SIGEF
INTERNATIONAL ASSOCIATION FOR FUZZY - SET MANAGEMENT AND ECONOMY

FUZZY ECONOMIC REVIEW

Vol. 22, No. 1, 2017, p. 45-55

ISSN: 1136-0593

FUZZY ECONOMIC REVIEW

www.sigef.net

PRIORITIZED INDUCED PROBABILISTIC DISTANCES IN TRANSPARENCY AND ACCESS TO INFORMATION LAWS

E. Avilés-Ochoa[a], L.A. Perez-Arellano[a],
E. León-Castro[a], J.M. Merigó[b]

In this paper, a new extension of the ordered weighted average (OWA) operator is developed using four different methods: prioritized operators, induced operators, probabilistic operators and distance techniques. This new operator is called the prioritized induced probabilistic ordered weighted average distance (PIPOWAD) operator. The primary advantage is that we include in one formulation different characteristics and information provided by a group of decision makers to compare actual and ideal situations. Finally, an example of transparency and access to information law in Mexico is presented to forecast the score based on the expectations of decision makers.

Keywords: *OWA operator, prioritized aggregation operators, induced aggregation operators, probabilistic aggregation operators, transparency and access to information.*

JEL Classification: *C69, G38, K39, O39*

1. INTRODUCTION

One of the primary aspects of a democratic society is the importance of transparency and the accessibility of government information to citizen; this is based on two concepts: access and communication (Grønbech-Jensen, 1998). With this, citizens can actively participate in government decision-making and are

[a] University of Occidente, Blvd. Lola Beltrán s/n esq. Circuito Vial, Culiacán, 80200, México.

[b] Department of Management Control and Information Systems, School of Economics and Business, University of Chile, Av. Diagonal Paraguay 257, 8330015, Santiago Chile.

an essential element to prevent corruption, ensure accuracy of government information and provide information to the public (Bertol *et al.* 2009; Quinn, 2003).

In Mexico, the Index of the Right of Access to Information in Mexico (IDAIM is the acronym in Spanish) is an index that measures the level of transparency of states. It is important to evaluate the difference between the most advanced states and the others to improve the states' government's decisions and make changes that can effectively improve the next year's evaluation. Some decision-making methods (Greco *et al.,* 2005; Liu *et al.,* 2011) are based on distance measures (Gil-Aluja, 1999), with the Hamming distance (Hamming, 1950) being one of the most common distance methods that compares two variables. It compares an ideal situation with diverse real situations, with the best alternative having results closest to the optimal situation.

When using distance measures in decision making, it is common to also employ a normalizing technique; among the techniques that have been used are the arithmetic mean to obtain the Normalized Hamming Distance (NHD) and the weighted average to obtain the Weighted Hamming Distance (WHD). However, some other aggregation operators have also been applied, such as the Ordered Weighted Averaging (OWA) operator developed by Yager (1988) to obtain the OWA Distance (OWAD) operator (Merigó and Gil-Lafuente, 2007; Zeng, 2016).

The goal of this paper is to present the Prioritized Induced Probabilistic Ordered Weighted Average Distance (PIPOWAD) operator. It is a new aggregation operator that introduces the Hamming distance into the PIPOWA operator (Perez-Arellano *et al.,* 2017). The primary advantage of this new operator is that one formulation combines the Prioritized OWA (PrOWA) operator (Yager, 2004), the Probabilistic OWA (POWA) operator (Merigó, 2012) and the Induced OWA (IOWA) operator (Yager and Filev, 1999) with the Hamming distance to solve more complex problems in a group decision-making process.

An application of the new approach in transparency and access to information law is also developed. We use information from a decision-making group formed of three experts that have knowledge of the topic and the expectation of growth in the field for Sinaloa in Mexico.

The paper is organized as follows: In Section 2, we review some aggregation operators. Section 3 introduces the PIPOWAD operator. Section 4 presents the use of the PIPOWAD operator in a financial selection case. Section 5 summarizes the primary conclusions of the paper.

2. PRELIMINARIES

In this section, we review the OWA operator, some of the primary extensions used in this paper, the distance techniques and the generalized aggregation operators.

2.1. OWA OPERATOR AND MAIN EXTENSIONS

The OWA operator introduced by Yager (1988) is an aggregation operator that provides a parameterized family of aggregation operators between the minimum and the maximum. It can be defined as follows:

Definition 1. An OWA operator of dimension n is a mapping of $\mathrm{OWA}: R^n \rightarrow R$ with a weight vector W of dimension n with $\sum_{i=1}^{n} w_i = 1$ and $w_i \in [0,1]$, such that:

$$\mathrm{OWA}(a_1, a_2, .., a_n) = \sum_{j=1}^{n} w_j b_j \quad (1)$$

where b_j is the j^{th} element and the largest of the collection $a_1, a_2, \ldots, a_n$.

The prioritized OWA (PrOWA) operator developed by Yager (2004) is an aggregation operator that is useful when problem-solving decision makers do not have the same standing in the final decision. Thus, this operator allocates additional impact to some decision makers and less to others. This operator can be defined as follows (Wang *et al.*, 2014; Yager, 2008, 2009):

Definition 2. Assume that a collection of criteria is divided into q distinct groups, $H_1, H_2, \ldots, H_q$, for which $H_i = \{C_{i1}, C_{i2}, \ldots, C_{in}\}$ denotes the criteria of the i^{th} category $(i = 1, \ldots, q)$ and n_i is the number of criteria in the class. Furthermore, we have a prioritization between the groups so that $H_1 > H_2 > \cdots . > H_q$. That is, the criteria in the category H_i have a higher priority than those in H_k for all $i < k$ and $i, k \in \{1, \ldots, q\}$. We denote the total set of criteria as $C = U_{i=1}^{q} H_i$ and the total number of criteria as $n = \sum_{i=1}^{q} n_i$. Additionally, suppose $X = \{x_1, \ldots, x_m\}$ indicates the set of alternatives. For a given alternative x, let $C_{ij}(x)$ measure the satisfaction of the j^{th} criteria in the i^{th} group by alternative $x \in X$, for each $i = 1, \ldots, q,\ j = 1, \ldots, i_i$. The formula is as follows:

$$C_{(x)} = \sum_{i=1}^{q} \sum_{j=1}^{n_i} w_{ij} C_{ij}(x) \quad (2)$$

where w_{ij} is the corresponding weight of the j^{th} criteria in the i^{th} category and $i = 1, \ldots, q$ and $j = 1, \ldots, i_i$. If $w_i = 1/n$ for all *i*, the PrOWA becomes the prioritized average (PrA).

Another extension of the OWA used in this paper is the probabilistic OWA (POWA) operator. This operator uses a weighted vector and a probability vector, making it possible to underestimate or overestimate based on the knowledge and attitude of the decision maker. This operator can be defined as follows (Merigó, 2012):

Definition 3. A POWA operator of dimension n is a mapping of $\mathrm{POWA}: R^n \rightarrow R$ with an associated weighting vector P, where $p_i \in [0,1]$ and $\sum_{i=1}^{n} p_j = 1$, expressed as follows:

$$\mathrm{POWA}(a_1, a_2, \ldots, a_n) = \sum_{j=1}^{n} \widehat{p_j}\, b_j \quad (3)$$

where b_j is the j^{th} element of the largest of the collection $a_1 a_2, \ldots, a_n$, where each argument a_i is associated with a probability p_i, where $\sum_{i=1}^{n} p_i = 1$ and $p_i \in [0,1]$, $\hat{p}_j = \beta w_j + (1-\beta) p_j$ with $\beta \in [0,1]$, and p_j is the probability of p_i ordered according to b_j, according to the j^{th} largest element of a_i. Additionally, if $\beta = 0$, we obtain the PA operator, and if $\beta = 1$, we obtain the OWA operator.

Another extension that is used in this paper is the induced OWA (IOWA) operator (Yager and Filev, 1999). The main characteristic of this operator is that the weights are not assigned based on the value of the argument, but instead they are induced based on the knowledge or expectations of the decision maker (León *et al.,* 2017). This operator can be defined as follows:

Definition 4. An IOWA operator of dimension n is a mapping of $\mathrm{IOWA}: R^n \times R^n \rightarrow R$ that has an associated weighting vector W of dimension n, where the sum of the weights is 1 and $w_j \in [0,1]$, where an induced set of ordering variables is included (u_i), so the formula is as follows:

$$\mathrm{IOWA}(\langle u_1, a_1 \rangle, \langle u_2, a_2 \rangle, \ldots, \langle u_n, a_n \rangle) = \sum_{j=1}^{n} w_j b_j \qquad (4)$$

where b_j is the a_i value of the OWA pair $< u_i, a_i >$ having the j^{th} largest u_i. u_i is the order-inducing variable and a_i is the argument variable. Note that we can distinguish the descending IOWA (DOWA) and ascending IOWA (AIOWA) operator following the same explanation as in Definition 1.

2.2. Distance techniques

Distance techniques are methodologies that can compare two set of elements to determine the distance between them, allowing selection of the alternative that is closer to the ideal set of data. The Hamming distance (Hamming, 1950) is a classical tool that can be used with fuzzy sets, interval-valued fuzzy sets, intuitionistic fuzzy sets and Bonferroni means (Xu and Yager, 2006; Merigó *et al.,* 2017). Some of the basic properties of distance techniques are (Merigó and Casanovas, 2010) as follows:

a) Non-negativity: $D(A_1, A_2) \geq 0$;

b) Commutativity: $D(A_1, A_2) = D(A_2, A_1)$;

c) Reflexivity: $D(A_1, A_2) = 0$; and

d) Triangle inequality: $D(A_1, A_2) + D(A_2, A_3) \geq D(A_1, A_3)$.

The Hamming distance can be defined as follows (Merigó *et al.,* 2014):

Definition 5. A normalized Hamming distance of dimension n is a mapping of $\mathrm{NHD}: [0,1]^n x [0,1]^n \rightarrow [0,1]$, such that

$$\text{NHD}(A, B) = \left(\frac{1}{N}\sum_{i=1}^{n}|a_i - b_i|\right) \quad (5)$$

where a_i and b_i are the i^{th} arguments of sets A and B, respectively.

An extension of the OWA operator can be obtained when it is combined with the Hamming distance, which is the OWA distance (OWAD) operator. This operator has an associated weighed vector to the normal Hamming distance and is defined as follows (Xu and Chen, 2008; Chen *et al.,* 2015):

Definition 6. An OWAD operator of dimension n is a mapping of $\text{OWAD}: [0,1]^n x[0,1]^n \to [0,1]$ that has an associated weighting vector W, with $\sum_{j=1}^{n} w_j = 1$ and $w_j \in [0,1]$ such that

$$\text{OWAD}(\langle x_1, y_1\rangle, \ldots, \langle x_n, y_n\rangle) = \sum_{j=1}^{n} w_j D_j \quad (6)$$

where D_j is the j^{th} largest of the differences $|x_i - y_i|$ and $|x_i - y_i|$ is the argument variable represented in the form of individual distances.

The probabilistic OWA distance (POWAD) operator is another extension that uses the distance measure, probabilities and OWA operator in the same formulation. This operator is defined as follows (Merigo *et al.,* 2013):

Definition 7. A POWAD operator of dimension n is a mapping of $\text{POWAD}: R^n x R^n \to R$ that has an associated weighting vector W such that $w_j \in [0,1]$ and $\sum_{j=1}^{n} w_j = 1$, according to the following formula:

$$\text{POWAD } (\langle x_1, y_1\rangle, \langle x_2, y_2\rangle, \ldots, \langle x_n, y_n\rangle) = \sum_{j=1}^{n} \hat{p}_j b_j \quad (7)$$

where b_j is the j^{th} largest individual distance of $|x_i - y_i|$, each argument $|x_i - y_i|$ has an associated weight (probability) p_i with $\sum_{i=1}^{n} p_i = 1$ and $p_i \in [0,1]$, $\hat{p}_j = \beta w_j + (1-\beta)p_j$ with $\beta \in [0,1]$ and p_j is the weight p_i ordered according to b_j, that is, according to the j^{th} largest of the $|x_i - y_i|$.

The induced OWA distance (IOWAD) operator is an extension of the OWAD including an induced reordering step. Its definition is as follows (Merigó and Casanovas, 2011):

Definition 8. An IOWAD operator of dimension n is a mapping of $\text{IOWAD}: R^n x R^n x R^n \to R$ that has an associated weighting vector W such that $w_j \in [0,1]$ and $W = \sum_{j=1}^{n} w_j = 1$, according to the following formula:

$$\text{IOWAD}(\langle u_1, x_1, y_1, u_2, x_2, y_2, \ldots, u_n, x_n, y_n\rangle) = \sum_{j=1}^{n} w_j b_j \quad (8)$$

where b_j is the $|x_i - y_i|$ value of the IOWAD triplet $\langle u_i, x_i, y_i\rangle$ having the j^{th} largest u_i, u_i is the order-inducing variable and $|x_i - y_i|$ is the argument variable represented in the form of the individual distances.

Additionally, distance measures can be added in the prioritized OWA operator, obtaining the prioritized OWA distance (PrOWAD) operator, which is defined as follows:

Definition 9. Assume a collection of criteria portioned into q distinct groups, $H_1, H_2, \ldots, H_q$ for which $H_i = \{C_{i1}, C_{i2}, \ldots, C_{in}\}$ denotes the criteria of the i^{th} category $(i = 1, \ldots, q)$ and n_i is the number of criteria in the class. Furthermore, we have a prioritization between the groups such that $H_1 > H_2 > \cdots > H_q$. That is, the criteria in category H_i have a higher priority than those in H_k for all $i < k$ and $i, k \in \{1, \ldots, q\}$. We denote the total set of criteria as $C = U_{i=1}^{q} H_i$ and the total number of criteria as $n = \sum_{i=1}^{q} n_i$. Additionally, suppose $X = \{x_1, \ldots, x_m\}$ indicates the set of alternatives and $Y = \{y_1, \ldots, y_m\}$ indicates the ideal value of the alternatives. For a given set of data z that is defined by $|x_i - y_i|$, let $C_{ij}(z)$ measure the satisfaction of the j^{th} criteria in the i^{th} group, for each $i = 1, \ldots, q,\ j = 1, \ldots, i_i$. The formula is as follows:

$$\mathrm{PrOWAD}(C_{(x_n, y_n)}) = \sum_{i=1}^{q} \sum_{j=1}^{n_i} w_{ij} C_{ij}(z) \quad (9)$$

where $C_{ij}(z)$ is the $|x_i - y_i|$ value of each criteria and w_{ij} is the corresponding weight of the j^{th} criteria in the i^{th} category, $i = 1, \ldots, q,\ j = 1, \ldots, i_i$.

3. THE PIPOWAD OPERATOR

The prioritized induced probabilistic ordered weighted average distance (PIPOWAD) operator is an aggregation operator that includes in the same formulation probabilities, induced variables, prioritized variables and distance techniques. This new operator can be used for different types of problems and generates additional, new scenarios. It is important to note that the PIPOWAD operator includes specific cases, such as the prioritized probabilistic ordered weighted average distance (PPOWAD) operator and the prioritized induced ordered weighted average distance (PIOWAD) operator. The PIPOWAD operator is defined as follows:

Definition 10. A prioritized induced probabilistic OWA distance (PIPOWAD) operator of dimension n is a mapping of $PIPOWAD: R^n x R^n \to R$ that has an associated weight vector W of dimension n where $w_j \in [0,1]$ and $\sum_{j=1}^{n} w_j = 1$, so that

$$PIPOWAD(\langle u_1, x_1, y_1\rangle, \langle u_2, x_2, y_2\rangle, \ldots, \langle u_n, x_n, y_n\rangle) = \sum_{i=1}^{q} \sum_{j=1}^{n_i} b_j \hat{v}_{ij} C_{ij}(z) \quad (10)$$

where b_j is the j^{th} largest of the differences $|x_i - y_i|$, $|x_i - y_i|$ is the argument variable represented in the form of individual distances based on u_t, u_t is the induced order of variables, $\hat{v}_{ij}$ is the corresponding weight of the j^{th} criteria in the i^{th} category, $i = 1, \ldots, q,\ j = 1, \ldots, n_i$, and $C_{ij}(z)$ measures the satisfaction of the j^{th} criteria in the i^{th} group by the $|x_i - y_i|$ value of each criteria, for each

$i = 1, \ldots, q,\ j = 1, \ldots, n_i$. Additionally, each element has an associated probability p_i with $\sum_{i=1}^{n} p_i = 1$ and $p_i \in [0,1]$, $\hat{v}_j = \beta w_j + (1-\beta) p_j$, where $\beta \in [0,1]$ and p_j is the probability of p_i.

4. TRANSPARENCY AND ACCESS TO INFORMATION LAWS WITH PIPOWAD OPERATORS IN MEXICO

Transparency can be defined as the openness of the government in informing citizens of how decisions are being made, what procedures are used and the consequences of those decisions (Florini, 1998). In Mexico, the IDAIM measures the quality of the transparency laws in relation to the best national and international practices in the area. This indicator is composed of three main variables: the normative design (v_1), the institutional design (v_2) and the procedures for access to public information and transparency obligations (v_3).

In the specific case of Sinaloa, there is an organization in charge of analyzing and generating new ideas to improve the level of transparency and access to information. It is named the State Commission for Access to Public Information Sinaloa (CEAIP is the acronym in Spanish). To use the PIPOWAD operator to forecast the future ranking of Sinaloa in 2017, based on the information obtained by the directors of the CEAIP.

The future expectations concerning Sinaloa according to the directors of the CEAIP are shown in Table 1.

Table 1. Expectations of the experts

	v_1	v_2	v_3
e_1	8.5	8	9.5
e_2	9	8	9
e_3	8	7.5	9

The results for each variable in the case of Coahuila are shown in Table 2.

Table 2. Results for Coahuila in 2015

	v_1	v_2	v_3
Coahuila	9.8	8.3	9.8

With the information in Tables 1 and 2, we obtain the distances between the results (Table 3).

Table 3. Distance between the expectations of the expert and the best scenario (Coahuila)

	v_1	v_2	v_3
e_1	1.3	0.3	0.3
e_2	0.8	0.3	0.8
e_3	1.8	0.8	0.8

The prioritized vector is $Pr =$ (0.4, 0.3, 0.3). This is based on the number of years that the experts have been working at the institution. The unified distance is shown in Table 4.

Table 4. Prioritized distance for Sinaloa

	v_1	v_2	v_3
e_1	1.30	0.45	0.60

According to the experts, the probability vector is $P =$(0.5, 0.3, 0.3), the weighted vector is $W =$ (0.4, 0.35, 0.25) and the induced vector is $U =$(5, 15, 10). With this information, we calculate the final difference based on the OWAD, POWAD, IOWAD, PrOWAD and PIPOWAD operators, as shown in Table 5.

Table 5. Distance between Sinaloa and Coahuila according to different operators

Operators	v_1	v_2	v_3
OWAD	0.3250	0.1200	0.2217
POWAD	0.6500	0.1400	0.1900
IOWAD	0.5200	0.1167	0.2217
PrOWAD	0.3250	0.1800	0.0630
PIPOWAD	0.2600	0.0338	0.0630

With the distance provided by the different operators, we can forecast the score that Sinaloa will have in the IDAIM in 2017. The result is shown in Table 6.

As can be observed, for different operators. the future score for Sinaloa changes because the information that each operator considers is different. It is important to note that the PIPOWAD operator adds more complexity and provides more information to the decision maker, which is why we consider these results to be more complete than those obtained from the other operators. However, it is also important to analyze the different scenarios that the other operators provide.

Table 6. Forecast for IDAIM score for Sinaloa in 2017

Operators	v_1	v_2	v_3
OWAD	9.4750	8.1800	9.5783
POWAD	9.1500	8.1600	9.6100
IOWAD	9.2800	8.1833	9.5783
PrOWAD	9.4750	8.1200	9.7370
PIPOWAD	9.5400	8.2662	9.7370

In the case of the IDAIM score for Sinaloa in 2017, it can be observed that it improves dramatically in comparison to the result in 2015. The experts that work at CEAIP share the opinion that the legislation in 2015 was obsolete, which is why the score of v_1 for that year was so low. Additionally, they consider that with the new law and different constitutional reforms that provide autonomy to the CEAIP, they can work to improve the valuation of v_2. Finally, in the case of the score obtained for v_3, they are creating different campaigns to improve the culture of openness and transparency, as well as to reveal the obligations of the government institutions.

5. CONCLUSIONS

The primary objective of this paper is the presentation of a new extension of the OWA operator. This new operator is the prioritized induced probabilistic ordered weighted average distance (PIPOWAD) operator. The primary contribution of this operator is that it presents a more complex and robust method to analyze the distance between the ideal scenario and the actual situation. Additionally, it is important to note that in the PIPOWAD operator, we add prioritized, probabilistic and induced vectors to the normal OWAD operator.

The PIPOWAD operator is used to address the transparency and access to information law problem. We employ the operator to forecast the future IDAIM score for Sinaloa, based on the knowledge of different experts concerning the position Sinaloa will be in due to the changes that have occurred since 2015. The information used to make these forecasts is based on the expertise and knowledge in the field of the decision makers. It is important to note that we compare the results with those of other operators to compare the scenarios generated by each. Additionally, by analyzing the results, we determine that there is an important improvement in Sinaloa in the case of transparency and access to information because of several legislative reforms and an important public awareness campaign.

Future research will consider new applications and extensions of the OWA operators by considering different techniques for working under uncertainty scenarios, such as expertons (Kaufmann, 1988), the forgotten effects methodology (Kaufman and Gil-Aluja, 1988), moving averages (León-Castro *et al.,* 2016) or linguistic variables (Xu, 2006).

REFERENCES

Beliakov, G.; Pradera, A.; Calvo, T. (2007). *Aggregation functions: a guide for practitioners.* Berlin, Springer-Verlag.

Bertot, J.C.; Jaeger, P.T.; Langa, L.A.; McClure, C.R. (2006). "Public access computing and Internet access in public libraries: The role of public libraries in e-government and emergency situations". *First Monday*, Vol. 11, No. 9.

Blanco-Mesa, F.; Merigó, J.M.; Kacprzyk, J. (2016). "Bonferroni means with distance measures and the adequacy coefficient in entrepreneurial group theory". *Knowledge-Based Systems*, Vol. 111, p. 217-227.

Calvo, T.; Mayor, G.; Mesiar, R. (2002). *Aggregation operators: New trends and applications.* New York, Physica-Verlag.

Casanovas, M.; Torres-Martínez, A.; Merigó, J.M. (2016). "Decision making in reinsurance with induced OWA operators and Minkowski distances". *Cybernetics & Systems*, Vol. 47, No. 6, p. 460-477.

Chen, S.; Mu, Z.; Zeng, S. (2015). "Atanassov's intuitionistic fuzzy decision making with probabilistic information and distance measure". *Journal of Intelligent & Fuzzy Systems*, Vol. 28, No. 1, p. 317-325.

Florini, A. (1998). "The end of secrecy". *Foreign Policy*, p. 50-63.

Fodor, J.; Marichal, J.L.; Roubens, M. (1995). "Characterization of the ordered weighted averaging operators". *IEEE Transactions on Fuzzy Systems*, Vol. 3, p. 236–240.

Gil-Aluja, J. (1999). *Elements for a theory of decision in uncertainty*. Germany, Springer Science & Business Media.

Greco, S.; Figueira, J.; Ehrgott, M. (2005). *Multiple criteria decision analysis*. Germany, Springer's International Series.

Grønbech-Jensen, C. (1998). "The Scandinavian tradition of open government and the European Union: problems of compatibility?". *Journal of European Public Policy*, Vol. 5 No. 1, p. 185-199.

Hamming, R.W. (1950). "Error detecting and error correcting codes". *Bell Labs Technical Journal*, Vol. 29, No. 2, p. 147-160.

Kaufmann, A. (1988). "Theory of expertons and fuzzy logic". *Fuzzy Sets and Systems*, Vol. 28, No. 3, p. 295-304.

Kaufmann, A.; Gil Aluja, J. (1988). *Models for the research of forgotten effects.* (In Spanish), Spain, Milladoiro.

León-Castro, E.; Avilés-Ochoa, E.; Gil-Lafuente, A.M. (2016). "Exchange rate USD/MXN forecast through econometric models, time series and HOWMA operators". *Economic Computation and Economic Cybernetics Studies and Research*, Vol. 50, p. 135–150.

León-Castro, E.; Avilés-Ochoa, E.; Merigó, J. M. (2017). "Induced heavy moving averages". *International Journal of Intelligent Systems*. DOI: 10.1002/int.21916

Liu, P.; Jin, F.; Zhang, X.; Su, Y.; Wang, M. (2011). "Research on the multi-attribute decision-making under risk with interval probability based on prospect theory and the uncertain linguistic variables". *Knowledge-Based Systems*, Vol. 24, No. 4, p. 554-561.

Merigó, J.M. (2012). "Probabilities in the OWA operator". *Expert Systems with Applications,* Vol. 39, p. 11456-11467.

Merigó, J.M. (2015). "Decision-making under risk and uncertainty and its application in strategic management". *Journal of Business Economics and Management*, Vol. 16, No. 1, p. 93-116.

Merigó, J.M.; Casanovas, M. (2010). "Induced and heavy aggregation operators with distance measures". *Journal of Systems Engineering and Electronics*, Vol. 21, No. 3, p. 431-439.

Merigó, J.M.; Casanovas, M. (2011a). "A new Minkowski distance based on induced aggregation operators". *International Journal of Computational Intelligence Systems*, Vol. 4, No. 2, p. 123-133.

Merigó, J.M.; Casanovas, M. (2011b). "Decision-making with distance measures and induced aggregation operators". *Computers & Industrial Engineering*, Vol. 60, No. 1, p. 66-76.

Merigó, J.M.; Gil-Lafuente, A. M. (2007). “The ordered weighted averaging distance operator”. *Lectures on Modelling and Simulation*, Vol. 8, No. 1, p. 1-11.

Merigó, J.M.; Gil-Lafuente, A.M. (2009). “The induced generalized OWA operator”. *Information Sciences*, Vol. 179, No. 6, p. 729-741.

Merigó, J.M.; Gil-Lafuente, A.M. (2010). “New decision-making techniques and their application in the selection of financial products”. *Information Sciences*, Vol. 180, No. 11, p. 2085-2094.

Merigó, J.M.; Casanovas, M.; Zeng, S. (2014). “Distance measures with heavy aggregation operators”. *Applied Mathematical Modelling,* Vol. 38, No. 13, p. 3142-3153.

Merigó, J.M.; Palacios-Marqués, D.; Soto-Acosta, P. (2017). “Distance measures, weighted averages, OWA operators and Bonferroni means”. *Applied Soft Computing*, Vol. 50, p. 356-366.

Merigó, J.M.; Xu, Y.; Zeng, S. (2013). “Group decision making with distance measures and probabilistic information”. *Knowledge-Based Systems*, Vol. 40, p. 81-87.

Pérez-Arellano, L.A.; León-Castro, E.; Avilés-Ochoa, E.; Merigó, J.M. (2017). “Prioritized induced probabilistic operator and its application in group decision making”. *International Journal of Machine Learning and Cybernetics*, DOI: 10.1007/s13042-017-0724-2

Quinn, A.C. (2003). “Keeping the citizenry informed: early congressional printing and 21st century information policy”. *Government Information Quarterly*, Vol. 20, No. 3, p. 281-293.

Shuler, J.A.; Jaeger, P.T.; Bertot, J.C. (2010). “Implications of harmonizing e-government principles and the Federal Depository Library Program (FDLP)”. *Government Information Quarterly*, Vol. 27, No. 1, p. 9-16.

Wang, H.; Xu, Y.J.; Merigó, J.M. (2014). “Prioritized aggregation for non-homogeneous group decision making in water resource management”. *Economic Computation & Economic Cybernetics Studies & Research*, Vol. 48, p. 247-258.

Xu, Z. (2006). “Induced uncertain linguistic OWA operators applied to group decision making”. *Information Fusion*, Vol. 7, No. 2, p. 231-238.

Xu, Z.S.; Chen, J. (2008). “Ordered weighted distance measures”. *Journal of Systems Science and Systems Engineering*, Vol. 17, No. 4, p. 432-445.

Xu, Z.; Yager, R.R. (2006). “Some geometric aggregation operators based on intuitionistic fuzzy sets”. *International journal of general systems*, Vol. 35, No. 4, p. 417-433.

Yager, R.R. (1988). “On ordered weighted averaging aggregation operators in multicriteria decisionmaking”. *IEEE Transactions on Systems, Man and Cybernetics,* Vol. 18, No. 1, p. 183-190.

Yager, R.R. (2004). “Generalized OWA aggregation operators”. *Fuzzy Optimization and Decision Making*, Vol. 3, No. 1, p. 93-107.

Yager, R.R. (2004). “Modeling prioritized multicriteria decision making”. *IEEE Transactions on Systems, Man and Cybernetics*, Vol. 34, p. 2396-2404.

Yager, R.R. (2008). “Prioritized aggregation operators”. *International Journal of Approximate Reasoning,* Vol. 48, p. 263-274.

Yager, R.R. (2009). “Prioritized OWA aggregation”. *Fuzzy Optimization and Decision Making,* Vol. 8, p. 245-262.