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Assessment of Organizational Innovation in Manufacturing Companies in Era of Industry 4.0 Using the WASPAS Method

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Abstract
Industrial production has undergone a paradigm shift as a result of ongoing technical advancements. Industry 4.0 is a novel concept that is increasingly common in industrial firms. Industry 4.0 focuses on modern technologies, but it also emphasizes the need for organizational changes. Investigating which organizational innovations are most suitable in this situation is necessary since they are a requirement for the deployment of modern technology in manufacturing organizations. The Fourth Industrial Revolution is just around the corner Emerging technologies (Internet of Things, Wireless Sensor Networks, Big data, cloud computing, Embedded systems and mobile etc.) in a production environment introduced. The fourth industry Production practices as a result of the revolution have become more complex (Industry 4.0 Also called), but they are have become automated and stable. Many European Manufacturing Studies Industry 4.0 In Under production is the exchange of information and Managed machinery and industry insists on having units. In this paper, the weighted aggregated sum product assessment (WASPAS) method was employed to rank organizational innovations. Based on six criteria, we assessed eight organizational innovations in this study. Based on the opinions of experts about the idea of Industry 4.0, criteria for the selection of organizational innovations were established. They are connected to the nature of production and the features of products in manufacturing firms. The result of the analysis is rank one for Made-to-order, rank six for Assembly-to-order, rank fifth for stock, rank fourth for Single unit production, rank second for small or medium batch, and rank three for large batch. According to research, manufacturing firms from poor nations would benefit most from organizational improvements relating to Made-to-Order, small or medium batches, and big batches in the framework of Industry 4.0.
Keywords: Industry 4.0, MCDM, Production controlling, Binding process flows

Introduction
Industry 4.0, the umbrella term for the fourth industrial revolution and the digital change it underpins, is rapidly developing. People's lives and workplaces are radically changing as a result of the digital revolution, and the public is nevertheless hopeful about the prospects that Industry 4.0 may present for sustainability [1]. Always changing in a highly competitive industry to fulfill customer requests Manufacturers are flexible, efficient and be responsive. Continually reducing operational costs Thus, they should be cost effective. Also, within the company's supply chain Out and out automation and digital This is made possible by extensive use of decentralization. [2]. Different functional subsystems including manufacturing, human resources, planning, and procurement are vertically integrated inside the firm. Automation has long been utilized in manufacturing settings. Although some manufacturing processes were automated, the other functional systems in the company were not integrated, so the benefits of automation were constrained [3]. The industrial and manufacturing sectors will experience dramatic transformation as a by-product of Industry 4.0, with effects seen across the complete value chain. It will also present a number of new opportunities in terms of business models, production technologies, the development of new jobs, and work organization [4]. Since disruption concerns get a consequence on SCs and data analytics has an impact on SCs, an association involving data-driven technology and SC destabilization risk monitoring makes perfect sense. As a result of the convergence and interconnection of data and computational processes, over the last few years, technology systems have developed the sharing and use of data sources for risk assessment, in addition to facilitating their simple finding. The cloud-based technology platform Supply on Industrial Revolution 4.0 Sensor Clouds enables real-time SC control, process optimization, and modification. The data analysis tools allow seamless recognition of all orders with surpassed production runs, enabling further quicker assessment of hazardous shipments [5]. Industry 4.0 has sparked a technological upswing that propels the digitization of business processes. "Digital threads" refer to the flow of data or digital communication along the entire value chain, and these streamline corporate processes [6]. Supply chains will develop into supply chain ecosystems as they become more digitalized through the adoption of the industry 4.0 concept. A network of enterprises that are interlinked, organize their actions, and experience some of the same challenges when it comes make form a business ecosystem [7]. Early industrial communications saw the development of specialized automation networks known as fieldbus systems, to minimize the communication barriers on the reduced ranks of the automation pyramid and get beyond the restrictions brought on by concurrent cabling between sensors, actuators, and controllers [8]. Amidst elevated rates of digitalization pushed on by Industry 4.0, because some human abilities, such as cognitive aptitude and problem-solving, are

still indispensable, Systems for assembling products still associated with manual interaction [9]. According to information processing theory, technological advances represent the firm's functionality to support managerial and environmental management decision-making processes. [10] Industry 4.0 enhances the productivity of industrial units by lowering energy consumption while also improving the fuel efficiency of industrial applications, using smart automation administration and monitoring, such as the steel sector. Automation and computerization breakthroughs are associated to the implementation of the I4.0 concept, enables the use of instrumentation in technologically production and logistics activities and Many elements of machine operation and its environments are regularly reviewed utilizing digital devices [11]. The shortcomings of traditional manufacturing may be overcome by several advanced manufacturing techniques manufacturing techniques such as nimble, versatile, and innovative production. These production techniques are interpretations of smart manufacturing entrepreneurs, where products and machines communicate with one another with little to no human intervention [12]. The term, Data science will be incorporated into industry as element of Industry 4.0, an emerging technological revolution, in a bid to construct technology infrastructure for superior industrial production [13]. In this study, 8 based on 6 criteria We evaluated organizational innovation. Regarding the concept of Industry 4.0 Institutional based on expert opinion for selection of findings Criteria were determined. They are productive Type of production and product in enterprises associated with attributes. Here in this paper alternative parameters are Made-to-order, Assembly-to-order, stock, Single unit production, small or medium batch, large batch. Evaluation parameters are cells in the factory, Production controlling, Binding process flows, Visual management, quality in production, operation management, improvement of production processes, energy management system.

Methodology

The WASPAS method, one of the newest and most accurate MCDM approaches that can improve the ranking accuracy of alternatives, combines the Weighted Product Model (WPM) with the Weighted Sum Model. The MCDM techniques are the most well-known approaches to decision-making problems (WSM) [14]. The WSM approach calculates an alternative's overall score as a weighted sum of the criteria values, whereas the WPM method calculates an alternative's score as a result of scaling each criterion to a power equal to that criterion's weight [15]. The weighted aggregate function is optimized by WASPAS in addition to these other methods in an effort to achieve the best estimation accuracy [16].

Step 1 The decision matrix X, which displays how various alternatives perform in relation to certain criteria, is created.

$$D = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & x\cdots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \quad (1)$$

Weight vector may be expressed as

$$w_j = [w_1 \cdots w_n], \quad (2)$$

where ,$\sum_{j=1}^{n}(w_1 \cdots w_n) = 1$

Step 2: The decision matrix is normalized. Beneficial and non-beneficial criteria are normalized

$$n_{ij} = \{\frac{x_{ij}}{max .x_{ij}} \mid j \in B \; \frac{min .x_{ij}}{x_{ij}} \mid j \in C \quad (3)$$

Where $max. x_{ij}$ and $min. x_{ij}$ are the maximum and minimum value of x_{ij} in the jth column for benefit (B) and cost criteria (C) respectively

Step 3 Weighted normalized decision matrix is calculated as follows:

$$w_{ij} = w_i n_{ij} \quad (4)$$

Step 4: The preference score for the given alternative, based on WSM, is calculated as follows:

$$S_i^{WSM} = \sum_{j=1}^{n} w_j n_{ij} \quad (5)$$

Step 5: The preference score for the given alternative, based on WSM, is calculated as follows:

$$S_i^{WPM} = \prod_{j=1}^{n} (n_{ij})^{w_j} \quad (6)$$

Step 6: The preference score for the WASPAS method is calculated using equations (5) and (6),

$$S_i^{WASPAS} = \lambda S_i^{WSM} + (1-\lambda) S_i^{WPM}$$

$$S_i^{WASPAS} = \lambda \sum_{j=1}^{n} w_j n_{ij} + (1-\lambda) \prod_{j=1}^{n} (n_{ij})^{w_j}$$

where λ is between 0 and 1.

Finally, the alternatives are ranked based on the S_i^{WASPAS} values. The best alternative has the highest S_i^{WASPAS} value. If the value of λ is 0, the WASPAS method is transformed to WPM and if λ is 1, it becomes WSM [17].

In this analysis alternative parameters are Made-to-order, Assembly-to-order, stock, Single unit production, small or medium batch, large batch. Evaluation parameters are cells in the factory, Production controlling, Binding process flows, Visual management, quality in production, operation management, improvement of production processes, energy management system

Analysis and Discussion

TABLE 1. Data set of Industry 4.0

	ee1	ee2	ee3	ee4	ee5	ee6	ee7	ee8
aa1	66	57	78	66	109	43	53	18
aa2	11	62	10	11	15	8	8	2
aa3	20	10	26	29	42	13	18	4
aa4	16	13	80	11	23	6	6	20
aa5	47	38	54	67	80	55	32	13
aa6	27	21	36	33	54	22	58	6

The dataset for the case study using industry 4.0 is displayed the table 1. In this analysis alternative parameters are Made-to-order (aa1), Assembly-to-order (aa2), stock (aa3), Single unit production (aa4), small or medium batch (aa5), Large batch (aa6). Evaluation parameters are cells in the factory (ee1), Production controlling (ee2), Binding process flows (ee3), Visual management (ee4), quality in production (ee5), operation management (ee6), improvement of production processes (ee7), energy management system (ee8).

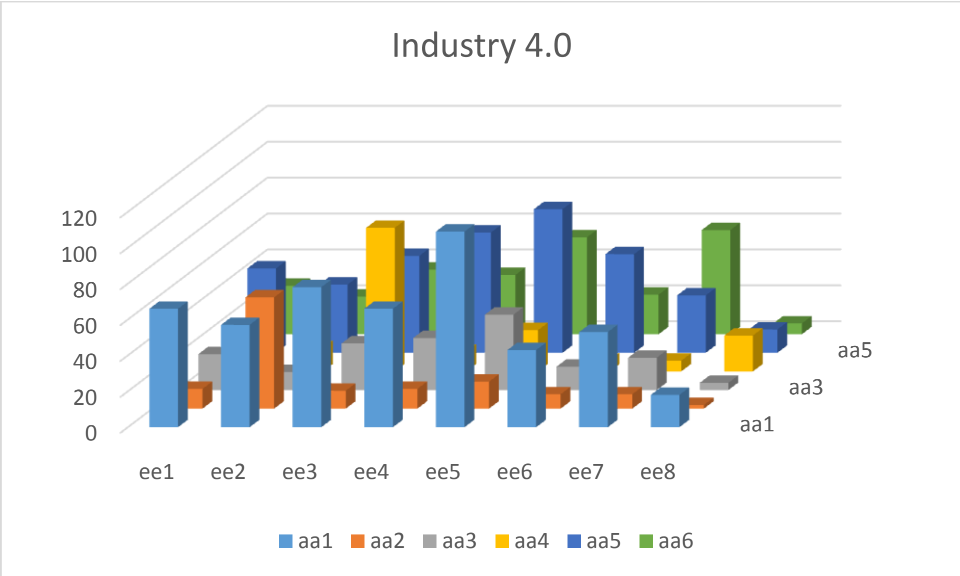

FIGURE1. Data set of Industry 4.0

The dataset for the case study using industry 4.0 are shown in Figure 1. In this analysis alternative parameters are Made-to-order (aa1), Assembly-to-order (aa2), stock (aa3), Single unit production (aa4), small or medium batch (aa5), Large batch (aa6). Evaluation parameters are cells in the factory (ee1), Production controlling (ee2), Binding process flows (ee3), Visual management (ee4), quality in production (ee5), operation management (ee6), improvement of production processes (ee7), energy management system (ee8).

TABLE 2. Normalized decision matrix

1.0000	0.9194	0.9750	0.9851	1.0000	0.7818	0.9138	0.9000
0.1667	1.0000	0.1250	0.1642	0.1376	0.1455	0.1379	0.1000
0.3030	0.1613	0.3250	0.4328	0.3853	0.2364	0.3103	0.2000
0.2424	0.2097	1.0000	0.1642	0.2110	0.1091	0.1034	1.0000
0.7121	0.6129	0.6750	1.0000	0.7339	1.0000	0.5517	0.6500
0.4091	0.3387	0.4500	0.4925	0.4954	0.4000	1.0000	0.3000

Table 2 shows the normalized array value calculated using equation three.

TABLE 3. Weight

0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125

Table 3 shows the weight value taken for the analysis as equally distributed among the evaluation parameters.

TABLE 4. Weighted normalized decision matrix (WSM)

0.1250	0.1149	0.1219	0.1231	0.1250	0.0977	0.1142	0.1125
0.0208	0.1250	0.0156	0.0205	0.0172	0.0182	0.0172	0.0125
0.0379	0.0202	0.0406	0.0541	0.0482	0.0295	0.0388	0.0250
0.0303	0.0262	0.1250	0.0205	0.0264	0.0136	0.0129	0.1250
0.0890	0.0766	0.0844	0.1250	0.0917	0.1250	0.0690	0.0813
0.0511	0.0423	0.0563	0.0616	0.0619	0.0500	0.1250	0.0375

Table 4 displays a weighted normalized decision matrix array calculated using WSM method using equation four

TABLE 5. Weighted normalized decision matrix (WPM)

1.0000	0.9895	0.9968	0.9981	1.0000	0.9697	0.9888	0.9869
0.7993	1.0000	0.7711	0.7978	0.7804	0.7859	0.7807	0.7499
0.8614	0.7961	0.8689	0.9006	0.8876	0.8350	0.8639	0.8178
0.8377	0.8226	1.0000	0.7978	0.8233	0.7581	0.7531	1.0000
0.9584	0.9406	0.9521	1.0000	0.9621	1.0000	0.9284	0.9476
0.8943	0.8734	0.9050	0.9153	0.9159	0.8918	1.0000	0.8603

Table 5 displays a weighted normalized decision matrix array calculated using WPM method using equation four

TABLE 6. Preference Score (WSM) (WPM)

	Preference Score (WSM)	**Preference Score (WPM)**
aa1	0.9344	0.9317
aa2	0.2471	0.1766
aa3	0.2943	0.2810
aa4	0.3800	0.2584
aa5	0.7420	0.7264
aa6	0.4857	0.4547

Table 6 lists the preference scores for the WSM Weighted Sum Model and the WPM Weighted Product. The preference score is calculated by adding the weighted normalized choice matrix (WSM) row values of the weighted normalized choice matrix (WSM). The preference score in the WPM Weighted Product Model from equation (5) is multiplied by the row value of the weighted normalized decision matrix (6).

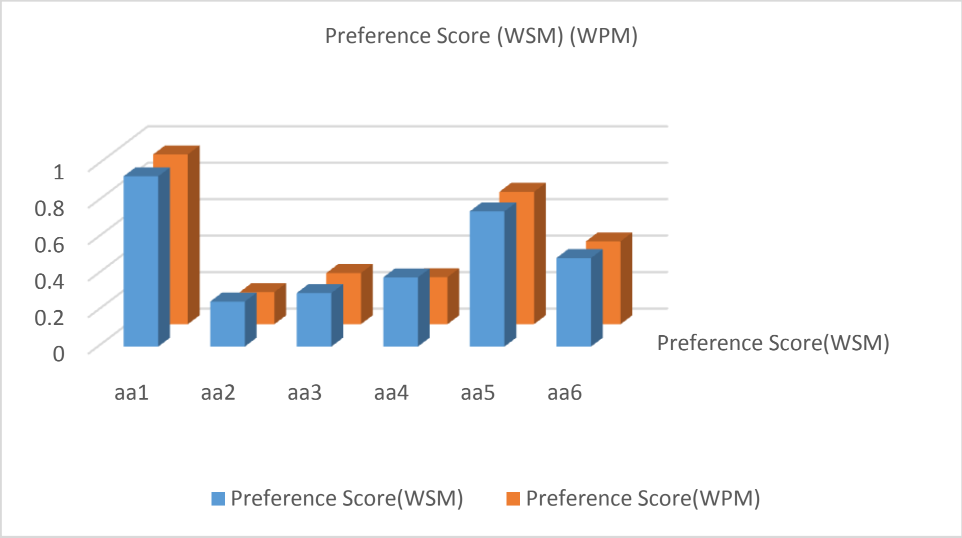

FIGURE 2. Preference Score (WSM) (WPM)

Figure 2 portrays the preference scores for the WSM Weighted Sum Model and the WPM Weighted Product. The preference score is calculated by adding the weighted normalized choice matrix (WSM) row values of the weighted normalized choice matrix (WSM). The preference score in the WPM Weighted Product Model from equation (5) is multiplied by the row value of the weighted normalized decision matrix (6).

TABLE 7. WASPAS coefficient

	WASPAS coefficient
aa1	0.933033
aa2	0.211833
aa3	0.287634
aa4	0.319186
aa5	0.734196
aa6	0.470186

Table 7 displays the WASPAS Coefficient value with a lambda value of 0.5. Alternative values for the parameters are 0.933033 for aa1, 0.211833 for aa2, 0.287634 for aa3, 0.319186 for aa4, 0.734196 for aa5, and 0.470186 for aa6.

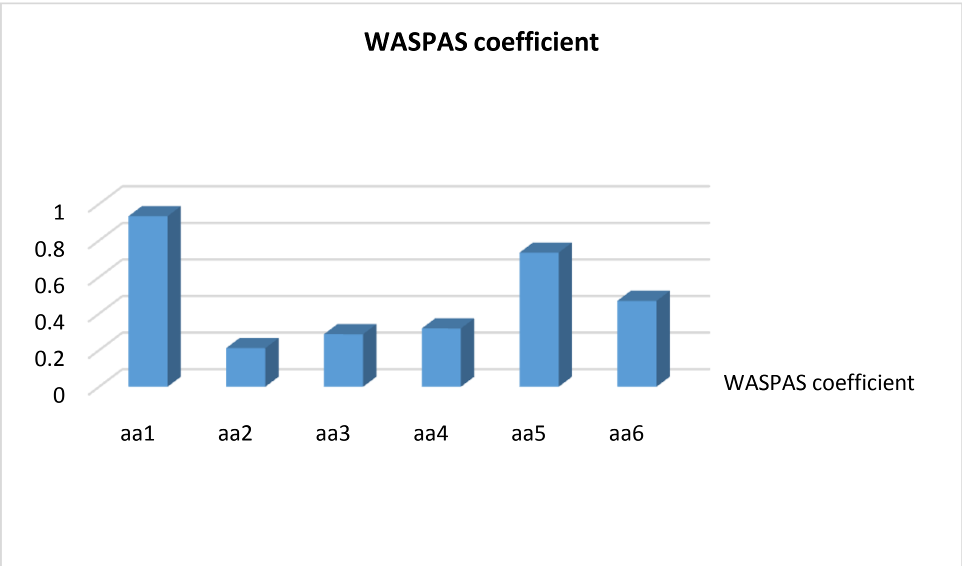

FIGURE 3. WASPAS coefficient

A graphical illustration of the WASPAS coefficient is shown in Figure 3. Alternative values for the parameters are 0.933033 for aa1, 0.211833 for aa2, 0.287634 for aa3, 0.319186 for aa4, 0.734196 for aa5, and 0.470186 for aa6.

TABLE 8. Rank

	Rank
aa1	1
aa2	6
aa3	5
aa4	4
aa5	2
aa6	3

The ranking of alternative WASPAS coefficient settings is displayed in Table 8. Alternative criteria. Rank for Alternative parameters are rank one for aa1, rank six for aa2, rank fifth for aa3, rank fourth for aa4, rank second for aa5, and rank three for aa6.

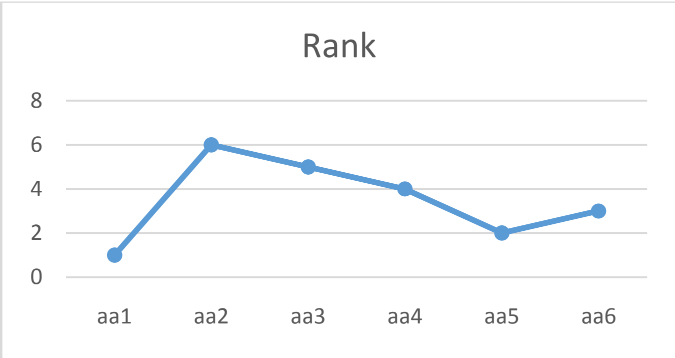

FIGURE 4. Rank

A graphical depiction of the rank of alternative WASPAS coefficient parameters is shown in Figure 4. Alternative criteria: rank one for Made-to-order, rank six for Assembly-to-order, rank fifth for stock, rank fourth for Single unit production, rank second for small or medium batch, and rank three for large batch. According to research, manufacturing firms from poor nations would benefit most from organizational improvements relating to Made-to-Order, small or medium batches, and big batches in the framework of Industry 4.0.

Conclusion

Industry 4.0 is focused on cutting-edge technologies. Therefore, nontechnological innovations are being overlooked while the majority of studies concentrate on technical breakthroughs in manufacturing organizations. Since diverse forms of innovations complement one another, it is important to look more closely at non-technological advances. Organizational innovations have recently been acknowledged as a key factor in a company's ability to compete on the market. The deployment of the industry 4.0 idea in manufacturing businesses also requires the integration of enterprises, which is made possible by organizational innovations.By converting analogue and centralized workflows into digital and decentralized production processes, Industry 4.0's breakthrough technologies are reshaping whole production systems. These cutting-edge technologies have a great chance to boost industrial productivity dramatically.This study ranked organizational innovations using the weighted aggregated sum product assessment (WASPAS) technique. In this study, we evaluated eight organizational innovations using six criteria. The selection criteria for organizational innovations were developed based on the opinions of experts on the concept of Industry 4.0. They are related to how things are made and how things are made in manufacturing companies.Alternative criteria: rank one for Made-to-order, rank six for Assembly-to-order, rank fifth for stock, rank fourth for Single unit production, rank second for small or medium batch, and rank three for large batch. According to research, manufacturing firms from poor nations would benefit most from organizational improvements relating to Made-to-Order, small or medium batches, and big batches in the framework of Industry 4.0.

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