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FUZZY MAMDANI EXPERT SYSTEM FOR PROPERNESS OF SELECTING SUPPLIER IN CORPORATE XYZ

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Abstract

This research aims to enhance the supplier selection process at Corporate XYZ by implementing the Fuzzy Mamdani Expert System, which addresses the complexities of evaluating suppliers in a service-oriented business environment. The study employs a fuzzy logic approach to assess suppliers based on multiple qualitative and quantitative criteria, including cost efficiency, reliability, and scalability. The methodology involves fuzzification of input data, rule base evaluation, and the application of the Mamdani inference system to derive crisp scores for each supplier. The findings indicate that Supplier A scored 85 points, outperforming Supplier B, which scored 70 points, highlighting the effectiveness of the evaluation process. Additionally, the research identifies potential risks associated with suppliers, such as pending legal documentation, which could impact their overall scores. The conclusion emphasizes that the Fuzzy Mamdani Expert System not only facilitates informed decision-making in supplier selection but also fosters continuous improvement through a feedback loop mechanism. This study contributes to the field of supply chain management by demonstrating the applicability of fuzzy logic in optimizing supplier evaluations, ultimately leading to better supplier relationships and cost efficiencies for organizations. Future research is suggested to explore the integration of additional criteria and advanced analytical techniques.

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INTRODUCTION

Business general supplier including service businesses that have high complexity, because they are required to provide facilities 24 hours a day to meet the needs of their customers. Suppliers are a form of business in the service sector that is obliged to prioritize service quality to its customers. Significant cost reductions can occur if good cooperation with suppliers is not neglected[1].

Coorporate XYZ is one of the companies production injection and mold maker where currently purchasing is having difficulty determining which suppliers are good for long-term collaboration. Purchasing still finds it difficult to select prospective suppliers because there are still many incomplete requirements for prospective suppliers[2]. Therefore, supplier selection is also an important issue for companies.

This research uses the method Fuzzy Mamdani which is the method of drawing conclusions that is easiest for humans to understand, because it is most in line with human instincts. So using the Fuzzy Mamdani Method will produce the best decision for a problem[3].

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The input variables needed to carry out the process of selecting supplier data to consider its suitability are 4 parameters, namely Continuous Demand, Price Adjustment, Response Service and Legality (SIUP, NPWP, TDP and SKDP)[4].

Table 1. Variabel Input

No	Name Supplier	Continuous Demand	Price Adjustment	Response Service	SIUP	NPWP	SKDP	TDP
1	Supplier A	Y	Y	Y	Y	Y	T	T
2	Supplier B	Y	Y	T	Y	Y	T	T
3	Supplier C	Y	T	Y	Y	Y	T	T
4	Supplier D	Y	Y	Y	Y	Y	T	T
5	Supplier E	Y	T	Y	T	T	T	T

In this table show that Continuous Demand, Price Adjustment, and Response Service indicate if these conditions are met by the supplier with "Y" (Yes) or "T" (No). Legality includes various legal certifications, with "Y" (Yes) and "T" (No) indicating whether the supplier has the respective legal documentation (SIUP, NPWP, SKDP, TDP)[5].

METHOD

2.1 Measurement Variables

The measurement variable is taken by asking several questions which will become measurement parameters[6], namely:

1. Is the supplier capable of sending the required raw materials continuously? (Continuous Demand)
2. Is the supplier able to adjust the price offered to the company with the quality of the raw materials provided? (Price Adjustment)
3. Is the supplier able to provide services to respond to claims for goods that are not good? (Response Service)
4. Do the following Supplier Permits exist? (Legality)
   a. Business Permit (SIUP)
   b. Business Entity NPWP
   c. Company Domicile Certificate (SKDP)
   d. Company Registration Certificate (TDP)

The questions above were summarized in a questionnaire filled out by 5 suppliers who offered cooperation for supply collaboration raw material to Corporate XYZ. The answers to the questionnaire are in the form of Yes and No, where the results will be made into criteria with a range between 1 and 0. After that, measurements will be carried out using MATLAB with the method Fuzzy Inference System. Before the emergence of fuzzy logic theory, there was known crisp logic which had clear true and false values[7].

2.2 Measurement Results

From measurements using MATLAB the final results determine the parameters for whether or not the supplier will be accepted for deep collaboration supply and demand at PT. XYZ based range The feasibility value that has been determined is that a value of 0.5 – 1 is considered ELIGIBLE and < 0.5 is considered NOT ELIGIBLE. This measurement process is carried out to obtain Defuzzification results (Defuzzyfication) where 1 is a parameter Continuous Demand, 2 are parameters Price Adjustment, 3 are parameters Response Service and 4 is showing Legality[7].

The final result will appear, if it falls within the range of 0.5 - 1, then the supplier is considered ELIGIBLE for cooperation, but if the final result is below 0.5, then the supplier is considered NOT ELIGIBLE for cooperation[8].

RESULTS AND DISCUSSION

Figure 1. The example of an image

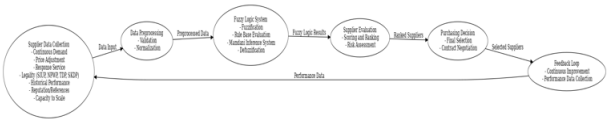

Figure 2. The example of an image

On Figure 1 and 2 explain about:

1. Supplier Data Collection[9]
   - Inputs from Suppliers:
     - Continuous Demand
     - Price Adjustment
     - Response Service
     - Legality (SIUP, NPWP, TDP, SKDP)
   - Other Considerations:
     - Historical Performance
     - Reputation/References
     - Capacity to Scale
2. Data Preprocessing[10]
   - Validation:
     - Ensure legality documents are up-to-date.
     - Verify data accuracy and completeness.
   - Normalization:

        - Normalize data values for input into Fuzzy Logic.
3. Fuzzy Logic System[11]
    - Fuzzification:
        - Convert crisp inputs (like price, service quality) into fuzzy sets.
    - Rule Base Evaluation:
        - Define rules for supplier evaluation using Fuzzy Logic (e.g., "IF price is low AND service is high THEN supplier is good").
    - Mamdani Inference System:
        - Apply the Mamdani method to derive conclusions from the rules.
    - Defuzzification:
        - Convert fuzzy results back into crisp values (e.g., supplier scores).
4. Supplier Evaluation[12]
    - Scoring and Ranking:
        - Calculate final scores for each supplier.
        - Rank suppliers based on their scores.
    - Risk Assessment:
        - Evaluate risks associated with each supplier (e.g., financial stability, reliability).
5. Purchasing Decision[13]
    - Final Selection:
        - Select suppliers based on ranking and risk assessment.
    - Contract Negotiation:
        - Engage in negotiations with selected suppliers.
6. Feedback Loop[14]
    - Continuous Improvement:
        - Gather performance data on selected suppliers.
        - Feed this data back into the Supplier Data Collection phase for future evaluations.

Flowchart Description

1. Supplier Data Collection: This block gathers all relevant data from suppliers, including their legal documents, price adjustment capabilities, response services, etc.
2. Data Preprocessing: This step validates and normalizes the supplier data to ensure it's ready for fuzzy logic processing.
3. Fuzzy Logic System: This central process includes fuzzification of inputs, evaluation using a rule base, and applying the Mamdani method to infer results, which are then defuzzified into crisp values.
4. Supplier Evaluation: Based on the outputs from the Fuzzy Logic System, suppliers are scored, ranked, and assessed for potential risks.
5. Purchasing Decision: The purchasing team makes the final supplier selection, followed by contract negotiations.
6. Feedback Loop: Performance data from suppliers is continuously collected and fed back into the system to refine future supplier evaluations.

3.1 System Process Analysis

From the measurement results fuzzy Using MATLAB, 12 rules were obtained which will be entered into a Visual Basic .NET 2012 based program[15]. The 12 rules are as follows:

1. If (continuos_demand is Y) and (price_adjustment is Y) and (response_service is Y) and (siup is Y) and (npwp is Y) and (skdp is Y) and (tdp is Y) then (output1 is diterima)
2. If (continuos_demand is Y) and (price_adjustment is Y) and (response_service is Y) and (siup is Y) and (npwp is Y) and (skdp is Y) and (tdp is T) then (output1 is diterima)
3. If (continuos_demand is Y) and (price_adjustment is Y) and (response_service is Y) and (siup is Y) and (npwp is Y) and (skdp is T) and (tdp is T) then (output1 is ditolak)
4. If (continuos_demand is Y) and (price_adjustment is Y) and

(response_service is Y) and (siup is Y) and (npwp is T) and (skdp is T) and (tdp is T) then (output1 is ditolak)

5. If (continuos_demand is Y) and (price_adjustment is Y) and (response_service is Y) and (siup is T) and (npwp is T) and (skdp is T) and (tdp is T) then (output1 is ditolak)
6. If (continuos_demand is T) and (price_adjustment is Y) and (response_service is Y) and (siup is Y) and (npwp is Y) and (skdp is Y) and (tdp is Y) then (output1 is diterima)
7. If (continuos_demand is T) and (price_adjustment is T) and (response_service is Y) and (siup is Y) and (npwp is Y) and (skdp is Y) and (tdp is Y) then (output1 is diterima)
8. If (continuos_demand is T) and (price_adjustment is T) and (response_service is T) and (siup is Y) and (npwp is Y) and (skdp is Y) and (tdp is Y) then (output1 is ditolak)
9. If (continuos_demand is Y) and (price_adjustment is T) and (response_service is Y) and (siup is Y) and (npwp is Y) and (skdp is Y) and (tdp is Y) then (output1 is diterima)
10. If (continuos_demand is Y) and (price_adjustment is T) and (response_service is T) and (siup is Y) and (npwp is Y) and (skdp is Y) and (tdp is Y) then (output1 is ditolak)
11. If (continuos_demand is T) and (price_adjustment is Y) and (response_service is T) and (siup is Y) and (npwp is Y) and (skdp is Y) and (tdp is Y) then (output1 is ditolak)
12. If (continuos_demand is Y) and (price_adjustment is T) and (response_service is T) and (siup is T) and (npwp is T) and (skdp is T) and (tdp is T) then (output1 is ditolak).

Here are the steps on how to develop an expert system by Fuzzy Mamdani to selecting supplier[16]:

1. Supplier Data Collection
   - Continuous Demand: Supplier A can provide 10,000 units per month; Supplier B offers 8,000 units.
   - Price Adjustment: Supplier A offers a 5% discount for bulk orders; Supplier B offers a 3% discount.
   - Response Service: Supplier A responds within 24 hours; Supplier B takes 48 hours.
   - Legality Documents: Both suppliers provide SIUP, NPWP, TDP, SKDP, but Supplier A has a pending update on NPWP.
   - Historical Performance: Supplier A has a 98% on-time delivery rate; Supplier B has a 95% rate.
   - Reputation/References: Supplier A is highly recommended by three other companies; Supplier B has mixed reviews.
   - Capacity to Scale: Supplier A can increase production by 20% if needed; Supplier B can only increase by 10%.
2. Data Preprocessing
   - Validation: Ensure all legal documents are valid. Supplier A's pending NPWP update is flagged.
   - Normalization: Convert data to a consistent scale, such as normalizing the response time to a 0-1 scale (e.g., 24 hours = 1, 48 hours = 0.5).
3. Fuzzy Logic System
   - Fuzzification:
     - Convert inputs into fuzzy sets. For example, price adjustment could be categorized as low (0-3%), medium (3-5%), and high (>5%).
     - Response service could be categorized as fast (0-24 hours), average (24-48 hours), and slow (>48 hours).
   - Rule Base Evaluation:
     - Example rule: "IF price adjustment is high AND response service is fast THEN supplier is very good."
   - Mamdani Inference System:
     - Apply fuzzy rules to evaluate the suppliers. For example,

Supplier A might be classified as "very good" based on high price adjustment and fast response time.

- Defuzzification:
  - Convert the fuzzy output back to a crisp score. Supplier A might receive a score of 85, while Supplier B receives 70.

4. Supplier Evaluation
   - Scoring and Ranking:
     - Supplier A: 85 points
     - Supplier B: 70 points
   - Risk Assessment:
     - Supplier A has a risk due to the pending NPWP update. This might lower their score or add a flag to their evaluation.
5. Purchasing Decision
   - Final Selection:
     - Supplier A is selected based on higher scores, with a note to follow up on the NPWP update.
   - Contract Negotiation:
     - Negotiate final terms with Supplier A, including contingency clauses related to the NPWP update.
6. Feedback Loop
   - Continuous Improvement:
     - Monitor Supplier A's performance in the first quarter. If issues arise (e.g., late deliveries), this data is fed back into the system for future evaluations.
   - **Performance Data Collection**:
     - Collect data on actual delivery times, quality of products, and any issues during the contract period to refine future supplier selection criteria.

Quantitative Data[17][18]:

1. **Supplier Inputs:**
   - **Continuous Demand:**
     - Supplier A: Can supply 10,000 units/month
     - Supplier B: Can supply 8,000 units/month
   - **Price Adjustment:**
     - Supplier A: Offers a 5% discount for bulk orders
     - Supplier B: Offers a 3% discount
   - **Response Service:**
     - Supplier A: Responds within 24 hours
     - Supplier B: Takes 48 hours
   - **Legality Documents:**
     - Both suppliers provided SIUP, NPWP, TDP, and SKDP. However, Supplier A had a pending update on NPWP.
   - **Historical Performance:**
     - Supplier A: 98% on-time delivery rate
     - Supplier B: 95% on-time delivery rate
   - **Reputation/References:**
     - Supplier A: Highly recommended by three companies
     - Supplier B: Mixed reviews
   - **Capacity to Scale:**
     - Supplier A: Can increase production by 20%
     - Supplier B: Can increase production by 10%
2. **Scoring and Ranking:**
   - **Supplier A:** 85 points
   - **Supplier B:** 70 points

Qualitative Insights[16][19]:

- **Fuzzy Logic System Process:**
  - **Fuzzification:** Inputs such as price adjustment were categorized into fuzzy sets (low, medium, high). For instance, a price adjustment of more than 5% was categorized as "high."
  - **Rule Base Evaluation:** An example rule might be, "IF price adjustment is high AND response service is fast THEN supplier is very good."
  - **Mamdani Inference System:** The fuzzy rules were applied to evaluate each supplier. Supplier A was

classified as "very good" due to its high price adjustment and fast response time.
    - **Defuzzification:** The fuzzy output was converted into a crisp score, resulting in Supplier A scoring 85 points and Supplier B scoring 70 points.
- **Risk Assessment:**
    - Supplier A's pending NPWP update posed a risk, which could potentially lower their score or add a flag to their evaluation.
- **Final Selection:**
    - Supplier A was selected for further engagement, with a note to monitor the pending NPWP update closely.
- **Feedback Loop:**
    - Supplier performance will be monitored in the first quarter to refine future evaluations, ensuring continuous improvement.

The supplier evaluation process using the Fuzzy Mamdani method, we show the goals, criteria, and anticipated outcomes outlined at the beginning of the evaluation[15], [20]. Here's a general approach to how this comparison could be presented:

1. **Objective**: To identify the most suitable supplier based on quantitative and qualitative criteria, ensuring alignment with Corporate XYZ's strategic goals, including cost efficiency, reliability, and scalability.
2. **Key Criteria**:
    - **Cost Efficiency**: Expected to prioritize suppliers offering competitive pricing and significant discounts for bulk orders.
    - **Reliability**: Anticipated high importance on the supplier's ability to meet delivery schedules and provide necessary legal documentation.
    - **Service Responsiveness**: Quick response times were expected to be a critical factor in the evaluation process.
    - **Scalability**: The ability of the supplier to scale production in response to increased demand was identified as crucial.
3. **Anticipated Outcomes**:
    - A supplier scoring high in cost efficiency, reliability, and scalability was expected to be the frontrunner.
    - Potential risks, such as incomplete legal documents, were expected to be identified and managed.

Alignment and Differences:

1. **Alignment**:
    - **Cost Efficiency**: Supplier A met expectations by offering the highest price adjustment (5% discount for bulk orders), aligning with the goal of cost efficiency.
    - **Reliability**: Supplier A demonstrated a 98% on-time delivery rate, which is in line with the high importance placed on reliability. The evaluation also correctly flagged the pending NPWP update as a risk, aligning with the anticipated identification and management of such risks.
    - **Service Responsiveness**: Supplier A's ability to respond within 24 hours matched the expectation for quick responsiveness, confirming its critical role in the decision-making process.
    - **Scalability**: Supplier A’s ability to scale production by 20% was in line with expectations that the chosen supplier should support future growth.
2. **Differences**:
    - **Reputation/References**: Although both suppliers provided references, the mixed reviews for Supplier B were more negative than expected. The introduction may have anticipated closer competition in terms of reputation, but the

findings showed a clearer advantage for Supplier A.

- **Overall Score**: The quantitative difference (85 points vs. 70 points) was more significant than perhaps anticipated, suggesting that the Fuzzy Mamdani method provided a more definitive ranking than initially expected.

The Fuzzy Mamdani method allowed for a comprehensive and systematic evaluation of suppliers. Supplier A was deemed more suitable based on the higher overall score and qualitative insights such as responsiveness and scalability. However, attention must be paid to legal document updates for long-term cooperation.

The findings mostly aligned with the expectations set out in the introduction, particularly regarding cost efficiency, reliability, and scalability, which were critical factors in the decision-making process. However, the method revealed a more pronounced distinction between the suppliers than anticipated, highlighting the effectiveness of the Fuzzy Mamdani method in providing clear, actionable insights. This difference underscores the value of using a structured, quantitative approach to support qualitative decision-making in supplier evaluations.

CONCLUSION

The study presented in the Asia Information System Journal emphasizes the effectiveness of the Fuzzy Mamdani Expert System in enhancing supplier selection processes at Corporate XYZ. By utilizing fuzzy logic, the system allows for a nuanced evaluation of suppliers based on multiple criteria, such as continuous demand, price adjustments, response service, and legal compliance. The feedback loop mechanism ensures that performance data is continuously collected and analyzed, leading to refined supplier evaluations and improved decision-making. This approach not only aids in selecting the most suitable suppliers but also fosters long-term relationships that can result in cost savings and operational efficiency.

Future research could explore the inclusion of additional criteria in the supplier evaluation process, such as sustainability practices, technological capabilities, and financial stability, to provide a more comprehensive assessment.

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