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Benchmark the best factory data collection system (FDC) using AHP-GRA method

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Abstract

Purpose – The purpose of this paper is to propose a multi-criteria decision making method to evaluate factory data collection (FDC) system alternatives.

Design/methodology/approach – "Information" in is fundamental resource to the success of any business which is as valuable as capital or people. The factory data (information) collection system (FDC system) consists of the various paper documents, terminals, and automated devices located throughout the plant for collecting data on shop floor operations for compiling and processing the data. In this paper, nine alternatives of FDC methods are evaluated on the basis of eight criteria. The weight of each criterion is determined using Analytic Hierarchy Process, and the same weights are used to evaluate alternatives of FDC system using Grey Relational Analysis – A multi-criterion decision making method.

Findings – The methodology facilitates the selection of the best FDC system that will minimize the data entry time and chances of errors. The methodology suggests Radio-Frequency Identification (RFID) system is the most preferred choice (ideal) among the nine alternatives whereas Operation tear strips is the worst solution.

Originality/value – The proposed methodology will provide a useful tool to the decision maker, which may help to eliminate the associated risks during data entry. The selected best FDC system, i.e. RFID is most suitable tool for ERP system to integrate internal (manufacturing) and external (sales and service) management information system.

Keywords Information management, Decision support systems, Analytical hierarchy process (AHP), Factory data collection (FDC) system, Grey relational analysis (GRA)

Paper type Research paper

1. Introduction

Various techniques are used to collect data from the factory floor. These techniques range from clerical methods that require workers to fill out paper forms that are later compiled, to fully automated methods that require no human participation. The factory data collection (FDC) system consists of the various paper documents, terminals, and automated devices located throughout the plant for collecting data on shop floor operations, plus the means for compiling, and processing the data. The FDC system serves as an input to the order progress module in shop floor control, as illustrated in Figure 1. It is also an input to priority control, which affects order scheduling. The FDC system collects various types of data on factory operations such as piece counts completed at each work center, direct labor time expended on each order, parts that are scrapped, parts requiring rework, and equipment downtime. The data collection system can also include the time clocks used by employees to punch in and out of work (Groover, 2009). The ultimate purpose of the FDC system (Figure 1) is to supply status and performance data to the shop floor control system and to provide current information to production foremen, plant management, and production control personnel.

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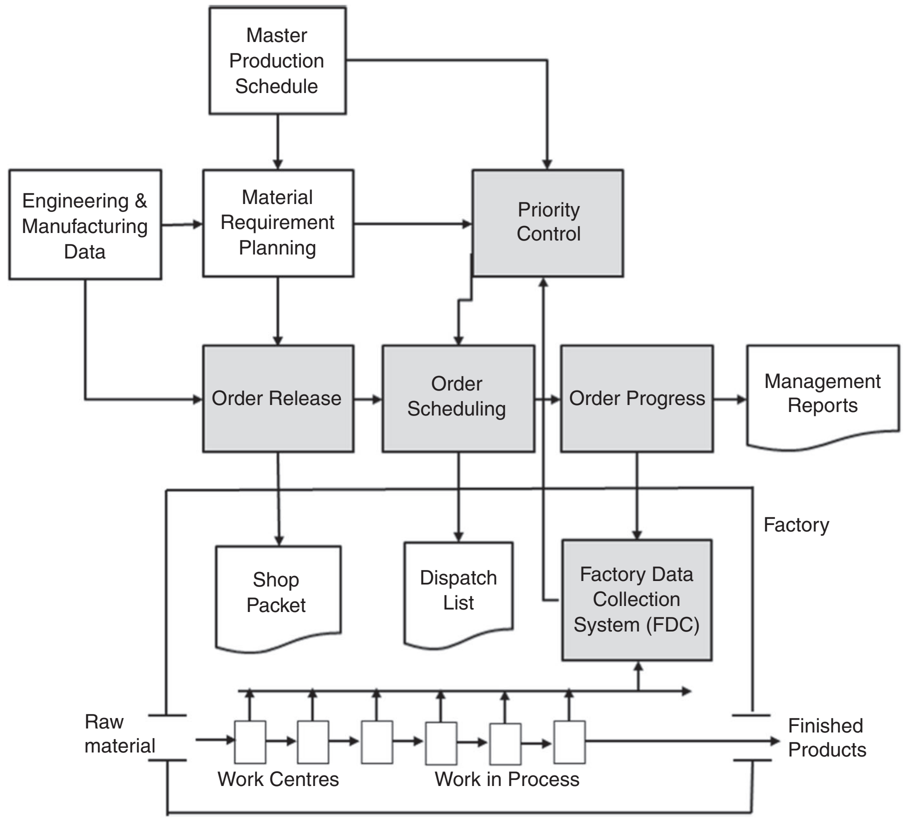

Figure 1.
Factory data collection system

Source: Groover (2009)

To accomplish this purpose, the FDC system must input data to the plant computer system. In current CIM technology, this is done using an on-line mode, in which the data are entered directly into the plant computer system and are immediately available to the order progress module. The advantage of on-line data collection is that the data file representing the status of the shop can be kept current at all times. As changes in order progress are reported, these changes are immediately incorporated into the shop status file. Personnel with a need to know can access this status in real time and be confident that they have the most up-to-date information on which to base any decisions. Even though a modern FDC system is largely computerized, paper documents are still used in factory operations, and our coverage includes both manual (clerical) and automated systems (Groover, 2009).

To be competitive in the market and to face the global challenges, manufacturing industries have to select and adopt an appropriate manufacturing strategies and techniques. The selection of the best strategies and/or technique is complex as it involves more than one dimension. In most of the situations, the decision maker has to evaluate a wide range of alternatives based on a set of conflicting criteria to choose the best alternative by including various dimensions like technological, economic, social, and legal, etc. Although there have been significant applications of multi-criteria decision making (MCDM) technique reported MCDM in the literature, but there is scarce in application of MCDM technique for selection of the best FDC system. Hence, MCDM methods are the most specific way to solve such complex problem. In this work, nine different FDC methods (alternatives) are identified and evaluated on the basis of eight criteria. The weight of each criterion is determined using Analytic Hierarchy Process (AHP). A MCDM method – Grey Relational Analysis (GRA) is used to evaluate alternatives of FDC system. The paper is organized in five sections. Relevant literature has been given in Section 2. This is followed by the detailed description on systematic methodology for generating and evaluating various FDC system alternatives in Section 3. Application of the methodology for selection of the best FDC system has been given in Section 4 and finally Section 5 discusses the results and conclusion.

2. Literature review

Efforts have been made by few researchers related to factory data system in a shop floor and supply chain environment. Riddick and Loreau (1997) mentioned that increasing shop floor efficiency through scheduling has become one of the major concerns in manufacturing industries. The manufacturers have to overcome the problem mainly: difficulty in putting the information needed for scheduling; and reacting to changes in the shop floor environment that occurred after the schedule has been started. Methods to facilitate the transfer of data for the production of initial schedules must be devised along with methods to reschedule based on updated information from the shop floor. They described a model which shows shop floor status data and defined a simple message protocol for communicating shop floor status information for which an integrated system has been developed. The general architecture of the system, the components of the system, and the function of each of the components also described. Then, an information model which describes entities needed to maintain shop floor status has been presented.

The effect of inventory inaccuracy on supply chain management was simulated by Fleisch and Tellkamp (2005). It has been shown that inventory inaccuracy is a main issue in businesses dealing with physical assets. The relationship between inventory inaccuracy and performance is examined in a retail supply chain. They simulated a three echelon supply chain with one product in which end-customer demand is exchanged between the echelons. In the base model, they considered that without alignment of physical inventory and information system inventory, inventory information becomes inaccurate due to low process quality, theft, and items becoming unsalable. But in a modified model, it is also considered that these factors that cause inventory inaccuracy are still present, but physical inventory and information system inventory are aligned at the end of each period. The results in the literature indicate that an elimination of inventory inaccuracy can reduce supply chain costs as well as the out-of-stock level. They also mentioned that an automatic identification technology that is becoming available offers the potential to achieve inventory accuracy.

Gunasekaran *et al.* (2004) emphasize on the measurement of supply chain performance to enhance the organizational productivity and profitability. Their literature on SCM deals with strategies and technologies for effectively managing a supply chain is quite vast. In recent years, organizational performance measurement and metrics have received much attention from researchers and practitioners. The role of these measures and metrics in the success of an organization cannot be overstated because they affect strategic, tactical and operational planning and control. Performance measurement and metrics have an important role to play in setting objectives, evaluating performance, and determining future courses of actions. Performance measurement and metrics pertaining to SCM have not received adequate attention from researchers or practitioners. They have developed a framework to promote a better understanding of the importance of SCM performance measurement and metrics. For the sustenance of the concept like Radio-Frequency Identification (RFID) systems in manufacturing, more efforts needed than execution. Hence Lin (2009) developed an integrated framework for the development of RFID technology, which includes the hierarchy of factors, structural procedure, and the sequence of adoption is presented in the research; and it can be applied in other scenarios after the users make some modifications according to their specific needs.

3. Methodology

This work makes an attempt to develop a systematic methodology (Figure 1) to select the best FDC system based on the various criteria (Figure 2).

3.1 Types of FDC system

The various FDC systems are classified as fully manual and semi-automatic system. The classification of fully manual and semi automatic FDCs is shown in Table I.

3.1.1 Manual (clerical) data input techniques. Manually oriented techniques of FDC require production workers to read from and fill out paper forms indicating order progress data. The forms are subsequently turned in and compiled, using a combination of clerical and computerized methods. The paper forms include the following.

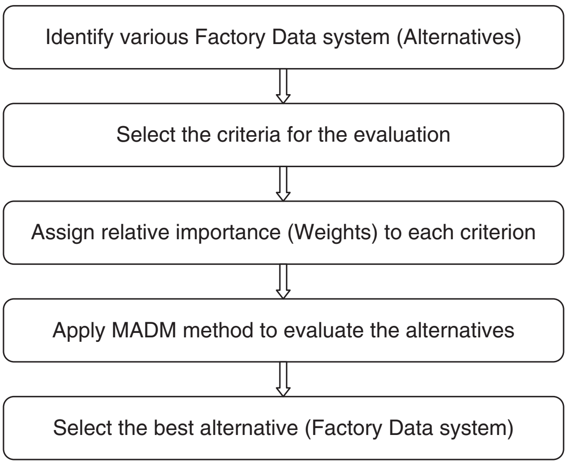

Figure 2. Methodology for selection of factory data collection system

Table I. Types of FDC system

Fully manual FDC	Automatic and semi-automatic FDC
Job traveler	RFID
Employee time sheets	Barcoding
Operation tear strips	One centralized terminal
Pre-punched cards	Workstation terminals

3.1.1.1 Job traveler. This is a log sheet that travels with the shop packet through the factory. Workers who spend time on the order are required to record their times on the log sheet along with other data such as the date, piece counts, defects, and so forth. The job traveler becomes the chronological record of the processing of the order. The trouble with this method is its inherent incompatibility with the principles of real-time data collection (Groover, 2009).

3.1.1.2 Employee time sheets. In the typical operation of this method, a daily time sheet is prepared for each worker, and the worker must fill out the form to indicate work that he/she accomplished during the day. The time sheet is turned in daily, and order progress information is compiled (usually by clerical staff).

3.1.1.3 Operation tear strips. With this technique, the traveling documents include a set of preprinted tear strips that can be easily separated from the shop packet. The preprinted data on each tear strip includes order number and route sheet details. When a worker finishes an operation or at the end of the shift, the worker tears off one of the tear strips, records the piece count and time data, and turns in the form to report order progress.

3.1.1.4 Pre-punched cards. This is essentially the same techniques as the tear strip method, except that pre-punched cards is that mechanized data processing procedures can be used to record some of the data to compile the daily progress report.

3.1.2 Automated and semi-automated data collection system. To avoid the problems associated with the manual/clerical procedures, some factories use data collection terminals located around the factory. Workers input data relative to order progress using simple keypads or conventional alphanumeric keyboards. Following are some of the semi-automated FDC systems mentioned.

3.1.2.1 Barcode system. A barcode system is a network of hardware and software, consisting primarily of mobile computers, printers, handheld scanners, infrastructure, and supporting software. Barcode systems are used to automate data collection where hand recording is neither timely nor cost effective. Barcode systems are less costly, easy to use, less error proofs, non recyclable when compared to RFID systems. Certain types of data such as order number, product identification, and operation sequence number can be entered with automated techniques using barcoded or magnetized cards included with the shop documents. But the main problem with the Barcode system is that it is not feasible to use in the Oily/wet condition as barcodes are not working properly when they get wet by oil. Otherwise in many manufacturing plants where there is proper atmosphere to use the barcodes; there mobile devices for scanning barcodes can be used to operate FDC at low cost. The comparison of barcode with RFID is shown in Table II.

Sr. no.	Barcode system	RFID system
1.	Less costly than RFID	More costly due to reader cost
2.	Oily atmosphere destroys life of barcodes	No effect of coil on transponder as well as on reader
3.	Initial as well as operating cost high	Operating cost low, initial cost high
4.	There are some technical issues on operating level	Problems occurs in barcode already eliminated in RFID
5.	Easy to understand first time time	Difficult to understand first time
6.	POKA-YOKE weaker than RFID	POKA-YOKE stronger than RFID

Table II. Barcode compared with RFID

3.1.2.2 RFID systems. RFID is the use of a wireless non-contact system that uses radio-frequency electromagnetic fields to transfer data from a tag attached to an object, for the purposes of automatic identification and tracking. RFID systems are more costly, reliable, error free than barcode systems.

3.1.2.3 One centralized terminal. In this arrangement there is a single terminal located centrally in the plant. This requires all workers to walk from their workstations to the central location when they must enter the data.

3.1.2.4 Satellite terminals. In this configuration, there are multiple data collection terminals located throughout the plant. The number and locations are designed to strike a balance between minimizing the investment cost and maximizing the convenience of the plant workers.

3.1.2.5 Workstation terminals. The most convenient arrangement for workers is to have a data collection terminal available at each station workstation. This minimizes the time lost in walking to satellite terminals or a single central terminal.

3.2 Define attributes/criteria

Table III shows the criteria for FDC and the expected affinity in the matrix. The criteria are taken from the shop point of view to the system point of view. The proposed solution should at least satisfy all the criteria in ideal manner. The selection of criteria completely depends upon the actual problems faced by shop floor personnel and management to ensure data in the ERP system. The criteria are selected after discussion with personnel at various positions in the organizations such as plant head, project head, PPC head, SAP head, IT head, and department head where this system is to be implemented. The ratings are taken from these personnel.

3.3 Decide weights (w_j) of different attributes using AHP technique

One of the most popular analytical techniques for complex decision making problems is the AHP. Saaty developed AHP which decomposes a decision making problem into a

Table III.
Criteria for evaluation

No.	Attribute	Criteria/attribute description	Affinity
B_1	Cost of the project (CP)	It states the running cost, installation cost and Maintenance cost of the system	Lower
B_2	Time to update in the system (TC)	It states actual time required to flow the data from shop to ERP system	Lower
B_3	Real-time data update (RT)	It states that all the data from the warehouse of supplier to the end of customer should be available at any time, with right comportment, to any person to take imp decisions	Higher
B_4	Data entry time (DE)	It states the time required to shop floor worker to punch the data in the shop floor	Lower
B_5	Robustness (RO)	It states that the system should rigid enough so that not easily failed by the external atmospheric conditions	Higher
B_6	Chances of error (CE)	It states that while operating the system on the shop floor, the occurrences of errors may tend the bad impact on the SCM	Lower
B_7	Easiness (ES)	It states that the system should be so easy to operate in the shop atmosphere	Higher
B_8	Reliability (RY)	It states that the system should be reliable i.e. available at any time without failure	Higher

system of hierarchies of objectives, attributes (or criteria), and alternatives (Saaty, 1980). In AHP, it is essential to develop a hierarchical structure with a goal or objective at the top level, the attributes at the second level and the alternatives at the third level. A fundamental scale used for conversion of linguistic term into numerical assessment is shown in Table IV (Saaty, 1980). In this paper, eight criteria are considered for the comparison and evaluation of FDC system. The weights w_j (for $j=1, 2, \ldots, M$) of each criteria is calculated such that:

$$\sum_{j=1}^{m} w_j = 1$$

The pair-wise comparison matrix is then prepared. Assuming M attributes the pair-wise comparison of attribute "I" with attribute "j" yields a square matrix $B_{M\times M}$ where b_{ij} denotes the comparative importance of attribute "i" with respect to attribute "j." In the matrix $b_{ij}=1$, when $i=j$ and $b_{ij}=1/b_{ij}$. The pair-wise comparison matrix is shown in Table V.

Find the relative normalized weight (w_{j}) of each attribute by calculating the geometric mean of ith row using Equation (1) and normalizing the geometric means of rows in the comparison matrix using Equation (2):

$$GM_i = \prod_{i=1}^{M} \left[b_{ij}\right]^{1/M} \tag{1}$$

Numerical assessment	Linguistic meaning
1	Equal importance
3	Moderately more importance
5	Strongly more importance
7	Very strongly importance
9	Extremely more importance
2,4,6,8	Intermediate value of importance

Source: Saaty (1980)

Table IV. A fundamental scale for conversion of linguistic term into numerical assessment

Criteria	B_1	B_2	B_3	B_4	B_5	B_6	B_7	B_8
B_1	1	1	1/3	1	1	5	1	1
B_2	1	1	1	1	1	5	1/3	1
B_3	3	1	1	3	3	3	3	3
B_4	1	1	1/3	1	1	5	1	1
B_5	1	1	1/3	1	1	3	1	1
B_6	1/5	1/5	1/3	1/5	1/3	1	1/5	1/5
B_7	1	1	1/3	1	1	5	1	1
B_8	1	1	1/3	1	1	5	1	1

Note: Consistency ratio = 0.06524

Table V. Pair-wise comparison matrix

$$w_j = \frac{GM_i}{\sum_{i=1}^{M} GM_i} \quad (2)$$

The weights of these eight attributes are shown in Table VI. The consistency ratio (CR) must be equal to or less than 0.1 (Rao, 2007). It reflects the judgments given by the decision maker are consistent (perfect) regarding the problem under study. The CR is calculated as 0.06524. Hence the judgments are consistent.

3.4 MCDM

MCDM refers to making decisions in the presence of multiple, usually conflicting criteria. MCDM can be broadly classified into two categories: Multiple Attribute Decision Making (MADM); and Multiple Objective Decision Making. Each decision table (also called decision matrix) in MADM methods has four main parts, namely: alternatives; attributes; weight or relative importance of each attribute; and measures of performance of alternatives with respect to the attributes. The decision matrix is shown in Table I. It shows alternatives, A_i (for $i = 1, 2, \ldots, N$), attributes, B_j (for $j = 1, 2, \ldots, M$), weights of attributes, w_j (for $j = 1, 2, \ldots, M$) and the measures of performance of alternatives, m_{ij} (for $i = 1, 2, \ldots, N$; $j = 1, 2, \ldots, M$). It may be added here that all the elements in the decision table must be normalized to the same units so that all the possible attributes in the decision problem can be considered. Table VII shows the decision matrix for MCDM.

Table VI.
Weights of attributes

	Attributes	Weights
B_1	Cost of the project	0.1161
B_2	Time consumption to update in the system	0.1272
B_3	Real-time data update	0.2667
B_4	Data entry time	0.1161
B_5	Robustness	0.1083
B_6	Chances of errors	0.0333
B_7	Easiness	0.1161
B_8	Reliability	0.1161

Table VII.
Decision matrix for MCDM

	Attributes				
Alternatives	B_1 (W_1)	B_2 (W_2)	B_3 (W_3)	… …	B_m (W_4)
A_1	M_{11}	M_{12}	M_{13}	…	M_{1m}
A_2	M_{21}	M_{22}	M_{23}	…	M_{2m}
A_3	M_{31}	M_{32}	M_{33}	…	M_{3m}
…	…	…	…	…	…
…	…	…	…	…	…
A_n	M_{n1}	M_{n2}	M_{n3}	…	M_{nm}

Source: Rao (2007)

3.4.1 GRA. The grey system theory is proposed by Deng (1982). GRA solves MCDM problems by combining the entire range of performance attribute values being considered for every alternative into one, single value. This reduces the original problem to a single attribute decision making problem. Therefore, alternatives with multiple attributes can be compared easily after the GRA process. The procedure of GRA is given below:

Step 1: Grey relational enerating.

When the units in which performance is measured are different for different attributes, the influence of some attributes may be neglected. Therefore, processing all performance values for every alternative into comparability sequence, in a process analogous to normalization, is necessary. This processing is called grey relational generating in GRA.

For MCDM problem, the *i*th alternative can be expressed as $A_i = (y_{i1}, y_{i2}, y_{i3}, \ldots, y_{ij}, \ldots, y_{im})$ where *yij* is the performance value of attribute *j* of alternative *i*. The term *yi* can be translated into the comparability sequence $X_i = (x_{i1}, x_{i2}, x_{i3}, \ldots, x_{ij}, \ldots., x_{im})$ using Equations (3) and (4):

$$x_{ij} = \frac{y_{ij} - \text{Min}\{y_{ij}, i = 1, 2, ..., n\}}{\text{Max}\{y_{ij}, i = 1, 2, ..., n\} - \text{Min}\{y_{ij}, i = 1, 2, ..., n\}} \quad (3)$$

$$x_{ij} = \frac{\text{Max}\{y_{ij}, i = 1, 2, ..., n\} - y_{ij}}{\text{Max}\{y_{ij}, i = 1, 2, ..., n\} - \text{Min}\{y_{ij}, i = 1, 2, ..., n\}} \quad (4)$$

Equation (3) is used for larger-the-better attributes and Equation (4) for the smaller the better attributes (Kuo *et al.*, 2008).

Step 2: Reference sequence definition.

After the grey relational generating procedure, all the performance values are scaled into [0,1] an alternative will be the best choice if all of its performance values are closest to or equal to 1,however, such type of alternative may not exist. The reference sequence X_0 is to be defined as $(x_{01}, x_{02}, x_{03}, \ldots, x_{0j}, \ldots, x_{0m}) = (1, 1, \ldots, 1, \ldots, 1)$, and then aims to find the alternative whose comparability sequence is the closest to reference sequence.

Step 3: Grey relational coefficient calculation.

Grey relational coefficient is used for determining how close x_{ij} and x_{0j}. The larger the grey relational coefficient, the closer x_{ij} and x_{0j} are. The grey relational coefficients can be calculated using Equation (5):

$$\gamma(x_{0j}, x_{ij}) = \frac{\Delta_{\min} + \zeta\Delta_{\max}}{\Delta_{ij} + \zeta\Delta_{\max}} \quad (5)$$

where $\gamma\,(x_0 j, xij)$ is the grey relational coefficient between x_{0j} and x_{ij}, and $\Delta_{ij} = |x_{0j} - x_{ij}|$ $\Delta_{\min} = \text{Min}\ \{\Delta ij,\ i = 1,\ 2, \ldots, n;\ j = 1,2, \ldots, m\}$, $\Delta_{\max} = \text{Max}\ \{\Delta ij,\ i = 1,\ 2, \ldots, n;\ j = 1,2, \ldots, m\}$, ζ is the distinguishing coefficient, $\zeta \in [0,1]$.

The distinguishing coefficient can be taken by the decision maker exercising judgment. The rank order of alternative remains always same though the different coefficient are adopted (Kuo *et al.*, 2008). After grey relational generating, Δ max will be equal to 1 and Δ min will be equal to 0. In this paper, the distinguishing coefficient is set as 0.5.

Step 4: Grey relational grade calculation.

After calculating the entire grey relational coefficient γ (x_{0j}, x_{ij}), grey relational grade can be calculated using the below equation:

$$\Gamma(X_0, X_i) = \sum_{j=1}^{m} w_j \gamma\left(x_{0j,} x_{ij}\right) \quad for\, i = 1, 2, \ldots, n \tag{6}$$

Γ (X_0, X_i) is the grey relational grade (PDSI) between X_0 and X_i. It represents the level of correlation between the reference sequence and the comparability sequence. The grey relational grade indicates the degree of similarity between the reference sequence and the comparability sequence. If the comparability sequence for an alternative gets the highest grey relational grade with the reference sequence, it means that the comparability sequence is most similar to the reference sequence, and that alternative would be the best choice.

4. Example

The objective of this paper is to identify the best FDC system. The alternatives of this FDC systems are job traveler (A_1), employee time sheets (A_2), operation tear strips (A_3), pre-punched cards (A_4), barcoding (A_5), RFID (A_6), one centralized terminal (A_7), satellite terminal (A_8) and work-station terminal (A_9). The decision matrix (Table) of nine alternatives and eight criteria is shown in Table VIII.

Step 4.1: Grey relational generating, X_{ij} (normalization).

In GRA, the first step is to normalize the data of decision matrix. The comparability sequence, X_{ij} for larger-the-better attributes for the smaller the better attributes is determined using Equations (3) and (4), respectively. The sample calculation to obtain the comparability sequence, X_{ij} for smaller the better attributes, i.e. cost of the project is shown in Table IX.

Step 4.2: Grey relational coefficient (γ) calculation.

The grey relational coefficients (γ) can be calculated using Equation (5). The grey relational coefficients for nine alternatives are shown in Table X.

Step 4.3: Grey relational grade calculation (Γ).

Table VIII.
Decision matrix

	Criteria							
Alternatives	B_1	B_2	B_3	B_4	B_5	B_6	B_7	B_8
Weight	0.1161	0.1272	0.2667	0.1161	0.1083	0.0333	0.1161	0.1161
A_1	5	1	1	5	5	1	5	3
A_2	5	1	1	7	3	3	7	3
A_3	5	1	1	5	5	1	3	3
A_4	5	1	1	1	1	1	1	1
A_5	3	7	7	7	1	7	7	1
A_6	3	7	7	7	7	5	7	5
A_7	1	7	7	7	7	5	1	5
A_8	1	7	7	7	7	5	1	5
A_9	1	7	7	7	7	5	1	5

The grey relational grade for each alternative is determined (Table XI) using Equation (4). The alternative with highest grey relational grade with the reference sequence would be the best choice.

5. Result and conclusion

The result of the proposed approach applied for the selection of the best factory data system is shown in Table XI. From the Table XI, it is understood that factory data system alternative; RFID is the most preferred choice among the nine alternatives. "RFID" is the best ideal solution whereas "Operation tear strips" the worst solution.

The RFID tag can be affixed to an object and used to track and manage inventory, assets, people, etc. For example, it can be affixed to cars, computer equipment, books, mobile phones, etc. RFID offers advantages over manual systems or use of barcodes.

A_i	y_{ij}	X_{ij}	Δ_{ij}	γ
A_1	5	0	1	0.333
A_2	5	0	1	0.333
A_3	5	0	1	0.333
A_4	5	0	1	0.333
A_5	3	0.5	0.5	0.500
A_6	3	0.5	0.5	0.500
A_7	1	1	0	1
A_8	1	1	0	1
A_9	1	1	0	1

Table IX. Comparability sequence, X_{ij} for the attribute cost of the project (CP)

A_i	B_1	B_2	B_3	B_4	B_5	B_6	B_7	B_8
A_1	0.33	0.33	0.33	0.42	0.6	1	0.6	0.5
A_2	0.33	0.33	0.33	0.33	0.42	0.6	1	0.5
A_3	0.33	0.33	0.33	0.42	0.6	1	0.42	0.5
A_4	0.33	0.33	0.33	1	0.33	1	0.33	0.33
A_5	0.5	1	1	0.33	0.33	0.33	1	0.33
A_6	0.5	1	1	0.33	1	0.42	1	1
A_7	1	1	1	0.33	1	0.42	0.33	1
A_8	1	1	1	0.33	1	0.42	0.33	1
A_9	1	1	1	0.33	1	0.42	0.33	1

Table X. Grey relational coefficients (γ)

Sr. no.	Alternative	Γ value	Rank
1	Job traveler	0.4458	5
2	Employee time sheets	0.4493	4
3	Operation tear strips	0.4259	7
4	Pre-punched cards	0.4330	6
5	Optical barcoding	0.6927	3
6	RFID	0.8455	1
7	One centralized terminal	0.8261	2
8	Satellite terminal	0.8261	2
9	Workstation terminal	0.8261	2

Table XI. Grey relational grade (Γ) values and ranking of the alternatives

The tag can be read if passed near a reader, even if it is covered by the object or not visible. Although "Bar coding" system is another option after RFID but, the RFID tag can be read inside a case, carton, box or other container, and unlike barcodes, RFID tags can be read hundreds at a time. Barcodes can only be read one at a time. Also in some places like indoor logistics barcode is not feasible whereas outdoor long distance logistics, RFID will not be suitable due to movement constraints of cards. Although the cost of the RFID project is considerable high but time consumption to update in the system is so negligible. Also as soon as the RFID tags get punched in front of readers, the real-time data get easily stored and accessible to anyone in ERP end user system. Data entry time is negligible in RFID since the operator in the shop just has to show the card in front of reader. Hardware Robustness is also best in case of RFID and it can work in any robust conditions. In the shop floor, during manual data entry, wrong data or multiple entries for the same data may enter in the ERP system. Barcoding system doesn't have control on repetitive entries, i.e. multiple entries may get created with single barcode. In case of RFID, these possibilities are completely eliminated as unique number is assigned to RFID card. Hence, chances of errors are less and can be easily traced out and reliability of RFID is good as compared to other FDCs. Although RFID has potential to implement in the organization but adaptability by people, infrastructure availability, and system compatibility may influence the implementation. Future scope of this application of RFID can be extended in supply chain from tracking the product from source to end customer.

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