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SYSTEM OF MULTI-SOURCING SUPPLIER'S SELECTION AND EVALUATION IN THE HOSPITAL SECTOR INTEGRATING THE CRITERIA: TOTAL COST, GAP TIME, RISK-PERFORMANCE

Kaoutar Jenoui and Abdellah Abouabdellah
Laboratory Systems Engineering, MOSIL, ENSA, University IBN TOFAIL Kenitra, Morocco
E-Mails: k.jenoui@gmail.com

ABSTRACT

In the hospital sector, the suppliers are selected on the basis of three main criteria: the quality, deadlines, and the total cost. An efficient selection of suppliers in this sector must also be based on the risk supplier, as well as their past performance. The stake is to establish and maintain transparent relationships with efficient suppliers, engaged in a process of continuous improvement following the multi-sourcing strategy. This paper proposes a new system of evaluating of suppliers, monitoring simultaneously their risks, to be used to identify the axis of progress of the supplier's selection system in the hospital sector, and improve it by the implementation of a decision support system heuristic. Our paper is composed of five parts. The first shows the interest of the study. The second presents the literature review. The third explains the problematic situation. The fourth sets out the proposed system. Illustrating it the through a case study in the fifth part. And we finish our paper with a conclusion.

Keywords: past performance, process of continuous improvement, decision support system heuristic, the multi-sourcing strategy, supplier's selection system, risk supplier.

1. INTRODUCTION

Companies today adopt the outsourcing strategy to benefit from cost minimization and generate cost saving opportunities. They seek to proactively manage their purchases and strike up a close and highly effective link with suppliers to substitute internal services. This is the object of a new awareness and it constitutes an emergent function for all hospitals. A review of organizational processes is requested. The aim is to master especially the process of the evaluation of suppliers in a competitive environment and to effectively ensure continuously the quality level of their benefits, in relation to the contract terms. In fact, during the selection of suppliers, it's the ability to meet the requirements of the contract and the level of risks that are assessed. Furthermore, the performance of the suppliers should be followed throughout the contractual relationship. In this context, the selection of the "best" suppliers is paramount. This selection is influenced by several criteria such as price, time, quality, past performance etc. it takes into account these criteria which are conflicting objectives, a decrease in an objective leads to increase the other. Hence the need to simultaneously optimize these objectives and choose the compromise that is the optimal decision for the entire company. Following several concrete problems cited by Moroccan hospitals, we are interested in the supplier selection process that submits to the new constraints. Storage and distribution of medical products in Morocco cost the ministry of health over 30 million Dirhams per year [1]. Citizens do not often find drugs while other expired medications are mists. In addition, the centers of storage and distribution cost up one billion Dirhams per year. They are operated by 200-250 people [1]. As confirmed by the minister of health, these sums can build modern hospital equipments, or at least 20 clinics [1]. Also according to data obtained on medical devices in Morocco, we have found that there are 63 non-compliant consignments of 741 controlled medical devices in 2009 and 72 non-compliant consignments of 477 controlled medical devices in 2010 [2]. This explains that the rate of non-compliance of medical products is increasing more and more over the years. Consequently, it is necessary to develop a system of evaluation and selection of suppliers so hospitals can properly select suppliers and increase their capacity to respond to customer requirements in terms of cost, time and quality. It is in this perspective that our article sheds light on the supplier's selection problem in the hospital sector.

2. INTEREST OF THE STUDY

The objective of our study is to develop a system which adapts the multi-sourcing strategy to create competition between suppliers, and aims in the long term to have a number of reliable suppliers that deserve confidence as it focus on the principle of risk analysis. It's rather the primary necessity of adopting this strategy to provide a source of back-up, maintain the competition between suppliers, and avoid complacency from one supplier. The hospital has often been regarded as a separate business segment, with such a different mindset of an "Ordinary" company. We talk about the "Availability" of a medical product to save a person's life, a notion that makes the difference and seems nonexistent in the industrial sector. This demands a very effective control of the hospital-supplier relationship so as to make available medicines and medical devices of the required quality at the right moment with lower cost. Consequently, our study will be beneficial to all Moroccan citizens and hospitals, since it will treat and improve the upstream interface Supplier-Hospital to ensure the Hospital-Patient interface. In view of the evolution of costs in the health field, the objectives are to reduce total cost, inventory and

time delay, with the aim of improving the quality of services offered to patients.

3. LITERATURE REVIEW

Over the past few years, several works were carried out to determine the criteria for the selection of suppliers. The first ones are those of Dickson (1966) who was able to identify 23 criteria used by the companies to select their suppliers [3]. Later, Weber et al. (1991) showed that the relative importance to each of the criteria mentioned by Dickson changed following the change of the industrial context [4]. The order of the importance of the criterion was determined by the company according to its level of requirement and other factors; Vonderembse *et al.* (1995) indicated that the geographic location of the supplier got last position [5]. Verma and Pullma(1998) demonstrated that companies perceived the quality as the most important criterion [6]. Weber et al. (1991) proved that the criteria price (80 %), delivery (59 %) and quality (54 %) were the most frequently discussed in the literature. In our study, we have been interested in three criteria that influence the management of the upstream supply chain of the hospital: the total cost of the product, the time gap between the order and delivery date, and the risk-performance which reflects the level of qualification of suppliers. The problem of the choice of suppliers is complex because of many existing criteria to consider during the process of decision making. To deal with this problem, many methods have been proposed in the literature. They are classified according to six categories. The first category includes Timmerman (1986) who is among the first authors who proposed the weighted linear models [7]. In addition to him, Narasimhan (1983), Nydick and Hill 1992, Masella and Rangone (2000) proposed the method Ahp [8], [9], [10]. To end with, Kumar *et al.* (2004) proposed the method Fst [11]. In the second category, various approaches have been suggested in the literature in the form of statistical/probabilistic models. But all these approaches do not allow introducing the constraints. The third category presents methods that are based only on the total cost, as the method ABC (Activity Based Costing) Roodhooft (1997) and the method TCO (Total Cost of Owernship) Smytka and Clemens (1999), Ellram (1995) [12], [13], [14]. The fourth category proposes the method of categorization. It allows to group and segment suppliers. This method is considered by D'amours and all (2001) as a tool for pre-selecting of suppliers [15]. The fifth category aims at integrating the qualitative factors and the human expertise as artificial intelligence tools. We distinguish in this category the method Es (Expert System), Vokurka et al. (1966), the CBR method (Case based reasoning System), Ng and Skitmore (1995), which are based on the knowledge derived from similar experiments on the suppliers [16], [17]. And finally, the 6th category presents the mathematical programming models. In this category, Weber (1996), Weber and Al. (2000), Liu *et al* (2000) proposed the approach DEA to evaluate the efficiency of suppliers [18], [19], [20]. Hong and Hayya (1992) proposed a model of mathematical programming non-linear to integer variables [21]. Rayaraman *et al.* (1999), Ghodsypour and O'Brien (2001), Murthy *et al.* (2004) proposed a mathematical non-linear model to integrate mixed variables [22], [23], [24]. But these two methods allow only solving a mono-objective optimization problem. Multi-objective programming was developed by Weber and Current (1993) to simultaneously pursue several conflicting objectives [25]. Among the resolutions approach of these programs, we find Goal Programming method which minimizes the discrepancies between goals and accomplishments while dealing in priority with the differences related to the most important objectives. Other authors have shown the importance of Multi-Objectives programming in the selection of suppliers. [26], [27], [28], [29], [11]. All these techniques are mainly based on the principle of aggregation of criteria in a single criterion which makes it difficult to determine the weights and the relative importance of the criteria. Furthermore, articles published in the specialized journals in the areas of procurement and supply chain management, have allowed us to classify the different methods of evaluating suppliers according to many categories. And to adjust the problematic imposed in the hospital sector, we have proposed in our study a new system of evaluation of suppliers which is based principally on the control and the monitoring of the supplier performance since the first contract. We have opted for the method AHP, the results parameters of the evaluation system will be considered to determine a new formula which calculates the criticality of risks emerged in this system. And this system will be integrated in the proposed system of selection of suppliers. According to Aguezzoul et al. 2005B, Aguezzoul and Ladet 2004b, Aguezzoul and Ladet 2004d, Aguezzoul and Ladet 2004e , several sections have dealt with the problem of choosing suppliers due to the mono-objectif and the bi-objective model [30], [31], [32], [33]. The author has combined between the method of relative distance to an objective, the mathematical programming and the aggregation method. He has considered two criteria for evaluating suppliers: the total cost of the product and the delivery time to minimize. The weight associated to each of the criteria was determined by analyzing 8 options depending on 4 scenarios. In our study, we are going to improve his model by aggregating the set of methods used in his model and the methods Ahp (Analytic Hierarchy Process), by adding the risk-performance as a third criterion to minimize, and determining weights according to the analysis of 36 cases. Furthermore, no previous work has dealt with the problem of selection of suppliers under the tri-objective or multi-objective angle in the hospital sector, taking into account the constraints applied to medical products.

4. PROBLEMATIC

The medicines and medical equipments purchases are carried out by the hospital direction. They are required each year to send the tender to the purchasing and logistics division, and so they proceed to select the type of market, and the execution mode. Supplier selection is based on a study of three successive bidding offers: administrative,

technical and financial offer. Under regulations and details of all requirements and conditions of participation in the tender, the commission eliminates, during the examination of each bid, those which submitted non-responsive bids. The examination of financial proposals is concerned by only the selected candidates who are invited to the examination outcome of the technical offers. Then the commission retains the least expensive proposal without simultaneously being based on other criteria, including the turnaround time, the quality level of services provided by suppliers and the past performance. After awarding contract by tender or purchase order, the service in charge should carry out an evaluation of the supplier chosen besides the quality of the service provided [34]. A rate is given to each of these suppliers based on a number of criteria such as the respect of delay and the conformity of the product. The providers who have a total less than 6 points are considered as a failed, and the head of the service concerned by the purchase requests the direction to exclude them from participating in any market related to the hospital center for serious breach of commitments [34]. The problem of evaluating and selecting suppliers can be tackled as follows: in one hand, the problem of selecting suppliers is identified as a multi-criteria problem where the current supplier selection process does not help the decision maker to take a balanced decision based simultaneously on all criteria. The resulting decision doesn't take into account the removal of the order date imposed by hospitals to delivery date proposed by supplier, which generates a further time gap. Reception of a timing advance command requires the storage of medical products for an additional period of time, which generates a lot of waste with additional costs at several levels; products waste is due to the rapid exceeded expiration date, and the increased costs in terms of material and human resources. In another hand, the evaluation of suppliers according to the current system is done by an old approach based on a manual calculation of the overall score of the selected supplier. It shows many points of failures that disrupt the upstream supply chain of the hospital. Firstly, it doesn't take into account the pre-sampling evaluation since this approach does not help to build confidence in the ability to meet the needs of the hospital in term of the product quality. Secondly it does not allow to proceed to various comparative analyzes of overall scores obtained by all suppliers. Thirdly it does not determine the suppliers which have never been evaluated from those which must be revalued. Also it does not help to provide a summary giving the overall performance of the supplier. The objective of our paper is to propose a system that helps to measure and follow the supplier's performance, and select best suppliers. It mainly allows assessing the level of performance evaluation obtained by each supplier, and determining the risk level that a hospital incurs in doing business with this supplier. It aims at the analytical work of the selection committee, identifying practices that promote the selection of good suppliers, and improving its understanding of supplier selection system. To conclude, the suggested system aims at determining firstly a new system of evaluation of suppliers, whose results will be then promoted to be reused to select suppliers in a multi-sourcing strategy.

5. CONCEPTION OF THE GLOBAL SYSTEM

The global system is based on the multi souring strategy, and formed of three sub-systems: the evaluation system tool, which consists to compare the performance level results achieved by each supplier before and after having signed the contract, and delivered the order, to make a comparative analysis between all suppliers, and to perform a synthesis giving the overall performance of each of them after each delivery. Results provided will be reused in the system of risk analysis, to determine the level of risk that a hospital occurs in doing business with each supplier. This system aims principally to determine the element "Risk-Performance", which will be considered as a criterion to minimize, and it's presented as an input of the multicriteria system of supplier's selection.

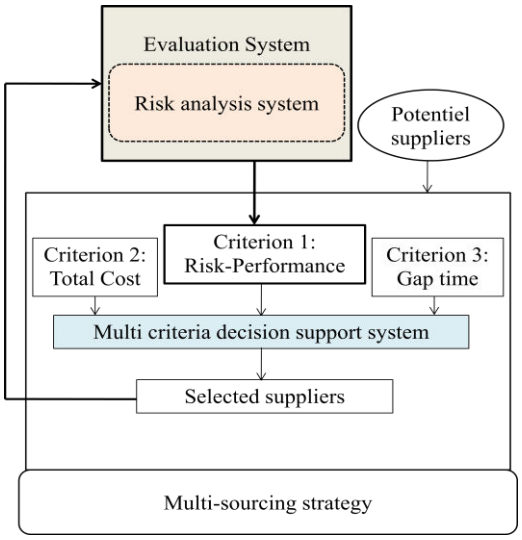

Figure-1. The structure of the proposed system.

5.1 Supplier's evaluation system

The supplier performance measurement and evaluation system that we propose, consist to characterize objectively and continuously the level of performance of each supplier's services. The Figure-2 shows that it's mainly based on four principle approaches wich are determinated each year through each contract.

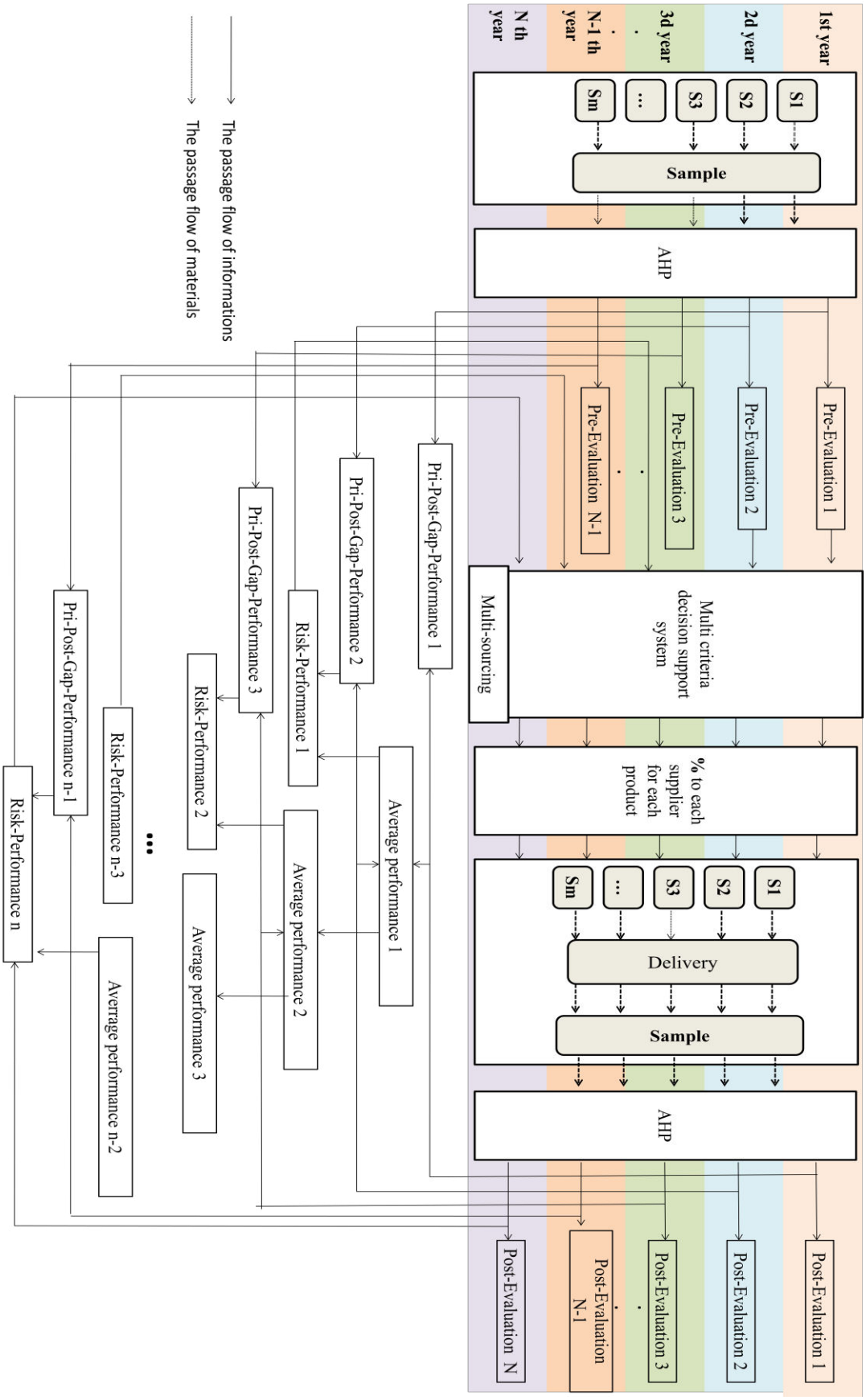

Figure-2. The flow modeling system.

-The Pre-Assessment Evaluation (AE_Pre): Corresponds to the supplier pre-qualification phase. To measure the ability of the supplier to meet requirements of the products quality.

-The Post-Assessment Evaluation (AE_Post): it's concerned with the measurement of actual performance of the supplier after the placing of the order.

To measure the AE_Pre and the AE_Post value, we add to our heuristic the AHP approach, which is applied as an evaluation technique for the sample suppliers. It is a method that allows to systematically assess the consistency of the choices [35]. The key element of this method is the establishment of a well-built and well-understood hierarchy. In our case the top of the hierarchy is "quality", and the intermediate levels we offer are refined in the following sub-categories: Conditioning, labeling, packaging, packing and product conformity. The decision maker must perform binary comparisons between the different elements of the hierarchy. The resulting matrices are then in the form of comparison matrices. From these matrices, we extract the vectors of relative priority in the form of scores which are treated by our approach to calculate the gap generated: Pre-Post-Gap-Performance.

-The Pre-Post-Gap Performance (PPGP): it's to actually check the delivery performed by the supplier before and after signing the contract and placing the order. Each supplier is characterized by a score resulted by the Ahp method: Pre-Post-Gap Performance =
Post-Assessment Evaluation – Pre-Assessment Evaluation

-The average performance in the past (APP): it concerns the evolution of the performance level of the supplier achieved in the past since the first contract.

5.2 Risk supplier analysis method

The second step of a supplier evaluation system is to define a methodology to analyze and calculate the risks considered in the assessment of suppliers [36]. The assessment starts with a list of requirements, derived from the user requirements specification. For each supplier and each requirement, is defined if the requirement is critical and a risk scenario is defined. The risk assessment team determines the Severity, Probability and together with the tables below the Risk priority is calculated for each requirement [36].The severity of the risk is estimated by a subjective method based on a scale [36]. Which presents a number of limits to obtain the intensity of the effect of risk. In this study, our method aims to propose an objective technique which allows determining the level of risk of each supplier. The negative Pre-Post-Gap-Performance generated by each supplier sets a target position which is the pedestrian and a source of danger that affects the hospital supply chain, this gap decrease the level of confidence in the selected supplier. In fact for each contract and each supplier we have:

Pre-Post-Gap Performance = AE _Post – AE _Pre

- If: Pre-Post-Gap Performance ≥ 0

Then: The score associated to this supplier after signing the contract and delivering the order is equal or better than the score associated to this supplier before signing the contract and delivers the order.

Then: Risk-Performance = 0

-If: Pre-Post-Gap Performance < 0

The removal of the target position, leads to remove the dangerous situation. As indicated in the Figure-3 We propose to measure the severity level linked to this supplier by the gap created between the two levels of performance, and also associate it to the level of the average performance in the past.

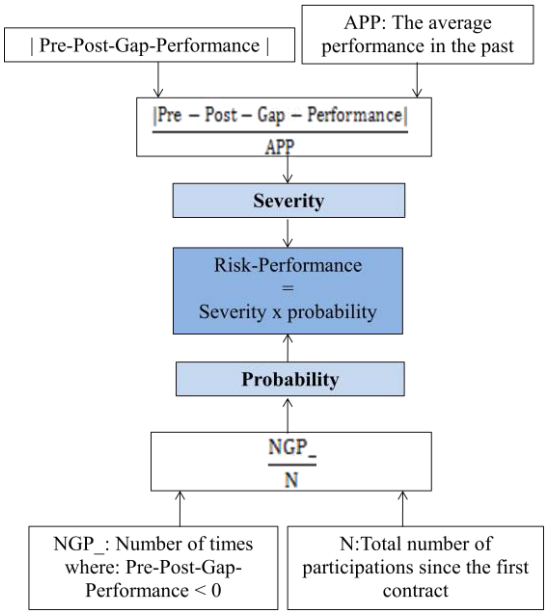

Figure-3. Risk-based approach to compliant PxS according to the proposed system.

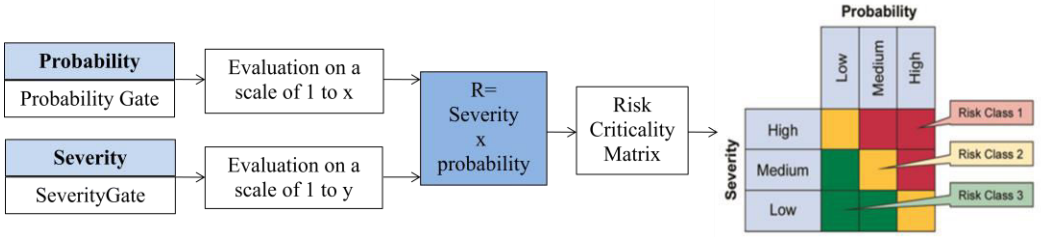

Figure-4. Risk-Based approach to compliant PxS.

Consequently the Risk-Performance level related to each supplier is proposed as follow:

$$\text{Risk-Performance} = \text{Severity} \times \text{Probability} = \frac{|\text{Pre-Post-Gap-Performance}|}{\text{APP}} \times \frac{\text{NGP}}{\text{N}}$$

And Risk-Performance resulted is communicated to the system of selecting suppliers in such a way that it ensures the best performing suppliers.

5.3 Proposed methodology for selecting suppliers

A methodology for solving a multi-criteria problem consists of transforming it to another problem with a single criterion; the proposed methodology aims initially at determining a priori knowledge about the problem addressed, then proposing a solving approach that translates the rights-based information into parameters to find optimal solution respecting the preferences. This methodology can be modeled by the formalism actigramme to model the physical flow of the process studied [34]. Figure-1 shows that the inflows are the informations provided by the hospital and all suppliers, the outflows are the results of the proposed solving approach, and flow control are the constraints and objectives, specifying how the flow will be transformed [26]. Then the resolution approach based on the multi sourcing strategy determinate a percentage allocated to each supplier for each product. Identifying suppliers that present good profiles among a profile that has the lowest level of risk-performance, a profile that delivers the order in the earliest date to the requirement date imposed by hospital, and the one referred to a least cost profile, taking into account constraints applied in medical field.

To select suppliers in the industrial sector, Aguezzoul considered the following resolution methods: Aggregation, E-constraint, Lexicographic [30], [31], [32], [33]. The author showed that the Aggregation method gives the best result. In this work, we try to improve the best heuristic proposed by Aguezzoul. We begin by recalling the following stages system:

Notation

In our model, notation that we use is as follow:

- F_e : Number of medical equipments suppliers. Each one represented by index: i ∈ {1,.., Fe}
- F_m : Number of medicines suppliers. Each one represented by index: i ∈ {Fe +1,.., $Fe + Fm$ }
- E : Number of types of medical equipments. Each one represented by index: j ∈ {1,.., E}
- M : Number of types of medicines. Each one represented by index: j ∈ {E+1,.., E+M}
- Q_j : The quantity requested by hospital for each product j. With: j ∈ {1,.., E} ∪ {E+1,.., E+M}
- c_{ij} : The total cost of each product j for each supplier i.
- C_{ij} : The production capacity of each supplier i for each product j.
- Df_{ij} : Delivery date indicated by each supplier i for each product j.
- Dh_j : The requirement date imposed by the hospital for each product j; With: i ∈ {1,.., Fe} and j ∈ {1,.., E} ; Or i ∈ {Fe +1,.., $Fe + Fm$ } and j ∈ {E+1,.., E+M}
- S_{ij} : The period of validity indicated by each medicines supplier i for each product j.
- T_{ij} : The time remaining to the start of validity period indicated by the supplier i for each product j. With: i ∈ {Fe +1,..,$Fe + Fm$ } et j ∈ {E+1,.., E+M}
- r_j = Risk-Performance value determined for each supplier j by the evaluation system.

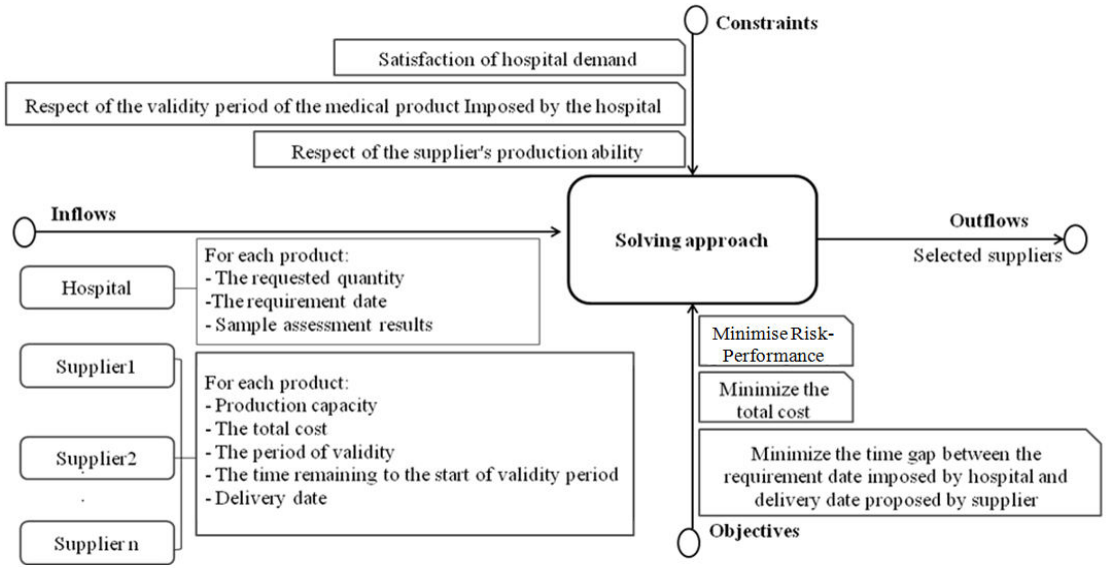

Figure-5. The formalism actigramme.

5.4 Function objective

For suppliers' selection method, Aguezzoul considered two criteria, the total cost of the product, and delivery time. The aggregation method is used to transform the bi-criterion problem to a single criterion problem, and the method of relative distance to an objective is used to bring the objectives to the same scale. It consists of minimizing the following objective function:

$$Z = \delta \left| \frac{f(X) - f*}{f*} \right| + (1 - \delta) \left| \frac{g(X) - g*}{g*} \right|$$

With f * and g *, optimums found by solving successively the single criterion problem, that firstly minimize the total cost, and secondly delivery time. ∂ and (1- ∂) are the weights associated to two objectives of the model. To improve this function objective we thought of adding Risk-Performance as a third criterion to be minimized. The final function objective to be minimized is as follows:

$$Z = \alpha \left| \frac{f(X) - f*}{f*} \right| + \beta \left| \frac{g(X) - g*}{g*} \right| + \lambda \left| \frac{r(X) - r*}{r*} \right|$$

Where r * is the optimum found by solving the single criterion model to minimize Risk-Performance value. And α, β, and λ are the weights associated to the three objectives with its sum equal to 1.

We propose formulas for cost and quality functions as follows:

- The criterion "Total cost" to minimize:

$$f(X) = \sum_{i=1}^{i=Fe} \sum_{j=1}^{j=E} X_{ij} Q_j c_{ij} + \sum_{i=Fe+1}^{i=Fe+Fm} \sum_{j=E+1}^{j=M+E} X_{ij} Q_j C_{ij}$$

- The criterion "Risk-Performance" to minmize:

$$r(X) = \sum_{i=1}^{i=Fe} \sum_{j=1}^{j=E} \boldsymbol{r_j} X_{ij} + \sum_{i=Fe+1}^{i=Fe+Fm} \sum_{j=E+1}^{j=M+E} \boldsymbol{r_j} X_{ij}$$

For the expression of the time, we adapted an expression given by several authors in the area supplier's choice to measure their performance in terms of delivery (Pan 1989 Chaudhy *et al.* 1993 Rayaraman *et al.* 1999) the expression that we proposed is as follows:

- The criterion "Time gap" to minimize:

$$g(X) = \sum_{i=1}^{i=Fe} \sum_{j=1}^{j=E} \left(Df_{ij-} Dh_j \right) X_{ij} + \sum_{i=Fe+1}^{i=Fe+Fm} \sum_{j=E+1}^{j=M+E} (Df_{ij-} Dh_j) X_{ij}$$

5.5 Decision variable

The heuristic proposed by Aguezzoul solves a bi-criterion problem; assuming that the optimal solution can choose one or more suppliers. The decision variable X_i considered determines the percent of the total quantity allocated to each supplier i. In this work we keep the same calculation rule since we can have the same assumption of sharing the quantity between several suppliers in the hospital sector. We change the value of the index to take into account one or more types of medical products offered by the same supplier.

X_{ij} : The percent of D_j assigned to the supplier i for the product j;

5.5.1 Constraints

Taking into account the constraints of selecting suppliers in the hospital sector is made by considerating the validity period, which is required by the hospital to be at least 18 months at the time of delivery [34].

$\forall$ i ϵ $\{Fe+1,.., Fe + Fm\}$ $\forall$ j ϵ {E+1,.., $E+M$} 18 $\leq$ S_{ij} - (Df_{ij} - T_{ij})

In Aguezzoul work, the consideration of the quantity requested by a company must be shared among all selected suppliers. The total quantity to buy from each supplier must be less than its production capacity. We adapt the same constraints in the hospital sector in modifying the indexes.

- For medical equipments suppliers

$$\forall j \in \{1,.., E\} \quad \sum_{i=1}^{i=Fe} X_{ij} = 1$$

$$\forall i \in \{Fe+1,.., Fe + Fm\} \ \forall j \in \{E+1,.., E+M\} \quad X_{ij} Q_j \leq C_{ij}$$

- For medicines suppliers:

$$\forall j \in \{E+1,.., E+M\} \quad \sum_{i=Fe+1}^{i=Fe+Fm} X_{ij} = 1$$

$$\forall i \in \{1,.., Fe\} \ \forall j \in \{1,.., E\} \quad X_{ij} Q_j \leq C_{ij}$$

6. EXPERIMENTS "CHU IBN SINA MOROCCO"

For the problem addressed, we have taken the example of 4 medical equipments suppliers and 4 medicines suppliers; Each one of them is characterized by: The level of performance according to the results of sampling before and after signing the contract and placing the order, the total number of participations and the level of the average performance since the first contract. These results belong to the year 2015.

Table-1. Supplier's performance data.

	Medical equipments suppliers			
	Fm1	**Fm2**	**Fm3**	**Fm4**
AE_Pre	0,452	0,1485	0,325	0,123
AE_Post	0,362	0,1325	0,333	0,1426
PPGP	-0,09	-0,016	0,008	0,0196
APP	0,236	0,652	0,183	0,1425
N	3	4	2	2
NGP_	1	1	1	1
Severity	0,38135593	0,02453988		
Probability	0,33333333	0,25		
Risk-Performance	0,12711	0,00613	0	0
	Medicines suppliers			
	Fe1	Fe2	Fe3	Fe4
AE_Pre	0,5264	0,4582	0,237	0,6322
AE_Post	0,3126	0,3741	0,245	0,5263
PPGP	-0,2138	-0,0841	0,008	-0,1059
APP	0,2365	0,322	0,635	0,5215
N	5	5	7	10
NGP_	2	1	2	5
Severity	0,90401691	0,26118012		0,203068
Probability	0,4	0,2		0,5
Risk-Performance	0,36160677	0,05223	0	0,10153

To be based in these results and select suppliers in the year 2018, we have proposed to study the 36 options, according to all possible combinations of α, β, and λ whose sum is equal to 1. We consider four types of medicines, three types of medical equipments, four medicines suppliers, and four medical equipments suppliers. For each option, we measure the value of the functions f, g, r, f * g *, r *, and the function Z, using Excel Solver. The tables below contain information on suppliers and products:

Table-2. Data obtained from suppliers.

Supplier index	**Medicines suppliers**		**i=1**	**i=2**	**i=3**	**i=4**
			Fm1	**Fm2**	**Fm3**	**Fm4**
j=1	M1	Production capacity (Unit)	600	800	700	1000
		Total cost (Dh/Unit)	150,5	135,3	140,9	138,8
		Delivery time (Day)	90	120	115	85
		The period of validity (Day)	700	850	786	623
		The time remaining to the start of validity period (Day)	20	36	40	18
j=2 j=3 j=4	M2 M3 M4	...				
Supplier index	Medical equipments suppliers		i=5	i=6	i=7	i=8
			Fe1	Fe2	Fe3	Fe4
j=5	E1	Production capacity (Unit)	70	100	120	80
		Total cost (Dh/Unit)	20,7	23,2	23,5	22,8
		Delivery time (Day)	60	80	98	85
j=6 j=7	E2 E3 E4	...				

Table-3. Data obtained from hospital.

	M1	**M2**	**M3**	**M4**	**E1**	**E2**	**E3**	**E4**
Quantity requested (Unit)	400	1800	700	650	400	800	950	750
The requirement date imposed by Hospital (Day)	150	200	100	150	100	135	100	120

The Table-5 below shows the functions value obtained for the 36 options using Excel Solver. The results obtained by varying the weights of the objectives, implies the variation of function values and the quantities ordered to suppliers too. The heuristic proposed by Aguezzoul selects the optimal suppliers, determining the order quantity to be allocated to each of them. Several options are being explored by the value of ∂= 0.1, 0.2,.., 0.9. It determines the minimum value of Z and offers proportions allocated to each supplier. In our heuristic, we propose to transform the values obtained in percent based on the histogram shown in Figure-7, we seek the option represented as the best compromise in terms of delay, cost and risk-performance. For our case the option chosen is number 6 corresponding to $\lambda = 0.6$, $\alpha = 0.3$ and $\beta = 0.1$, the decision variable that presents the percentage allocated to each supplier for each product is determined by the Excel Solver as follows:

Table-4. Outflow of the proposed system.

	Medicines			
	M1 %	**M2 %**	**M3 %**	**M4 %**
Fm1	7,474104	5,6540127	3,52119737	2,2620854
Fm2	42,42144	56,3684019	12,7033706	30,1198791
Fm3	32,13031	0,95314114	56,9720585	33,2364946
Fm4	17,97415	37,0244442	26,8033736	34,3815409
	Medical equipments			
	E1 %	E2 %	E3 %	E4 %
Fe1	2,63254	44,58	7,47215	19,27458
Fe2	32,7852	18,2653	12,6254	30,32655
Fe3	18,2563	17,2563	45,8526	23,78546
Fe4	46,32596	19,8984	34,04985	26,61341

7. CONCLUSIONS

In this article, we have proposed a new system that integrates an evaluation process, and a new heuristic for selecting suppliers in a multi-sourcing strategy. The evaluation system has seen a new tool appear: The calculation of the criticality of the risk associated to suppliers based on the performance results before and after placing the order. The objective is to create competition between suppliers, to improve firstly their quality performance, secondly ensure the satisfaction of the internal services in term of compliance of medical products, thirdly manage the supplier relationship and take into account the sustainable development strategy for the suppliers the most critical. In this work the new heuristic of selecting supplier demonstrated better efficacy in the context of decision support based simultaneously on qualitative and quantitative criteria. Further work is available in three orientations, the first devises an evaluation of the solution proposed by our heuristic to maintain control and measure its efficiency, the second consists of making a satisfaction questionnaire for the validation of the model proposed, the third examines the proposal approach by developing an appropriate algorithm with a programming language that likely should be less costly in computation time.

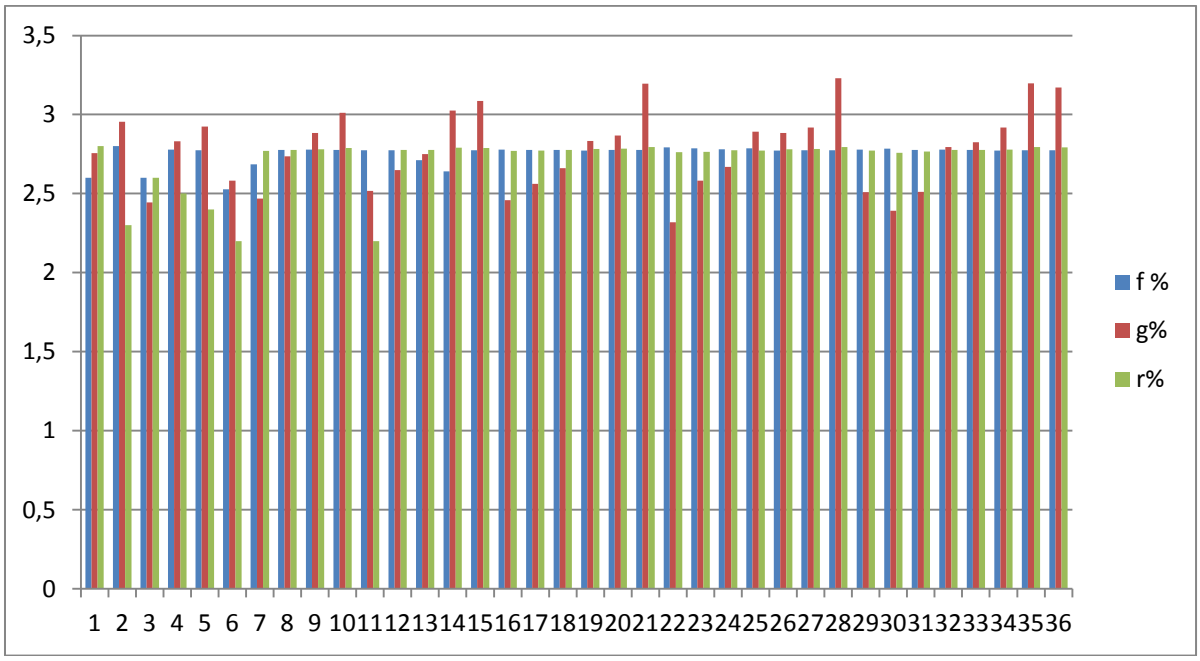

Figure-6. Evolution of the functions «f», «g », and «r » according to the value of α, β and λ.

Table-5. Functions values obtained by Excel Solver.

Option	λ	α	β	f(x)	g(x)	r(x)	f*	g*	r*	Z
1	0,8	0,1	0,1	270306,39	139,6192486	116,40007	10856,687	4,3670269	20,5	9,2293341
2	0,7	0,2	0,1	269560,5	149,6507079	116,90169	11790,659	3,9893998	20,5	11,315415
3		0,1	0,2	270843,5	123,813578	115,94115	7981,7153	5,4702002	21,382928	10,715634
4	0,6	0,2	0,2	269926,83	143,4594256	116,80518	10328,405	4,2552894	20,5	14,388212
5		0,3	0,1	269487,7	148,0935263	116,90354	12199,03	4,1466495	20,5	12,620243
6		0,1	0,3	270170,89	130,764828	116,49862	6917,8069	4,4516302	23,263343	14,722511
7	0,5	0,1	0,4	270128,39	125,0941469	116,33047	5562,9909	5,0597056	24,30897	16,138001
8		0,2	0,3	269733,39	138,5874908	116,57967	10039,937	4,6256857	20,5	16,204742
9		0,3	0,2	269849,76	146,078238	116,74848	10852,958	3,7937169	20,5	17,007835
10		0,4	0,1	269629	152,5684448	117,12927	12790,461	3,5808685	20,5	14,549657
11	0,4	0,1	0,5	269570,33	127,5690209	116,37205	7063,4514	5,2876662	21,095996	17,08582
12		0,2	0,4	269432,48	134,1848099	116,60463	8644,5529	4,7044262	20,5	18,91803
13		0,3	0,3	269506,69	139,3611364	116,55149	9333,6991	5,0589773	20,555333	18,194617
14		0,4	0,2	269850,73	153,255969	117,13859	11956,358	3,5519381	20,5	18,942916
15		0,5	0,1	269522,36	156,3004109	117,08741	13632,081	3,3065323	20,5	15,897243
16	0,3	0,1	0,6	269962,22	124,5439859	116,28624	7004,4785	5,5943307	21,961435	17,800165
17		0,2	0,5	269720,58	129,7635166	116,39706	7776,2715	5,0308878	22,218115	20,405348
18		0,3	0,4	269613,21	134,8314412	116,62466	9238,5861	4,5400992	20,5	21,34088
19		0,4	0,3	269388,34	143,5136331	116,83062	10668,276	4,4244562	20,5	20,541189
20		0,5	0,2	269712,81	145,3195696	116,95089	11288,662	4,1596081	20,5	19,644834
21		0,6	0,1	269670,64	161,8733971	117,31403	14619,425	2,9234892	20,5	17,321414
22	0,2	0,1	0,7	271192,53	117,4918304	115,98439	5508,9546	5,4879984	23,703125	19,887608
23		0,2	0,6	270661,05	130,8317002	116,05233	9321,0707	5,0591154	20,5	21,456081
24		0,3	0,5	270109,79	135,2202706	116,49514	8979,0862	4,5034284	21,41557	24,125616
25		0,4	0,4	270694,09	146,4497619	116,44712	10887,15	4,0464496	20,5	24,558387
26		0,5	0,3	269391,03	146,1036974	116,78269	11426,219	4,2911632	20,5	22,141899
27		0,6	0,2	269480,72	147,8077186	116,87891	11703,587	4,1122243	20,5	21,14427
28		0,7	0,1	269451,48	163,6189561	117,34922	14749,93	2,8017661	20,5	18,772309
29	0,1	0,1	0,8	269974,32	127,1130113	116,44796	5895,314	5,3936494	23,512964	22,928453
30		0,2	0,7	270542,04	121,1141639	115,83432	7183,8454	5,8315535	22,159903	21,592812
31		0,3	0,6	269799,38	127,1772085	116,16082	8165,9031	5,5516635	21,397188	23,199571
32		0,4	0,5	269845,93	141,6059706	116,58442	10695,434	4,0464496	20,5	25,788265
33		0,5	0,4	269644,96	143,1231969	116,62115	11155,993	4,378161	20,5	24,730192
34		0,6	0,3	269384,85	147,8067112	116,65837	11282,842	4,0601266	20,5	24,816237
35		0,7	0,2	269443,01	161,9707942	117,34082	13409,533	2,965059	19,241231	24,600516
36		0,8	0,1	269574,87	160,6690334	117,26231	14518,992	3,0588946	20,5	19,678172

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