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Market Matching Online to Recommend MSME Export Products Destination by Using Fuzzy Control

Nurdewanto Bambang[1]*, Sonalitha Elta[1], Ratih Salnan[2] and Nadia Rosmalita Sari[3]

[1]Department of Information System, Faculty of Information Technology, University of Merdeka Malang, Malang, Indonesia
[2]Faculty of Engineering, Universitas Brawijaya, Malang, Jawa Timur 65145, Indonesia
[3]Faculty of Computer Science, Universitas Brawijaya, Malang, Jawa Timur 65145, Indonesia

ABSTRACT

MSME is a business group of society that does not have an integrated system like a large industry which makes it difficult to access information toward the location of foreign markets. This study develops Market Matching application to determine the location of foreign marketing and the type of products that must be exported to reduce the number of losses due to the congestion of turnover of goods to make it profitable for MSME. Stages to develop this market matching system are the identification and analysis of ongoing export marketing activities in MSME, designing marketing system that fits the analysis, establishing market matching system, and system implementation. This study proposes fuzzy control to determine the number of export and export market destination. Market matching application obtained recommendation of export destination based on the types of product and level of importer need. This study obtained the system's accuracy in 100% range.

Keywords: Economy, fuzzy control, market matching, Micro Small Medium Enterprises (MSME)

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E-mail addresses:
nurdewa@unmer.ac.id (Nurdewanto Bambang)
elta.sonalitha@unmer.ac.id (Sonalitha Elta)
salnanratih@gmail.com (Ratih Salnan)
nadiaroosmalitasari@gmail.com (Nadia Rosmalita Sari)
* Corresponding author

INTRODUCTION

When the economic crisis occurs in the world, it will automatically worsen economic condition in Indonesia. The crisis condition hits the world in the period of 1997 to 1998. This caused the Indonesian economy getting worse and worse, but only the sector of MSME (Micro Small Medium Enterprises) were able to remain strong (Suci, 2017). Based on data from Statistic's

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Center Indonesia, after the crisis, the number of MSME in Indonesia was not reduced, even increased until 2012. In that year the number of MSME reached the percentage of 99.99%, and the remaining 0.01% was a large-scale business. MSME is a productive business to be developed to support macro and micro economic development in Indonesia and affects other sectors, for example banking services sector.

Currently, MSME export products have constraints in slow product turnover in importer countries because the product stock is not sold out soon in those countries and sometimes it reaches the expiration limit. This is because there is no information about the development of market location and MSME competition with the same product. The lack of information on the amount of demand and supply of products in each country greatly affects the turnover of goods. For example, there are five industries with the same type of product delivering to Australia where the demand for the product is small. Without proper information the five industries only export products regardless of the availability of products in the country. Therefore, the number of products in Australia exceeds the number of request. This resulted in the accumulation of products, so the industry losses due to the lack of sales. Products with fast turnover are goods sold out in a relatively quick time. Determination of the right export market based on the criteria needed is one of the efforts made by business actors in order to increase profits and reduce losses due to the risk of delayed turnover of the products.

Considerations of the purpose of the goods export are the criteria to be taken into account. Criteria considered include: (1) financial limitations of MSME in producing commodities; (2) the difficulty in knowing the needs of the export market, (3) the difficulty of knowing the fast or slow turnover of goods in the market.

MSME become the target of this study object, because MSME is a business group of society that does not have an integrated system like a large industry. MSME are difficult to conduct surveys and market analysis by themselves, due to limited capital and human resources in the field of information technology. This study proposes fuzzy control to determine the right target market at MSME in the world. Fuzzy control method is used to overcome the determination of a market that is influenced by the subjectivity of marketing actors. Determination of this market cannot be separated from the subjectivity and experience of MSME export marketing actors. Some target markets for the same product will elicit a complex calculation to consider which markets and countries in which the product will be distributed.

Sari et al. (2017) stated that fuzzy had reasoning ability that was similar to human reasoning ability. This is because the fuzzy system has the ability to provide responses based on inaccurate, qualitative, and ambiguous information. Therefore, in this study, output would be used as consideration in deciding the export destination of goods.

Recent Studies

Some previous researchers have successfully executed market matching by using a variety of approaches. Ackermann, et al. (2009) executed market matching with a stable matching approach introduced by Gale and Shapley. Stable matching can be computed in polynomial time, but many real-life markets lack a central authority to match agents. In those markets, match behaviors are formed by actions of dynamics. The results show that coordination is necessary in two-sided markets, as well as these markets do not stabilize quickly.

Che and Tercieux (2013) studied efficient and stable mechanisms in many-to-one matching markets when the number of agents was large and individuals' preferences were drawn randomly from a class of distributions allowing for both common value and idiosyncratic components. They proposed a new mechanism that was asymptotically efficient, asymptotically stable and asymptotically incentive compatible. The result of this study is the proposed mechanism is able to link matching markets efficiently and stable.

This research is a development of previous research (Nurdewanto, Amrullah, & Sonalitha, 2017). In the previous research, the application was developed in the form of a simple market matching application. The application was developed only limited to search market (importer) based on data base worldwide. This application is used by MSME to search for market destination with input category "goods" and "continent". The application produces the output of the name of the importer in accordance with the category and the continent.

Based on that background and previous research, to be more effective and efficient, an approach is needed by using artificial intelligence for market matching globally (many to many). The proposed approach is fuzzy control. This application is able to know the location of importer according to product type and capacity of product that can be imported. Fuzzy can provide the best option for MSMEs to determine the location of the importer based on the capacity of the appropriate product to be imported.

Fuzzy Controls

This study used fuzzy control to determine the location of foreign marketing and the types of product that must be exported. In fuzzy method, every consequence of the IF-THEN rules should be modeled with a fuzzy set with the same membership function (Sari & Mahmudy, 2017). As a result, the inference output of each rule is given explicitly. Fuzzy control has several stages, namely fuzzification, fuzzy inference engine, and defuzzification (Sari et al., 2017) shown in Figure 1.

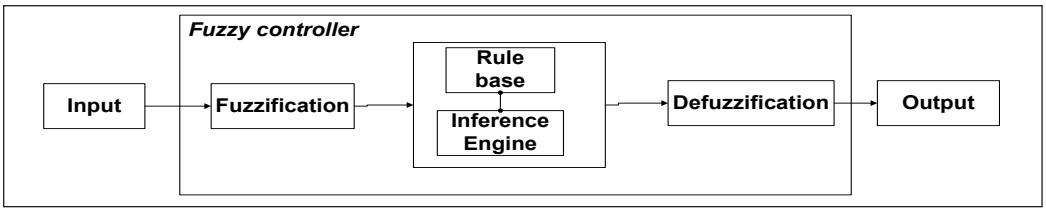


Figure 1. Fuzzy Control's Diagram
Note: Adapted from Sari et al., 2016 and Farzilah et al., 2017)

Fuzzification. The input and output variables in fuzzy control were divided into one or more fuzzy sets (Noor & Kamal, 2017). In this process, the parameters used to determine the market were efficiently represented as input variables. The input variables used in this study were Stock, Capacity, and Competitive, while the output variable in this process was in the form of Export (the amount of goods). The fuzzy set is a unity representing a particular state in a fuzzy variable. In this process used fuzzy set of three linguistic variables which were LOW, MEDIUM, and HIGH. The formation of this fuzzy set was customized based on expert opinion. The function for determining membership value is illustrated by Triangular Fuzzy Number shown in Figures 2, 3 and 4 (Sameer & Bakar, 2017). Membership function in each set is formulated in Eq. (1) - Eq. (10), where μ is the degree of membership and *x* is the object set (Sameer & Bakar, 2017).

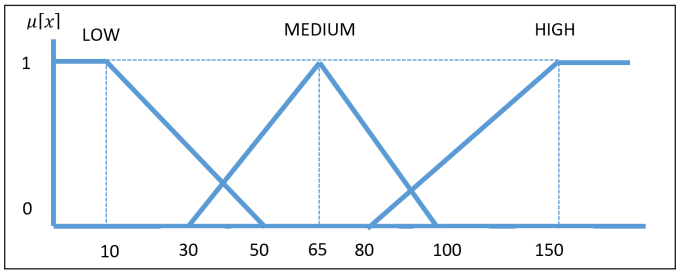
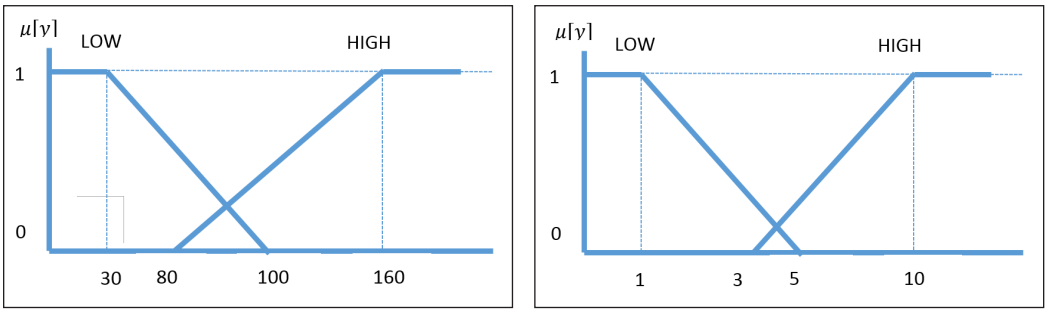


Figure 2. An example of Triangular Fuzzy Number Variable Input "Stock"

$$\mu StockLOW[x] = \begin{cases} 1, & x \leq 10 \\ \dfrac{50-x}{50-10}, & 10 < x < 50 \\ 0, & x \geq 50 \end{cases} \quad (1)$$

$$\mu StockMEDIUM[x] = \begin{cases} 0, & x \leq 30 \; or \; x \geq 100 \\ \dfrac{x-30}{65-30}, & 10 < x \leq 65 \\ \dfrac{100-x}{100-65}, & 65 < x < 100 \end{cases} \quad (2)$$

$$\mu StockHIGH[x] = \begin{cases} 0, & x \leq 80 \\ \dfrac{x-80}{150-80}, & 80 \leq x \leq 150 \\ 1, & x \geq 150 \end{cases} \quad (3)$$



(a) (b)

Figure 3. An example of Triangular Fuzzy Number Variable Input: (a) "Capacity"; and (b) "Competitive"

$$\mu Low\ Capacity[y] = \begin{Bmatrix} 1, & y \leq 30 \\ \dfrac{100-y}{100-30}, & 30 < y < 100 \\ 0, & y \geq 100 \end{Bmatrix} \quad (4)$$

$$\mu High\ Capacity[y] = \begin{Bmatrix} 0, & y \leq 80 \\ \dfrac{y-80}{160-80}, & 80 < y < 160 \\ 1, & y \geq 160 \end{Bmatrix} \quad (5)$$

$$\mu Low\ Competitive[z] = \begin{Bmatrix} 1, & z \leq 1 \\ \dfrac{5-z}{5-1}, & 1 < z < 5 \\ 0, & z \geq 5 \end{Bmatrix} \quad (6)$$

$$\mu High\ Competitive[z] = \begin{Bmatrix} 0, & z \leq 3 \\ \dfrac{z-3}{10-3}, & 3 < z < 10 \\ 1, & z \geq 10 \end{Bmatrix} \quad (7)$$

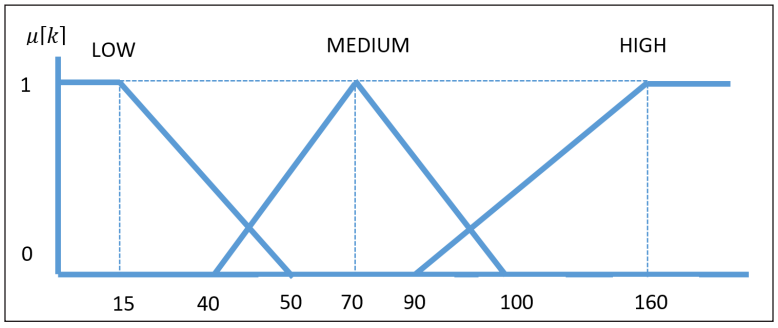


Figure 4. An example of Triangular Fuzzy Number Variable Input "Export"

$$\mu Low\ Export[k] = \begin{cases} 1, & k \leq 15 \\ \dfrac{50-k}{50-15}, & 15 < k < 50 \\ 0, & k \geq 50 \end{cases} \quad (8)$$

$$\mu Medium\ Export[k] = \begin{cases} 0, & k \leq 40\ atau\ k \geq 100 \\ \dfrac{k-40}{70-40}, & 40 < k \leq 70 \\ \dfrac{100-k}{100-70}, & 70 < k < 100 \end{cases} \quad (9)$$

$$\mu High\ Export[k] = \begin{cases} 0, & k \leq 90 \\ \dfrac{k-90}{160-90}, & 90 < k < 160 \\ 1, & k \geq 160 \end{cases} \quad (10)$$

Fuzzy Inference Engine. The results of the fuzzy membership value calculation process were then inferenced against fuzzy rules. In fuzzy control, the implication function used is Min. There are three input variables (t) that need to be implemented against fuzzy rules. The calculation of the number of rules is by multiplying the number of fuzzy set (two linguistic variables) by the number of input variable. In this stage the number of rules used 13 rules obtained from all input combinations. The fuzzy rules used in this study are shown in Table 1.

Table 1
The formation of Fuzzy Rules

Fuzzy Rules
[R1] IF stock LOW AND capacity LOW AND competitive LOW THEN export LOW
[R2] IF stock LOW AND capacity LOW AND competitive HIGH THEN export LOW
[R3] IF stock LOW AND capacity HIGH AND competitive LOW THEN en export HIGH
[R4] IF stock LOW AND capacity HIGH AND competitive HIGH THEN export MEDIUM
[R5] IF stock MEDIUM AND capacity LOW AND competitive LOW THEN export LOW
[R6] IF stock MEDIUM and capacity LOW AND competitive HIGH THEN export LOW
[R7] IF stock MEDIUM AND capacity HIGH AND competitive LOW THEN export HIGH
[R8] IF stock MEDIUM AND capacity HIGH AND competitive HIGH THEN export MEDIUM
[R9] IF stock HIGH AND capacity LOW AND competitive LOW THEN export MEDIUM
[R10] IF stock HIGH AND capacity LOW AND competitive HIGH THEN export LOW
[R11] IF stock HIGH AND capacity HIGH AND competitive LOW THEN export HIGH
[R12] IF stock HIGH AND capacity HIGH AND competitive HIGH THEN export LOW

Defuzzification

To get the output value (crisp) is by converting the input into a number on the fuzzy set domain or by defuzzification (Sari et al., 2016). Having obtained the value of α_i, then will be the process of calculating the value of each consequence each rule z_i in accordance

with the membership function used. The defuzzification method in fuzzy control is Center Average Defuzzifier which is formulated in Eq. (11).

$$Z = \sum_{i=1}^{n} \propto_i z_i \frac{\sum_{i=1}^{n} \propto_i z_i}{\sum_{i=1}^{n} \propto_i}$$

Where, in above Z is the result of defuzzification, whereas $\propto_i$ is the membership value antecedent, and z_i is the inference result of each rule.

RESULT AND DISCUSSION

The Dataset

MSME become the target of this study object, because MSME is a business group of society that does not have an integrated system like a large industry. MSME are difficult to conduct surveys and market analysis by themselves, due to limited capital and human resources in the field of information technology.

The case study used is the right selection of importers with the right amount, so that the exports made by MSME are efficient. This study used importer or buyer data which consisted of Buyer, Address, City, Nation, Region, Contact (Telephone, fax, Email), and Product. The data obtained from the Department of Industry and Trade of East Java Province in 2010. This study used sample data of four data. Company data is shown in Table 2. The data would be processed and be input data.

Table 2
MSME data in some regions

No	Buyer Name	Product
1	BOS LIMITED	Furniture
2	CENTURY CO., LTD.	Furniture
3	BOS LIMITED	Watches
4	Advertising Co., Ltd.	Watches

Experiment. This section presents case study related to matching market. There is a problem and a solution. The solution is a proposed approach in this study that is using fuzzy control method with the provisions that have been described in Section Fuzzy Control. The problem is that there is a buyer who imports the furniture product that is BOS LIMITED (BL).

BL → Stock = 12, capacity = 200, competitive = 2

Fuzzification. The membership function at fuzzification stage of the "Stock" input variable is shown in Table 3. While the fuzzification membership function in the input variables "Capacity" and "Competitive" are shown in Table 4 and Table 5.

Table 3
Fuzzification process in "Stock"

EMPLOYEE "BL"		
PARAMETER	MIN	MAX
LOW	10	50
MEDIUM	30	100
HIGH	80	150

Table 4
Fuzzification process in "Capacity"

EMPLOYEE "BL"		
PARAMETER	MIN	MAX
LOW	30	100
HIGH	80	160

Table 5
Fuzzification process in "Competitive"

EMPLOYEE "BL"		
PARAMETER	MIN	MAX
LOW	1	5
HIGH	3	10

Based on calculations using Eq. (1) - Eq. (7) obtained the membership VALUE on each input variable as follows.

$\mu StockLow[15] = 0.95$ $\mu CapacityLow[100] = 0$ $\mu CapacityLow[5] = 0.75$
$\mu StockMedium[15] = 0$ $\mu CapacityHigh[100] = 1$ $\mu CapacityHigh[5] = 0$
$\mu StockHigh[15] = 0$

Fuzzy Inference Engine. Based on the formation of membership function at fuzzification stage, can be done next process that is fuzzy inference engine. In this stage the process of calculating the function of the implication by applying fuzzy rules that have been established previously. The results of the implication value calculation are shown in Table 6.

[R1] IF stock LOW AND capacity LOW AND competitive LOW THEN Export MEDIUM formula

$$\alpha{-}predicate_1 = \mu StockLow \cap \mu CapacityLow \cap \mu CompetitiveLow$$
$$= \min(\mu StockLow(12), \mu CapacityLow(200), \mu CompetitiveLow(2)$$
$$= \min(0.95; 0; 0.75)$$
$$= 0$$
$$0 = \frac{50 - z_1}{50 - 15} => z_1 = 50$$

Table 6
The results of implication value calculation

Fuzzy Rules	$\alpha{-}predicate_n$	Implication Value *Zn*	$\alpha{-}predicate_n . Zn$
[R1]	0	50	0
[R2]	0	50	0
[R3]	0.75	142.5	106.875
[R4]	0	40	0
[R5]	0	50	0
[R6]	0	50	0
[R7]	0	90	0
[R8]	0	40	0
[R9]	0	40	0
[R10]	0	50	0
[R11]	0	90	0
[R12]	0	50	0
∑	0.75		106.875

Defuzzification. Having obtained the value of α predicate and implication value (Zn), then it will be done the process of calculating the defuzzification value by using Eq. (11). Based on the results of defuzzification calculation obtained the final value or crisp value of 143. The value is the number of goods from a company to be ready for export.

$$z = \frac{\sum_{n=1}^{12} \alpha{-}predicate_n \, x \, z_n}{\sum_{n=1}^{12} \alpha{-}predicate_n} = \frac{106.875}{0.75} = 142.5 = 143$$

Based on the results of manual calculations by using fuzzy control, it can be seen that on the BOS LIMITED buyer there are 143 items amount (Figure 5). The results are in accordance to the data base on the system developed. Therefore, the result of manual calculations with the system is accurate. The accuracy generated between manual calculations and output system in this study is 100%.

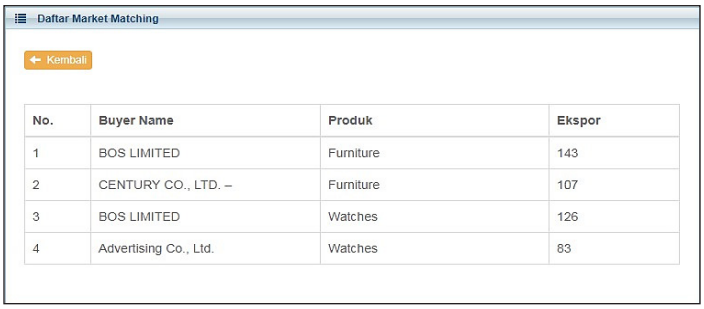


Figure 5. Display of Importer Result "Export" (Amount of goods). BL Buyer produces 143 outputs (capacity of goods)

CONCLUSION

Fuzzy control method used in this study can be implemented to determine the number of export and export destination in a company. This study obtained the system's accuracy in 100% range. This study is still in progress, so the data used in this study is sample data. In this study, fuzzy rule determination is done manually based on expert opinion. If the fuzzy rules are determined manually, it will be more experimental. There is a probability that the determination is less fit. Therefore, the implementation of genetic algorithm in subsequent study is needed to optimize fuzzy rules. The optimization of fuzzy rules aims to improve the accuracy of the system better. Genetic Algorithm has been widely used to solve problems related to optimization such as study that has been done by (Wijayaningrum & Mahmudy, 2016).

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REFERENCES

Ackermann, H., Goldberg, P. W., Mirrokni, V. S., Röglin, H., & Vöcking, B. (2009). Uncoordinated two-sided matching markets. *ACM SIGecom Exchanges*, *8*(1), 8-15.

Che, Y. K., & Tercieux, O. (2013). Efficiency and stability in large matching markets. *American Economic Assosiation, 2013*, 1–56.

Farzilah, N., Mailah, Y. H., Amran, M., & Radzi, M. (2017). DC-link Capacitor Voltage Regulation with Effort-reduction Fuzzy Logic Control for Three-level Inverter-based Shunt Active Power Filter. *Pertanika Journal of Science and Technology*, *25*(S), 11–20.

Noor, I. M. M., & Kamal, M. (2017). Control of Wastewater Treatment by using the Integration MATLAB and LabVIEW. *Pertanika Journal of Science and Technology*, *25*(S), 77–84.

Nurdewanto, B., Amrullah, F., & Sonalitha, E. (2017). Aplikasi Market Matching Untuk Pencarian Tujuan Export Produk UMKM [Market Matching Application For Searching Purpose Of Export Of UMKM Products]. In *Seminar Nasional Sistem Informasif (SENASIF)* (Vol. 1, pp. 874–879). Universitas Merdeka Malang, Indonesia.

Sameer, F., & Bakar, M. R. A. (2017). Modified Kohonen Network Algorithm for Selection of the Initial Centres of Gustafson-Kessel Algorithm in Credit Scoring. *Pertanika Journal of Science and Technology*, *25*(1), 77–90.

Sari, N. R., & Mahmudy, W. F. (2017). *Fuzzy inference system Tsukamoto untuk menentukan kelayakan calon pegawai* [FIS Tsukamoto for Determine Eligibility of Prospective Employees] (pp. 245–252). Presented at the Seminar Nasional Sistem Informasi Indonesia (SESINDO 2015), Institut Teknologi Sepuluh Nopember (ITS): Open Access Journal of Information Systems (OAJIS).

Sari, N. R., Mahmudy, W. F., & Wibawa, A. P. (2016). Backpropagation on Neural Network Method For Inflation Rate Forecasting in Indonesia. *International Journal of Advances in Soft Computing and its Applications*, *8*(3), 70–87.

Sari, N. R., Mahmudy, W. F., & Wibawa, A. P. (2017). The Effectiveness of Hybrid Backpropagation Neural Network Model and TSK Fuzzy Inference System for Inflation Forecasting. *Journal of Telecommunication, Electronic and Computer Engineering (JTEC)*, *9*(2), 111–117.

Suci, Y. R. (2017). Perkembangan UMKM (Usaha Mikro Kecil dan Menegah) di Indonesia [UMKM Development in Indonesia]. *Jurnal Ilmiah Cano Ekonomos*, *6*(1), 51–58.

Wijayaningrum, V. N., & Mahmudy, W. F. (2016). Optimization of Ship's Route Scheduling Using Genetic Algorithm. *Indonesian Journal of Electrical Engineering and Computer Science*, *2*(1), 180–186.