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RESEARCH ARTICLE OPEN ACCESS

USING BAYESIAN NETWORKS AND FUZZY LOGIC TO PREDICT WAREHOUSE PLANNING DISRUPTION RISKS

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ABSTRACT

The main role of warehouse managers is to establish a schedule adapted to different circumstances. Late arrival of vehicles, lack of handling resources and shortage of packaging supplies all affect this schedule. This is why one of the requirements of quality management in warehousing operations is to anticipate the various likely situations. This article focuses on analysing the risks that can be associated with handling goods in a warehouse, from receipt to delivery. Each risk has two negative effects: the first is the addition of extra costs and the second is the loss of customer confidence. With this in mind, the research presented in this article focuses on the creation of a predictive model to anticipate these risks, using an approach that estimates the degree of disruption to the pre-established schedule, based on a predictive analysis combining Bayesian networks (BN) and fuzzy logic. The model was validated and the parameters influencing the risk studied were identified by analysing the specialist literature and examining scenarios derived from a survey of professionals in the warehousing sector. The results help planners to minimise the impact of disruptions, thereby reducing the time taken to process goods in the warehouse.

I. INTRODUCTION

The effectiveness of warehouse governance is always impacted by unforeseen disruptions. Indeed, the management of tasks of goods processing operations in a warehouse always encounters disruptions at the level of their pre-established planning. These are often unforeseen disruptions due to unfavorable conditions coming from different sources [1],[2]. Applying the principle of regulation or control to them requires an almost total knowledge of the components involved in the warehouse management system, as well as the sources responsible for the disruption or the correct estimation of their values.

For a long time, warehouse management has been a major source of conflicts and problems between customers and suppliers in the absence of effective collaboration or cooperation between them [3], given the difficulty in making a good estimate of unforeseen disruptions. This is further accentuated with the supply chains of e-Commerce and Industry 4.0, as well as during health, ecological and energy crises [4].

The estimation of these disruptions must converge towards values closer to reality for solving this problem.

According to a large study in the literature, we distinguish two types of data processing, the one that is generally done by exact methods [5], when it comes to the existence of exactly defined parameters, and the one based on approximate values, estimated following the analysis of a survey carried out among experts [6]. In this article, our problem is studied by applying two artificial intelligence methods, namely Bayesian networks and fuzzy logic. The first method produces exact numerical results, while the second produces results in the form of intervals or degrees of membership to an interval [7].

The rest of the article is structured as follows: - a first section gives an overview of the literature on planning disruption in the field of warehouse management and a real case study as an application; - a second section provides a brief review of Bayesian networks and presents the construction of our model; - a final section reserved for the discussion of the results obtained; - the article ends with a conclusion and perspectives of the work presented in this article.

II. RELATED WORK

According to a literature review, risks due to disruptions in supply chains are the most frequent compared to other risks in the industrial environment [8]. More selectively, some of the most relevant research focuses on the study of disruption at the warehouse level [9].

Overall, the management of supply chain disruption risks is becoming necessary [10], and particularly the management of planning disruptions within warehouses is a crucial topic that has been addressed in several research works and case studies [11]. Disruptions also increase the fragility of the supply chain, which leads to an increase in the operational and financial impact of supply chain disruptions [12].

Disruptions to warehouse planning can have significant impacts on several aspects of processing operations:

- Delays in order preparation and delivery operations, these disruptions can lead to delays in receiving or shipping orders, affecting delivery times to customers.
- Increased order processing costs, and disruptions can require overtime or temporary resources to compensate for delays.
- Impact on customer satisfaction, disruptions involve delays or errors in order processing that can affect customer satisfaction.

With over 56% of warehouses worldwide experiencing a disruption in their supply chains at the warehouse level each year, warehouses have started to take these disruptions more into account [13].

Disruptions are linked to internal or external causes, the analysis of different disruptions, such as vehicle delays [14], unexpected breakdowns related to handling equipment, infrastructure events [15] or other sources of problem, allows a delimitation of major problems and convergence towards the application of feasible solutions. The use of statistical and simulation methods allows anticipation of the impacts of disruptions on operating operations. This study will be applied to a real case through the collection and analysis of testimonies and experiences of warehouse experts. These research axes and methods allow a better understanding and management of disruptions in warehouses, thus contributing to better operational efficiency and cost reduction.

III. PROBLEM AND OBJECTIVE

A good planning of loading/unloading allows to reduce costs considerably [16], and demand planning allows to develop the order plan according to the forecasts [17]. On the other hand, a disruption in planning leads to additional costs, which result in:

- A delay in receiving goods.
- A delay in delivering orders.
- A total or partial shutdown of warehouse operations, leading to the shutdown of all parties related to the warehouse.

For this reason, and according to [18], planning can be the most difficult step. According to [19] highlight several criteria for the analysis of the Supply Chain, including the analysis and measurement of the performance of demand planning.

In general, the major problem of the organization and management of warehouse operations lies in the disruption of the planning of functional processes, given its impact on the various stakeholders of the warehouse.

This article seeks to determine the probability of occurrence of disruptions in the functional planning of a warehouse. To do this, identifying the elements, triggers, or amplifiers, responsible for such disruptions is essential. These are elements, presented in the following, that we have identified through the analysis of the literature that focuses on the efficient use of resources and their availability to minimize costs [20] relating to the processing of logistics operations within a warehouse. These elements and their causal links make it possible to create a knowledge base to apply an approach based on Bayesian networks and fuzzy logic theory. This to:

- eliminate their effects as soon as possible.
- update, if necessary, the logistics operations schedule.
- postpone tasks that can be rescheduled.
- inform customers and suppliers of possible delays caused by possible disruptions in planning.

In the event of unacceptable delays [21], planning consists of finding a solution that best meets this requirement, as illustrated in Figure 1.

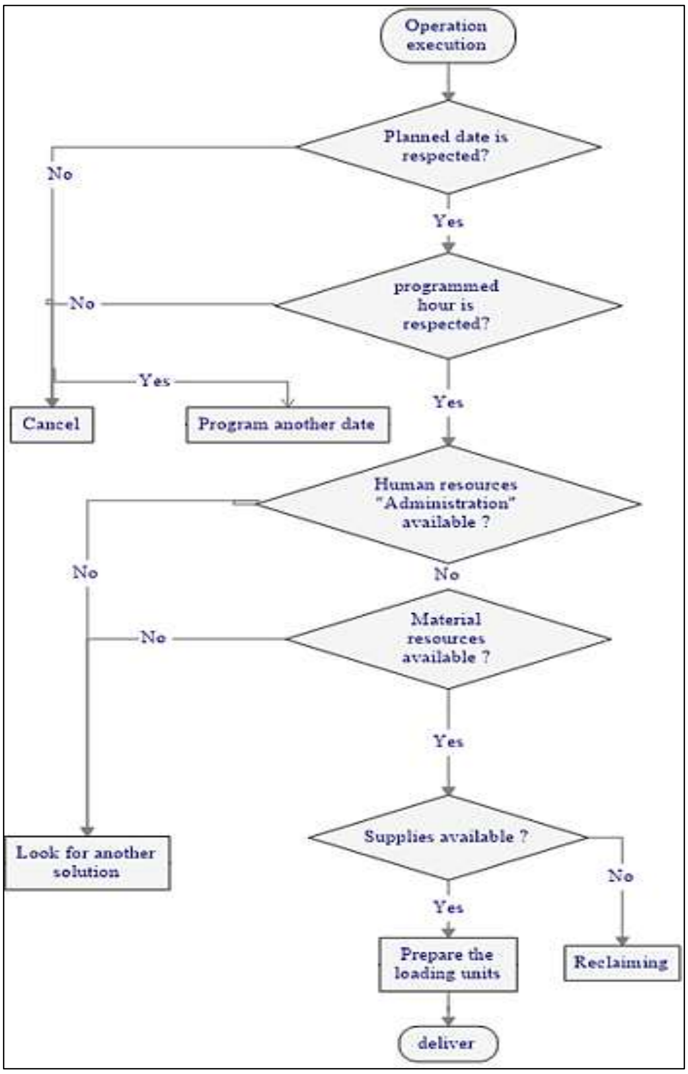

Figure 1: Process of executing an operation.
Source: Authors, (2025).

The use of a causal network of the Bayesian or fuzzy Bayesian network type involves the quantification of variables and the choice of conditional probabilities to build a predictive model. To do this, we can either rely on algorithms from artificial intelligence, which are very complex and have a considerable cost and which must rely on often confidential data, or call on experts to weight their responses and prepare a model close to reality. Developing solutions that can be applied in reality requires the study of a problem situation that also arises from reality.

The model proposed in this article is based on the opinions of several 10 experts, through the analysis of their responses about a questionnaire that we proposed to them (See below), developed in coordination with 3 of the aforementioned experts.

IV. MODELLING THE RISK OF DISRUPTION TO PLANNING BY APPLYING FUZZY BAYESIAN

This section presents the method applied in this study, as well as the variables or parameters used to simulate the scenarios.

IV.1 PRINCIPE OF BAYESIAN NETWORKS

A Bayesian network is a graphical probabilistic model that combines artificial intelligence with statistics to represent uncertain information and reason from data that is incomplete. A Bayesian network consists of two components [22]: A causal acyclic-oriented graph, (see Figure 2), whose nodes are variable and whose arcs characterize the dependency relations between these variables. It is a form of qualitative representation of knowledge. The probability entity contains three branches, conditional probability, total probability, and static independence.

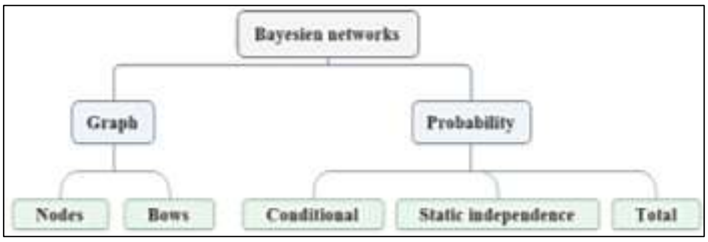

Figure 2: Bayesian network components.
Source: Authors, (2025).

The conditional probability is the degree of occurrence of an event knowing the probability of the second event that corresponds to it, and the total probability, each event of the set of possible events corresponds to a single degree of occurrence, on the other hand. Static independence is the occurrence of an event dependent on, or independent, of another event.

Table 1: Ranking of warehouse parameters.

Space	Material resources	Personal resources
Saturated zone - Saturated parking - Inaccessibility to the warehouse	- Blocked door - Lateness of vehicle - Vehicle puncture - Lack of equipment - Information system failure - Lack of packaging supply	- Lack of staff resources

Source: [23].

IV.2 ELABORATION OF INITIAL PARAMETERS OF BAYESIAN NETWORKS

According to a study carried out by [23], the basic parameters governing the operation of a warehouse are classified into three categories (space, material resources, and personnel resources) presented in Table 1.

The parameters listed in this table are more general, the following part presents the most primary parameters in the form of Bayesian networks.

IV.2.1 DETERMINING THE PRIMARY NODES OF BAYESIAN NETWORKS

In the following, our study focused on determining the main nodes disrupting workflows planning in a warehouse. This section considers the identification and study of the most initial nodes.

Figure 3 gives an overview of the primary nodes responsible for inaccessibility to the warehouse. This criterion is conditioned by the infrastructure and climatic conditions.

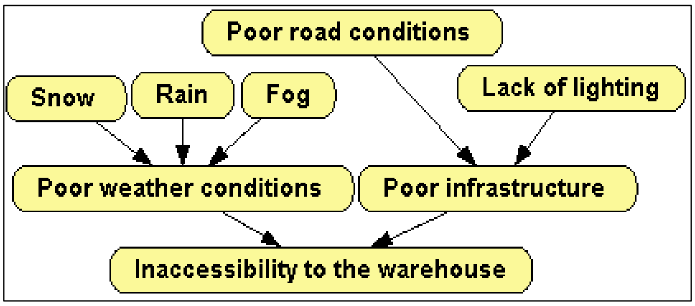

Figure 3: Diagram of inaccessibilité to the warehouse.
Source: Authors, (2025).

Climatic conditions occur periodically during the year with varying proportions depending on the existence of snow, rain, or fog. Infrastructure is measured by two criteria, the condition of the road and lighting.

Figure 4. Deals with the causes of car park saturation (drivers' strike, and vehicle blockage). Vehicle blocking occurs either because of the mechanical condition of the vehicle due to overloading, lack of maintenance, or misuse by the driver.

The energy entity can translate into the battery being discharged due to lack of fuel or exhaustion if the vehicle is electric or hybrid, also the self-degradation of the batteries affects its range [24]. The driver is involved in blocking the vehicle in cases where the driver leaves the vehicle and goes elsewhere for reasons related to the warehouse (administrative document, claim, etc.), or related to personal occupations (eating, smoking, talking on the phone, etc.). A driver's strike is generally linked to working conditions, which involves the total blocking of traffic in parking lots (or absence of traffic).

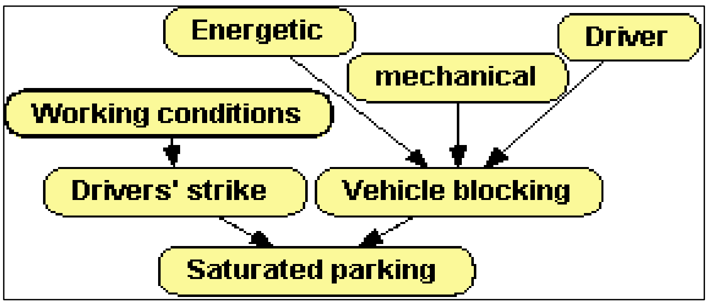

Figure 4: Vehicle Park saturation network.
Source: Authors, (2025).

The saturation of the zones is the result of different factors, as shown in Figure 5, such as:

Blockage of machines in the area, whatever the cause, causes saturation of the area.

Leaving the goods, after storage in the areas, for a considerable time causes saturation of the area.

The dispersion of products in the work areas causes saturation of the area.

Programming zones as temporary passages (dynamic zones) also increases the risk of blocking zones.

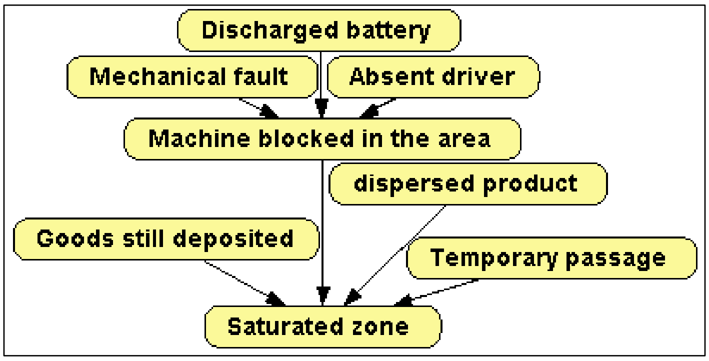

Figure 5: Zones saturation network.
Source: Authors, (2025).

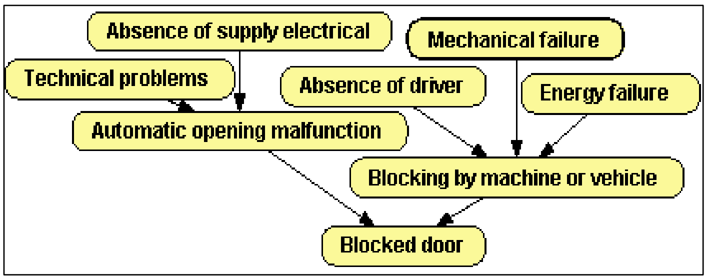

Figure 6: Door blocking network.
Source: Authors, (2025).

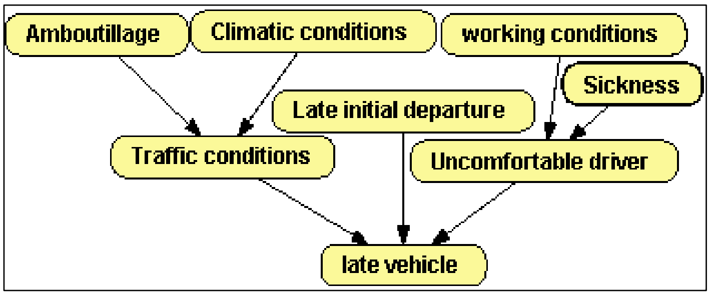

Figure 7: Network showing vehicle delay.
Source: Authors, (2025).

Figure 7. Shows the causes responsible for the door jamming, which can be explained by:

- Blocking of the door operation management: According to the problem diagnosis system [25], this results from the absence of a power supply, or a technical or physical problem (connection, programming, or component degradation).
- The parking or blocking of vehicles in front of the doors is one of the factors contributing to the doors not operating properly, whatever the cause (mechanical failure, electrical failure, driver absence).

Material resources are the main element for handling goods in the warehouse, so their absence or lack disrupts normal operations. For that purpose, we need to study the causes of this lack. Figure 8 lists the different scenarios that lead to a lack of material resources.

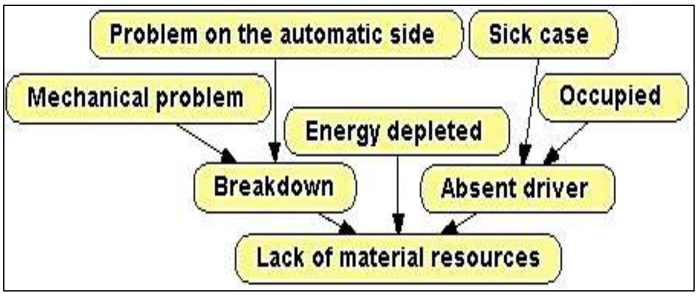

Figure 8: Network of lack of material resources
Source: Authors, (2025).

A vehicle's late arrival causes a double disruption, the first in relation to the reception operation and the second about the departure after unloading. For this reason, identifying the causes of this disruption helps to find an optimal solution, as shown in Figure 8. Since vehicles are not the only users of the road network, they must share it with others [24], and the sources causing this delay are increasing, among other things.

Human resources are the main players or brains of the warehouse [26], influencing all warehouse stakeholders. To ensure the smooth operation of the supply chain, human resources must be at the top of the warehouse's priorities. This architecture enables optimized warehouse management by helping staff to work under better conditions [1].

Figure 9. Gives a clearer vision by identifying the causes responsible for the lack of human resources, such as:

- Staff absence can be caused by illness, strikes, or demonstrations [27].
- Delays can be caused by a lack of motivation or overload at work which leads to fatigue [28].

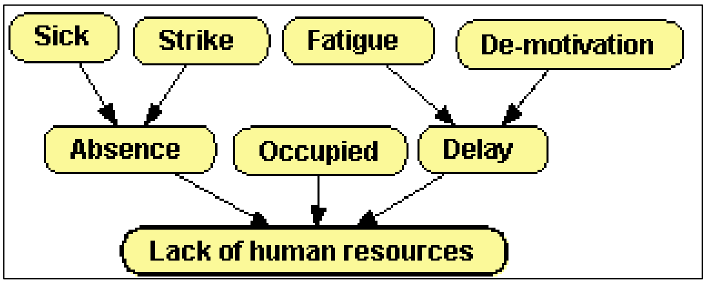

Figure 9: Network of lack of human resources.
Source: Authors, (2025).

In the warehouse, goods are reorganized, dissociated, packed, or repacked [29]. Hence, packaging supply is an essential tool [30] for order processing or storage. Figure 10 helps to avoid any possible lack of supply.

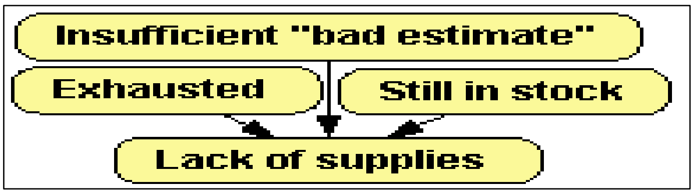

Figure 10: Network of lack of supplies.
Source: Authors, (2025).

The lack of supply, Figure 10, translates to three situations: The first is when the need is underestimated.

The second is when a large number of unexpected orders are received.

The third is when the supply exists in the warehouse, but is still in stock and not available for immediate use.

As shown in Figure 11, a vehicle can break down due to: Lack of energy, discharged battery, or low fuel level. A mechanical problem with parts and components.

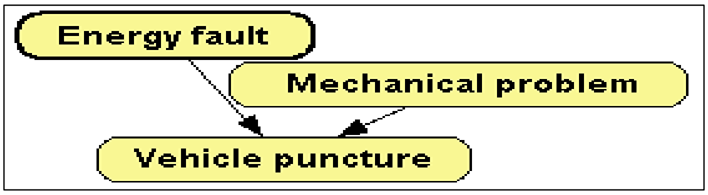

Figure 11: Vehicle puncture.
Source: Authors, (2025).

The information system is the nerve center of the warehouse [31], managing all activities within the warehouse. The phenomenon of saturation of the management system, which cannot adapt and grow ad infinitum to meet the needs of new users [24]. Blocking the latter blocks activities in the warehouse or slows them down if we switch to manual processing and recording. Figure 12. clearly shows the inputs that can contribute to blocking the information system.

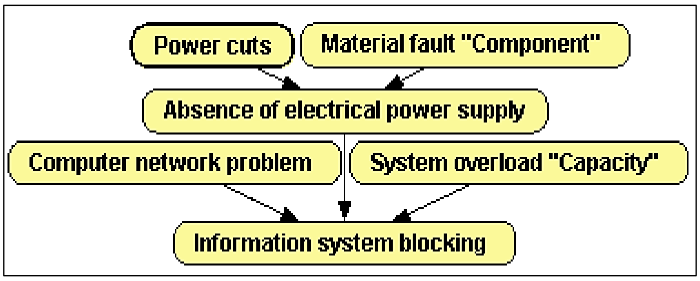

Figure 12: Information system blockage.
Source: Authors, (2025).

With a high volume of information (Intense), the computer network can have complications processing it.

The absence of power to the system due to a power failure or problems [29] with the components used causes the system to come to a complete standstill.

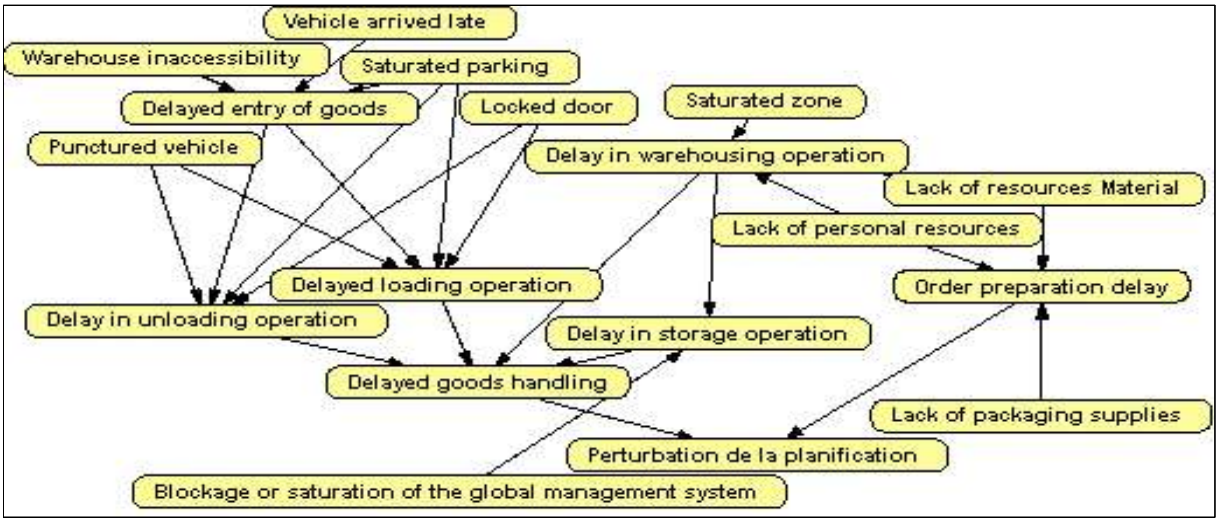

Figure 13: Global Bayesian network representation.
Source: Authors, (2025).

V. GLOBAL BAYESIAN NETWORK

Elaborating the primary nodes of different problems participating in the planning disturbance helps to establish a global Bayesian network, see Figure 13.

Once the global Bayesian network of different sources of disturbance has been constructed, it remains to assign suitable values to each variable to calculate the conditional probabilities. Databases containing rich values and useful information are insufficient or generally of a private nature [32]. For the generation of probabilities systematically, we call upon the application of fuzzy logic which is characterized by its force of reasoning which resembles the reasoning of human beings and natural languages [33].

V.1 QUESTIONNAIRE (PARAMETERS VALUE ATTRIBUTION)

To feed our Bayesian network, we sent a questionnaire to experts in the field of warehouse management (the following section) Table 2.

This questionnaire concerns the absence of a problem concerning the criterion concerned.

Table 2: Example of questionnaire.

Question	Possible answer (single choice)
Saturation of the area	1. Low 2. medium 3. high
Car's park Saturation	1. Low 2. medium 3. high
Inaccessibility to the warehouse	1. Low 2. medium 3. high
Blocked doors	1. Low 2. medium 3. high
Door blockage	1. Rarely 2. Often 3. Frequently
Vehicle delays	1. Rarely 2. Often 3. Frequently
Vehicle punctures	1. Rarely 2. Often 3. Frequently
Lack of equipment	1. Rarely 2. Often 3. Frequently
Information system failure	1. Rarely 2. Often 3. Frequently
Lack of packaging supply	1. Rarely 2. Often 3. Frequently
Lack of personal resources	1. Rarely 2. Often 3. Frequently

Source: Authors, (2025).

As mentioned in the previous section, Bayesian networks are used to represent the knowledge of a system through the simulation of its behavior, this is done through data analysis.

It is therefore necessary to have data to feed our Bayesian network. These data or more generally, the conditional probabilities can be generated from two different methods:

- Objective method: By using a database for automatic learning of probabilities. The latter requires a large data size, and that the database contains exactly the parameters considered in our case study. As a result, we did not find a database that was complete enough and that met these criteria. Therefore, we returned to the subjective methods.
- Subjective methods: by extracting knowledge from warehousing experts in the field of warehouse logistics. We opted for this method by sending a questionnaire to 10 Warehouse's managers in Tangier Free Zone in Morocco.

We used decimal scales from 1 to 9, which indicate the following meaning, Table 3:

Table 3: Correlation between questionnaire values.

Value at %	Interval	Linguistic values
[1%-30%]	[1-3]	Faible or Rarement
]30%-60%]	]3-6]	Moyenne or Souvent
]60%-99%]	]6-9]	Elevé or Fréqement

Source: Authors, (2025).

Note that the starting value is 1% because a parking lot will never be empty in reality, and we stop at 99% because a parking lot will never be full.

The result obtained by this questionnaire is indicated in Table 4, Table 5, Table 6, Table 7, and Table 8.

Table 4: Spatial entity.

	Saturated zone	Saturated parking	Inaccessibility to the warehouse
Present	[1-30]	[6-9]	[7-9]
Absent	[6-9]	[1-30]	[1-3]

Source: Authors, (2025).

30% temporally and spatially, i.e. most of the time the zones are 30% saturated, and temporally we find that 30% of the time the zones are 90% saturated.

Table 4 shows that the saturation of the areas is present with a coefficient ranging from 1 to 3, while the saturation of the parking lot and the inaccessibility to the warehouse are present with a variable factor between 7 and 9.

Table 5: Material resources entity.

	Blocked door	late vehicle	vehicle puncture	lack of machine
Present	[7-9]	[7-9]	[7-9]	[7-9]
Absent	[1-3]	[1-3]	[1-3]	[1-3]

Source: Authors, (2025).

Table 5 shows that the coefficient of the presence of constraints at the material resources entity is between 7 and 9.

Table 6 shows that the value that reflects the lack of personal resources is present with a factor ranging from 7 to 9.

Table 6: Personal resource entity.

	Lack of staff resources
Present	[7-9]
Absent	[1-3]

Source: Authors, (2025).

Table 7: Blockage or saturation of the global management system.

	Blockage or saturation of the global management system
Present	[1-3]
Absent	[7-9]

Source: Authors, (2025).

Table 7 shows that the management system blocking problem is low, it is between 1 and 3.

Table 8: Lack of packaging supply.

	Lack of packaging supply
Present	[1-3]
Absent	[7-9]

Source: Authors, (2025).

Table 8, shows that the lack of supply is less dominant, it is given by a factor ranging from 1 to 3.

VI. FUZZY LOGIC AGGREGATION WITH THE PREVIOUS APPROACH

According to [34], fuzzy logic is considered one of the rare techniques capable of modeling fuzzy and ambiguous knowledge derived from experts. Therefore, it is applied to problems not linearly defined. This application is based on two principles [35]:

- Linguistic variables that take qualitative or nominal values;
- Conditional rules "if-then", which establish a connection between input variables to produce an output or consequence, known as the mechanism called "fuzzy inference system".

VI.1 FUZZIFICATION

The fuzzification is used to transform real input values into fuzzy values by determining their degree of membership in each fuzzy set via the membership function [36].

Table 9 presents the fuzzy variables and their linguistic values highlighted to address our problem statement.

VI.2 INFERENCE

Inference is the implementation of fuzzy rules, which are also called fuzzy implications or fuzzy conditional instructions [37], are represented in the form 'IF... Then.' The number of these rules in a fuzzy inference system depends on the number of variables (input and output) and the number of zones in each of them [38].

To synthesize the approach applied, we will present the generation of the total conditional probabilities of the 'planning disruption' node following the events linked to the state of the primary nodes: Goods handling and Order preparation.

Table 9: Fuzzy variables and linguistic values.

Variables	Linguistic values
Inaccessibility to the warehouse	Low, medium, high
Vehicle arrives late	Low, medium, high
Overcrowded car park	Low, medium, high
Door blocked	Low, medium, high
Punctured vehicle	Low, medium, high
Lack of personal resources	Low, medium, high
Lack of material resources	Low, medium, high
Saturated area	Low, medium, high
Saturation of the global management system	Low, medium, high
Lack of packaging supplies	Low, medium, high
Delayed entry of goods	Low, medium, high
Delay in warehousing operation	Low, medium, high
Delay in unloading operation	Low, medium, high
Delay in loading operation	Low, medium, high
Delay in storage operation	Low, medium, high
Delay in order preparation	Low, medium, high
Delay in goods handling	Low, medium, high
Disruption to planning	Low, medium, high

Source: Authors, (2025).

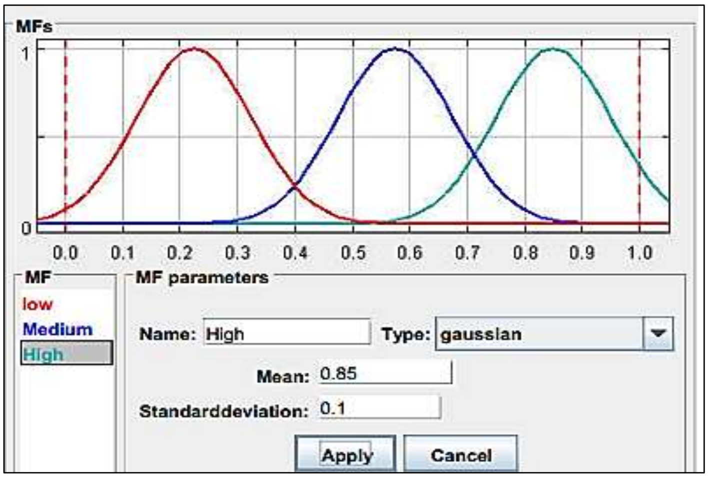

Figure 15: Representation of the Gaussian function, order picking delay.
Source: Authors, (2025).

The membership functions most commonly used in the literature for this type of problem are the triangular function, the trapezoidal function, and the Gaussian function, which will be applied in our case, for the different nodes. Because it generates fewer errors than the others [39]. Figure 14 shows the shape of the Gaussian function used. Subsequently, our work focuses on the study and application of the inference method to the last 'planning disruption' field. Table 10 gives the fuzzy rules for the 'planning disruption' node.

Table 11 shows the numerical values corresponding to the fuzzy variables.

Table 10: Fuzzy rules.

Rules	If Delayed goods handling	And order-picking delays	So Planning disruption
R1	Low	Low	Low
R2	Low	medium	Low
R3	Low	high	Low
R4	medium	Low	medium
R5	medium	medium	medium
R6	medium	high	medium
R7	High	Low	high
R8	High	medium	high
R9	High	high	high

Source: Authors, (2025).

Table 11: Fuzzy and numerical values.

Disruption to planning	Discrete value
Low	0.2
Medium	0.5
High	0.8

Source: Authors, (2025).

VI.3 STUDY AND ANALYSIS USING FUZZY LOGIC

This stage concerns the aggregation of conclusions triggered by activated rules. Table 12 shows an example case extracted from the simulation carried out during the study, Figure 15.

Applying the max operator between the different situations activated gives a single value.

Table 12: Presentation of activated rules.

Rule activated	Linguistic value	Degree of belonging
5	Medium	0.458
6	High	0.135
8	Medium	0.325
9	High	0.135

Source: Authors, (2025).

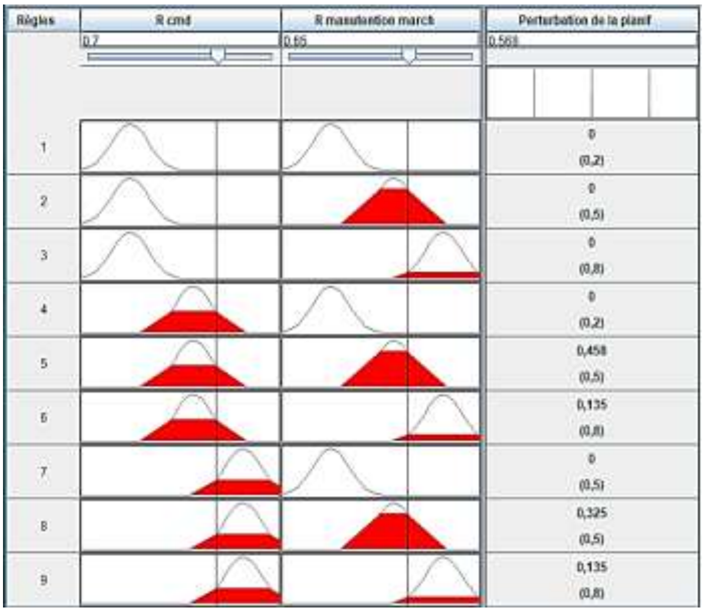

Figure 15: Global Bayesian network representation.
Source: Authors, (2025).

According to this scenario, the values of the 'planning disruption' output variable are as follows:

- For medium linguistic value: 0.458 and 0.325
- For high linguistic value: 0.135

The weak variable has not appeared in this configuration, so we assign it the value 0.001, because each case is possible to be present even if with a very weak degree of presence that is strictly positive.

- Disruption to planning (Low) = 0.001
- Disruption to planning (medium) = Max (0.458; 0.325) = 0.458
- Disruption to planning (high) = 0.135

Take the case of rule number 6 where the input variables have the following linguistic values:

- R. handling = Medium, and R. cmd= High, then:
- P (Perturbation=Low/ R. handling = Medium, R. cmd= High) = (0.001/0.001+0.458+0.135) =0.0016
- P (Disturbance=Medium/ R. handling = Medium, R. cmd= High) = (0.458/0.001+0.458+0.135) =0.771
- P (Disturbance=High/ R. handling = Medium, R. cmd= high) = (0.135/0.001+0.458+0.135) = 0.2273

The rest of the calculation of different situations concerning the conditional probabilities of the output variables (planning perturbation) from the values of the primary nodes is presented in Table 13.

Table 13: Calculation results for different situations.

					Perturbation de la planification		
Rules	**Handling delay**	**Values**	**order delay**	**Values**	**Low**	**Medium**	**High**
1	Low	0.1	Low	0.3	0.950	0.048	0.002
2	Low	0.1	Medium	0.45	0.148	0.850	0.002
3	Low	0.1	High	0.75	0.001	0.320	0.679
4	Medium	0.55	Low	0.3	0.766	0.233	0.001
5	Medium	0.55	Medium	0.45	0.148	0.850	0.002
6	Medium	0.55	High	0.75	0.001	0.262	0.737
7	High	0.70	Low	0.3	0.584	0.415	0.001
8	High	0.7	Medium	0.45	0.148	0.850	0.002
9	High	0.7	High	0.75	0.001	0.320	0.679

Source: Authors, (2025).

VI.3 RESULTS OF GRAPHICAL SIMULATION

Simulating the response of the fuzzy system under the 'Section' option produces two graphs leading to a comparative study between the two input variables. Each of these two variables (order delay & goods handling delay) is studied as a function of the output variable (planning disruption), (figure 16) and (figure 17).

Interpretation of the graphs: Fig. 16 shows the variation in planning disturbance as a function of the variation in order picking delay. When the order delay is in the range [0-15%], the variation between the two variables is proportional or linear. Above 15%, the impact of R.cmd remains constant even if its value increases and this is reflected in the fact that the order picking function is linear within the warehouse and the number of operators remains small, so this delay can be recovered in the order picking line. Figure 17, on the other hand, shows the disruption of planning as a function of goods-handling delays in three intervals:

[0-30%]: The merchandise handling delay has a 20% coefficient on planning disruption. This is because, in this phase, the disruption to planning generally shows a linear relationship with the order-picking delay.

[30-90%]: The variation is almost linear and proportional to the order-picking delay.

Above 90%, the disruption to planning no longer depends on either the order-picking delay or the goods-handling delay, as there are always unforeseen factors influencing the normal operation of the warehouse.

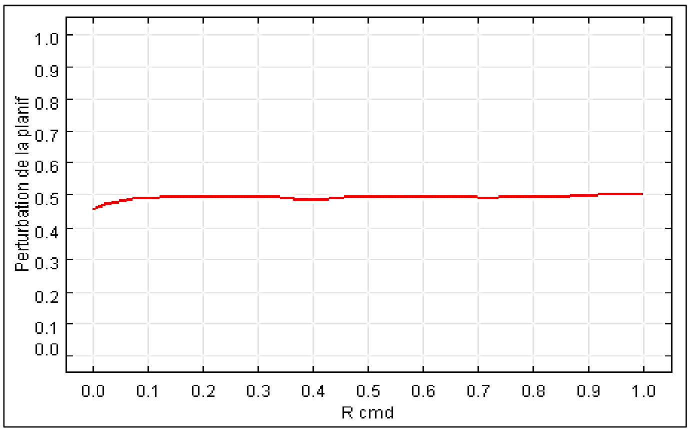

Figure 16: Planning disruption based on order delay
Source: Authors, (2025).

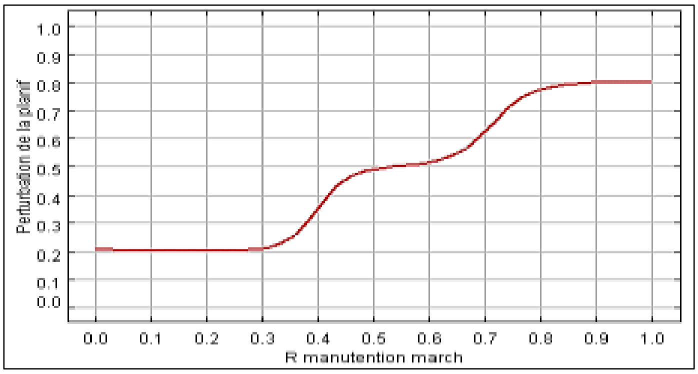

Figure 17: Disruption to planning due to delayed goods handling
Source: Authors, (2025).

VII. DISCUSSION

In this paper, a study of possible scheduling disruptions is developed by applying the Bayesian fuzzy model. The application of Bayesian networks is widely used in studies carried out for the analysis of disruption risks caused by delays in the marine and air navigation domains [40-42], or railways [43]. Our model focuses on the study of disruptions to the planning of order processing tasks in an industrial warehouse. This study considers several internal and external factors at the origin of the disruption.

Exploration and analysis of the results obtained from the study of the 'planning disruption' entity reveals that the influence of factors internal to the warehouse on the stability of pre-planning task progress is greater than that of external factors. This indicates that the decisions taken within the warehouse by the decision-makers in terms of designating materials or personnel to carry out the tasks have a more important factor in compliance with planning and, consequently, in meeting the deadlines for processing goods and orders.

So intelligent planning will be coherent planning between the programmed tasks and the resources designated for this purpose.

VIII. CONCLUSIONS

Respecting the order processing schedule in a logistics warehouse is crucial to ensuring the quality of logistics services. Unfortunately, this planning is often not respected, leading to more or less unfortunate consequences. This study focuses on forecasting the risks of planning disruption, anticipating them, avoiding them, or being prepared to reduce the consequences of a negative disruption to the plan.

In order to achieve this objective, this article proposes a fuzzy Bayesian model that combines the Bayesian approach and fuzzy logic to monitor disturbances in planning. This model is based on a series of causes that lead to the disruption of task planning and their causal relationships represented by a causality graph. Fuzzy logic is used to create fuzzy rules based on conditional probability tables.

A model like this is compelling, particularly for the problem discussed in this article. It is an alternative approach to Deep Learning for prediction when there is a lack of massive data.

One of the limitations of the proposed model is the elaboration of all the factors that influence the disruption of planning. The lack of integration of all these factors may affect the effectiveness of this model in correctly predicting possible disruptions. The application of this model to the treatment of all risks that may occur in the disruption of planning tasks is a potential perspective. A comparative study between a Bayesian fuzzy model and a model from Deep-Learning to predict the risks of disruption of planning tasks is a very promising avenue of research.

IX. AUTHOR'S CONTRIBUTION

Conceptualization: Kerouich Abdelilah, Azmani Abdellah, Azmani Monir.
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