee health [3]. In this context, risks in warehouses can have both internal and external consequences. Regarding external consequences, risks may lead not only to accidents but also to delays in delivery, disruptions, and errors in handling activities. Therefore, consequences can be of different levels and categories, which directly affect the functioning of the SC. In terms of internal consequences, the focus is on the humanization of work, where preventing employee injuries is often a higher priority than minimizing or eliminating material damage. In this regard, risks that may result in fatal outcomes for employees are given the highest priority, and all available resources are directed toward eliminating or significantly reducing such risks. The goal is to reduce all risks to common (universal) measurable units [4].

This paper aims to identify and evaluate key risks in distribution warehouses that mainly have negative consequences for employees. The purpose of the paper is to systematically present risks in distribution warehouses and propose measures for their reduction.

The paper is structured as follows: Section 2 focuses on risks in warehouses. Within this section, the terms risk and warehouse risk are defined. Section 3 is devoted to risk generators in warehouses. Section 4 presents methods for risk prioritization, which can be classified as qualitative, quantitative, and hybrid, and the Pilz method is described in detail. In the same section, the risks that most frequently occur in distribution warehouses are assessed and classified. Finally, the last section provides conclusions.

## **2. Risks and Risk Occurrence Zones in Warehouses**

The term risk is not clearly defined, and its interpretation can be complex. In most cases, it carries a negative meaning. In the literature, there is no single universally accepted definition of risk. Instead, different authors provide their own definitions and interpretations of this concept. In general, risk represents a potential danger and includes not only the consequences of exposure to a hazard but also the probability of its occurrence [1,5].

A warehouse is a place where material flows are transformed and, as such, numerous risks can be generated within it. These risks may differ from one warehouse to another depending on its position and role in the SC. A specific type is distribution warehouses. Distribution warehouses are divided into certain zones, where each zone has specific characteristics regarding the risks that occur within it. The following section of the paper will provide a more detailed analysis of risk occurrence zones in distribution warehouses [6].

A warehouse is a complex system that may consist of several technological units, such as the storage zone, picking zone, sorting zone, loading/unloading dock, battery charging zone for electric forklifts, etc. Within these zones, four key warehouse processes take place: receiving, processing, storage, and shipping of goods. These processes generate numerous risks that can be analyzed depending on the zone in which they occur [7,8].

Receiving and shipping represent two basic warehouse processes carried out at the loading dock. The loading dock in a warehouse represents the entry point for incoming goods and the exit point for outgoing goods. It also represents the connection between the warehouse and its environment and can therefore take different forms. The types of vehicles as well as the required operational volume influence its configuration. In practice, warehouses most often have loading docks adapted exclusively to road freight vehicles. In cases of lower operational volume, the receiving dock may also

serve as a shipping dock, which can increase the likelihood of certain risks. In the receiving/shipping zone, both external and internal transport equipment, employees, auxiliary equipment, etc. may be present simultaneously, thereby increasing the risk of material damage or employee injury. This is also supported by the fact that more than 15% of all warehouse accidents occur at loading docks [9].

Similar to the loading dock, the storage zone can be defined as the place where two basic warehouse processes are carried out; i.e., storage and processing. Storage is a static process, while processing represents a dynamic process. Processing activities within the storage zone may include merging, splitting, picking, sorting, and others. Accordingly, this zone may contain racks, forklifts, conveyors, employees, and other technological elements necessary for the execution of these processes. A special area of research includes temperature-controlled storage zones due to the specific risks that may arise within them [10].

In addition to the storage zone, processing can also be performed in separate zones depending on the applied organization. Among all forms of processing, particular emphasis should be placed on picking and sorting processes carried out in the picking and sorting zones. These zones are characterized by intensive flows of employees, equipment, and information, which makes them high-risk areas [4].

The battery-charging zone for electric forklifts is often located within the warehouse, since the dominant material handling equipment in warehouses is the electric forklift. Due to the optimization of empty travel distances, these zones are positioned close to the storage area but occupy a small space. This results in a higher number of forklifts being present simultaneously within a limited area. In addition, these zones contain high-voltage electrical lines. After identifying risk-prone zones in warehouses, the following section will identify key risk generators in distribution warehouses [10].

### **3. Risk Generators in Warehouses**

When analyzing risks in a warehouse, in addition to the zones where risks occur, risks can also be classified based on their generators. In most cases, risks cannot be attributed to a single generator; rather, they are the result of the combined action of multiple generators [8]. For effective risk management, it is necessary to identify and analyze all risk generators in the warehouse to determine the dominant one. The goal is to focus risk mitigation measures on the dominant generator. The most common risk generators in warehouses include storage equipment, handling equipment, people, goods, energy, and information.

Storage equipment includes various types of racks and shelving systems whose primary purpose is to store goods. The most common risks are falling goods into working aisles. The causes can be damaged logistics units, damaged packaging, contact between mobile equipment and racks, improper handling of handling equipment, and compromised stability of rack structures [11,12].

In order to carry out warehouse processes, handling equipment is required in addition to storage equipment. Depending on specific warehouse tasks, different types of handling equipment may be used, such as carts, forklifts, conveyors, robotic systems, cranes, etc. Each of these technologies generates a wide range of different risks. Forklifts are responsible for a significant number of risks, including falling loads from forklifts, collisions between forklifts, contact between forklifts and employees, overturning, and contact between forklifts and stationary warehouse equipment. All risks associated with forklifts can cause material damage as well as employee injuries. Conveyors are most commonly used at loading/unloading docks for handling non-palletized goods, as well as in picking and sorting zones. The risks generated by conveyors are related to goods falling from the conveyor or worker injuries due to manual handling of goods during loading or unloading. Cranes are used for handling heavy and oversized loads. Since their working area is above employees, racks, and other

equipment, risks arise mainly from falling loads from cranes. As for robotic systems, they represent an innovation in material handling processes. Robots and employees operate in the same working environment, so risks may be associated with contact between robots and workers.

Depending on the context of analysis, goods themselves can also be a risk generator. A particularly important and complex category is hazardous goods, which require special risk response analysis. Since this paper focuses on distribution warehouses, risks related to goods are mainly the result of damaged packaging, damaged logistics units, or improper stacking of goods on pallets. Since pallets can also be a risk generator, the most common risks include pallets falling from forklifts or racks. The causes of these risks may be damaged or overloaded pallets.

In addition to the above, one of the most common risk generators in warehouses is people/employees, as they are involved in many operational activities. In addition to being risk generators, people are also the most exposed to risks in warehouses. Considering that humanization of work is a priority, employees are given high importance in reducing risk exposure. Furthermore, protecting their health is of great significance. According to research, people are responsible for more than 90% of forklift-related incidents and more than 70% of rack-related incidents [13,14]. Accordingly, this research focuses on risks whose primary generator is the human factor and which have direct consequences on people. To a significantly lesser extent, risk generators include forklifts themselves, goods, or storage equipment.

#### 4. Risk Categorization in Warehouses

Risk categorization represents one of the key steps in the warehouse risk management process. It is used to determine priorities for risk mitigation actions [15]. Through this process, potential risks are assessed and ranked primarily according to the magnitude of their consequences [16]. By means of adequate risk analysis, opportunities are created for the timely elimination of risk occurrence or the reduction of its consequences [17]. Figure 1 shows risk categorization methods.

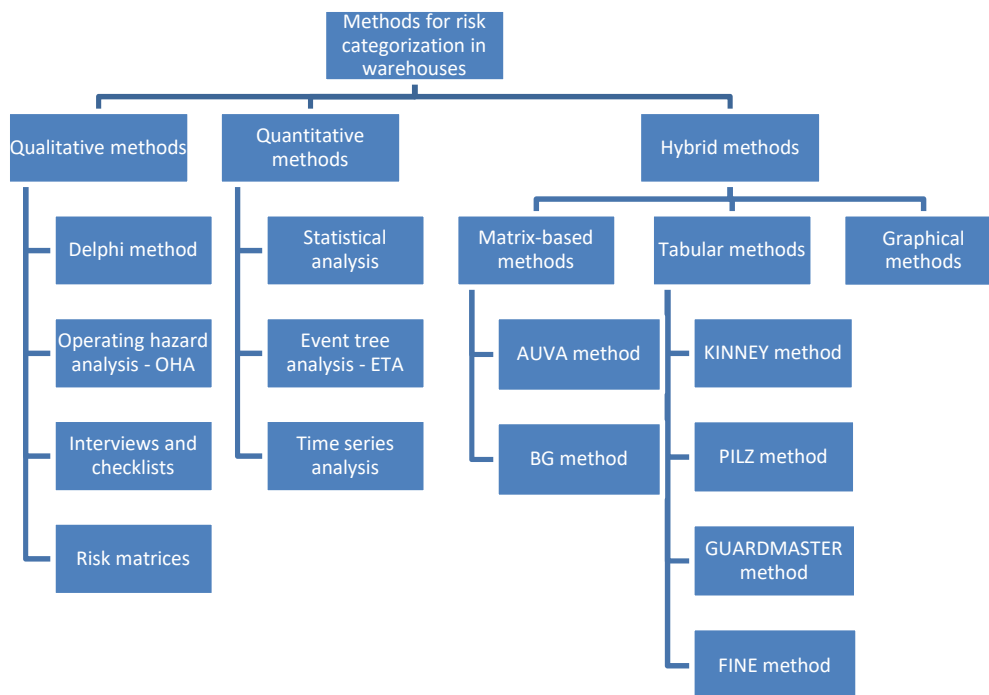


Fig. 1. Risk categorization methods in warehouses

Based on the literature review in this field [18-20] and the authors' findings, a suitable method for risk assessment in warehouses would be the Pilz method. It stands out from the mentioned methods because it includes the number of persons exposed to risk. It could have particular application in specific types of warehouses where a single risk may affect a large number of employees, such as hazardous goods warehouses, cold storage facilities, as well as distribution warehouses (due to the large number of employees involved in process execution). In the following part of the paper, the Pilz method will be explained.

#### 4.1 Pilz Method for Risk Assessment

The Pilz method belongs to the group of tabular hybrid methods. This means that qualitative values of criteria are converted into their quantitative equivalents using Tables 1-4. The risk value is obtained as the product of the probability of risk occurrence, the frequency of exposure to the risk, the severity of consequences, and the number of people exposed to the risk. Based on the calculated risk value, the risk level is determined, along with recommendations on whether it is necessary to take action (Table 5). This method is adapted for assessing risks to people, but not for material damage.

The probability of risk occurrence in the Pilz method is divided into eight categories (Table 1). The lowest risks, described as almost impossible or possible only under extreme circumstances, are assigned a quantitative value of 0.033. Risks that are certain to occur are assigned a value of 15. The steps between the qualitative descriptions of frequency in Table 1 are not uniform.

**Table 1**

Probability of risk occurrence (V) – Pilz method

Rank	Numerical value	Qualitative description of probability
1	0.033	Almost impossible – possible only under extreme circumstances
2	1	Very unlikely, but still possible
3	1.5	Unlikely, but possible
4	2	May occur, but is unusual
5	5	There is a chance of occurrence – the probability is 50%
6	8	Likely – not surprising
7	10	Very likely – expected to occur
8	15	Certain – will definitely occur

The frequency of exposure to risk takes values from 0.5 to five (Table 2), depending on the occurrence of the risk. Risks that occur once a year are assigned a value of 0.5, while risks that are constantly present are assigned a value of five.

**Table 2**

Frequency of exposure to risk (U) – Pilz method

Rank	Numerical value	Qualitative description of exposure frequency
1	0.5	Yearly
2	1	Monthly
3	1.5	Weekly
4	2.5	Daily
5	4	Hourly
6	5	Constantly

The consequences of risk exposure can be classified into seven categories (Table 3). The least severe consequences (scratches, bruises, or contusions) are assigned a value of 0.1, while risks that

may lead to a fatal outcome are assigned a value of 15. The qualitative descriptions of consequences sometimes require consultation with medical experts.

**Table 3**  
 Consequences/possible injuries or illnesses (P) – Pilz method

Rank	Numerical value	Qualitative description of consequences
1	0.1	Scratches, bruises, or contusions
2	0.5	Cuts, lacerations, burns
3	2	Fracture of small bones, minor illnesses (temporary)
4	4	Fracture of major bones, more serious illnesses (temporary)
5	6	Loss of an eye, hearing, limb, or permanent injuries
6	10	Loss of vision, multiple limbs, severe permanent injuries
7	15	Fatal injuries – death outcome

From Table 4, it can also be seen that the number of persons directly exposed to risk affects the overall risk value through different coefficients ranging from one to 12. The lowest value is assigned to risks to which a small number of persons are exposed (one to two), while the value of 12 is assigned to risks affecting more than 50 persons.

**Table 4**  
 Number of persons exposed to risk (B) – Pilz method

Rank	Numerical value	Qualitative description of the number of persons exposed to risk
1	1	1–2
2	2	3–7
3	4	8–15
4	8	16–50
5	12	More than 50

The Pilz method classifies risks into five categories (Table 5): negligible, low, moderate, high, and unacceptable risk. If a risk belongs to one of the first three categories, it can be considered not significant, and no major measures are required for its mitigation. When a risk is classified as high or unacceptable, it is mandatory to define measures and actions aimed at its reduction.

**Table 5**  
 Risk level (R) – Pilz method

Rank	Numerical value	Qualitative description of risk levels
1	0-5	Negligible risk – no actions are required to reduce the risk
2	6-50	Low risk – the risk exists and protective measures can be defined
3	51-250	Moderate risk – the risk exists and measures for its reduction are necessary
4	251-500	High risk – significant risk; defining risk reduction measures is mandatory
5	over 500	Unacceptable risk – working under such risk conditions is not acceptable

#### 4.2 Risk Categorization in Distribution Warehouses and Mitigation Measures

In this part, the Pilz method is applied to rank and assess risks in a distribution warehouse. Based on the literature and research findings [21,22], the most common risks in distribution warehouses include slipping, tripping and falling, falls from height, manual handling, forklift–equipment contact, and forklift–worker contact. To obtain input data presented in Table 6, a survey was conducted with 20 employees working in distribution warehouses in various positions, ranging from pickers to

warehouse managers. In all observed warehouses, more than 50 employees are employed. The final assessment was taken as the value from the table that was most frequently indicated by respondents.

**Table 6**  
 Ranking and categorization of risks in the explored distribution warehouse

Risk	Prob. of occurrence (V)	Frequency of exposure (U)	Consequences (P)	Number of exposed persons (B)	$R = V * U * P * B$	Risk level
Slipping, tripping, and falling ( $R_1$ )	5	2.5	2	12	300	High risk
Falls from height ( $R_2$ )	1	1	15	2	30	Low risk
Manual handling ( $R_3$ )	5	4	2	8	320	High risk
Forklift–equipment contact ( $R_4$ )	1	0.5	6	4	12	Low risk
Forklift–worker contact ( $R_5$ )	2	1	15	8	240	Moderate risk

Based on the results obtained from Table 6, two high risks, one moderate risk, and two low risks were identified. For the high risks—slipping, tripping and falling ( $R_1$ ) and manual handling ( $R_3$ )—as well as for the moderate risk—forklift–worker contact ( $R_5$ )—special attention should be paid and appropriate mitigation measures should be proposed.

Regarding risk  $R_1$ , its high value is the result of a high probability of occurrence and a large number of exposed persons (all pickers and other warehouse workers). A proposed measure for reducing/eliminating this risk is maintaining floor cleanliness and regular removal of empty packaging (boxes, stretch film, etc.) and other waste.

Risk  $R_3$  is a common occurrence in warehouses where manual picking processes are dominant. Measures for risk reduction are focused on employee training, application of ergonomic principles in material handling, as well as automation of these processes.

Considering the category of risk  $R_5$ , measures should also be proposed for its reduction. Its high ranking in the risk classification is a consequence of the severity of its potential outcomes. Measures that can contribute to reducing or eliminating this risk include separating picking routes from replenishment routes used by forklifts, or automation and robotization of this process.

## 5. Conclusion

In modern business operations, warehouse safety, and above all, employee safety, represent an imperative. Numerous resources are engaged in order to increase warehouse safety and prevent risks. Timely action aimed at reducing risks in warehouses significantly mitigates the consequences of those risks. This paper addresses the risks that frequently occur in distribution warehouses. Initially, risk occurrence zones were identified, followed by the potential generators within those zones, and finally, the risks generated by those factors. In addition, the Pilz method for risk assessment and ranking was presented. The main reason for risk categorization in many cases is the limitation of warehouse resources and the inability to act on all risks simultaneously, which makes it necessary to define priorities and the order of implementing measures. Various methods can be used for risk categorization: qualitative, quantitative, and hybrid, with the choice of method depending on the available information. In cases where historical data exist, statistical analysis can be used to derive appropriate conclusions. On the other hand, hybrid methods are often applied, as they

combine the advantages of qualitative and quantitative approaches and thus overcome their individual limitations.

Risks present in the explored distribution warehouses were ranked using the Pilz method. Input values were obtained through employee surveys conducted in warehouses. After determining risk categories, mitigation/elimination measures were proposed for moderate and high risks. It can be concluded that risks in distribution warehouses represent an important area that must be continuously monitored and improved. Furthermore, continuous monitoring is a prerequisite for successful risk management in warehouses. At the same time, this requirement is also imposed by various standards and regulations.

Directions for further improvement of this work may include the application of the proposed risk ranking and categorization method in a specific warehouse. In addition, for a more detailed analysis, it is necessary to identify a broader set of potential risks and conduct a larger number of employee surveys at all organizational levels. The study can also be extended to examine and categorize risks in specific types of warehouses, such as cold storage facilities, bulk material warehouses, and others.

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### Conflicts of Interest

The author declares no conflicts of interest.

### References

- [1] Fan, Y., & Stevenson, M. (2018). A review of supply chain risk management: definition, theory, and research agenda. *International Journal of Physical Distribution & Logistics Management*, 48(3), 205-230. <https://doi.org/10.1108/IJPDLM-01-2017-0043>.
- [2] Ho, W., Zheng, T., Yildiz, H., & Talluri, S. (2015). Supply chain risk management: a literature review. *International Journal of Production Research*, 53(16), 5031-5069. <https://doi.org/10.1080/00207543.2015.1030467>.
- [3] Cebi, S., & Ilbahar, E. (2018). Warehouse risk assessment using interval valued intuitionistic fuzzy AHP. *International Journal of the Analytic Hierarchy Process*, 10(2). <https://doi.org/10.13033/ijahp.v10i2.549>.
- [4] Ridwan, A., Nuroni, A., Adelia, A., & Sonda, A. (2022). Analysis of occupational health and safety at a maritime warehouse using Hazard Identification, Risk Assessment and Risk Control (HIRARC). *Journal Industrial Services*, 8(2), 187-192. <http://dx.doi.org/10.36055/jiss.v8i2.17293>.
- [5] Božić, M., Dabić-Miletić, S., & Pavlov, N. (2026). The Impact of Smart Packaging on the Digitalization of Supply Chains. *Applied Research Advances*, 2(1), 162-168. <https://doi.org/10.65069/ara21202620>.
- [6] Dabić-Miletić, S. (2026). Digital Transformation of Postal Logistics Supply Chains toward Sustainability and Efficient Management from a Web 4.0 Perspective. *Management Science Advances*, 3(1), 96-105. <https://doi.org/10.31181/msa31202637>.
- [7] Gwynne, R. (2018). *Warehouse management: a complete guide to improving efficiency and minimizing costs in the modern warehouse*. Kogan Page Limited, London, UK.
- [8] Đurđević, D., Andrejić, M., & Pavlov, N. (2022). Framework for improving warehouse safety. In *Proceedings of the 5th LOGIC Conference* (pp. 304-314).
- [9] RiteHite (2024). Guide to Loading Bay Safety.
- [10] Md Hanafiah, R., Karim, N. H., Abdul Rahman, N. S. F., Abdul Hamid, S., & Mohammed, A. M. (2022). An innovative risk matrix model for warehousing productivity performance. *Sustainability*, 14(7), 4060. <https://doi.org/10.3390/su14074060>.
- [11] Đurđević, D., & Miljuš, M. (2013). Some safety aspects of pallet racks. In *1st Logistics International Conference* (pp. 184-189).
- [12] Kostrzewski, M. (2017). Securing of safety by monitoring of technical parameters in warehouse racks, in high-bay warehouses and high storage warehouses-literature review of the problem. *LogForum*, 13(2). DOI: <https://doi.org/10.17270/j.log.2017.2.1>.

- [13] Jalal, A., Farooq, M., Anwer, I., Hayat, N., Munir, A., Zahid, I., ... & Riaz, F. (2025). Design and development of a low-cost, eco-friendly forklift for sustainable logistics management. *Frontiers in Built Environment*, 10, 1506495. <https://doi.org/10.3389/fbuil.2024.1506495>.
- [14] Esmaeili, S. V., Alboghobeish, A., Yazdani, H., Ghasemi Koozekonan, A., & Pouyakian, M. (2025). Optimizing in-store warehouse safety: A DEMATEL approach to comprehensive risk assessment. *PLOS One*, 20(2), e0317787. <https://doi.org/10.1371/journal.pone.0317787>.
- [15] Radu, L. (2009). Qualitative, semi-quantitative and, quantitative methods for risk assessment: case of the financial audit. *Analele Științifice ale Universității «Alexandru Ioan Cuza» Iași. Științe economice*, 56(1), 643-657.
- [16] Thomas, P., Bratvold, R. B., & Eric Bickel, J. (2014). The risk of using risk matrices. *SPE Economics & Management*, 6(02), 56-66. <https://doi.org/10.2118/166269-PA>.
- [17] Tiusanen, R. (2017). Qualitative risk analysis. *Handbook of Safety Principles*, Chapter 21, pp. 463-492. <https://doi.org/10.1002/9781119443070.ch21>.
- [18] Kovačević, P. N., Babić, P. B., Vlk, D., & Mak, A. (2021) Risk Assessment using the Combined "Five Steps-Pilz" Method. In *Proceedings from the VII International Scientific Professional Conference, Security and Crisis Management – Theory and Practice*, pp. 25-31.
- [19] Vishnu, C. R., Sridharan, R., & Kumar, P. R. (2019). Supply chain risk management: models and methods. *International Journal of Management and Decision Making*, 18(1), 31-75. <https://doi.org/10.1504/IJMDM.2019.096689>.
- [20] Kokangül, A., Polat, U., & Dağsuyu, C. (2017). A new approximation for risk assessment using the AHP and Fine Kinney methodologies. *Safety Science*, 91, 24-32. <https://doi.org/10.1016/j.ssci.2016.07.015>.
- [21] HSE. (2023). Transportation and storage statistics in Great Britain.
- [22] Kharisma, D., & Hartono, M. (2023). Warehouse Safety in Order Picking. In *Proceedings of the 4th International Conference on Informatics, Technology and Engineering 2023 (InCITE 2023)* (pp. 7-14). Springer Nature. [https://doi.org/10.2991/978-94-6463-288-0\\_2](https://doi.org/10.2991/978-94-6463-288-0_2).