Digital manufacturing and its role in enhancing environmental sustainability::A Case Study in the Northern State Cement Company / Badoush Expansion Cement Factory in Nineveh Governorate

د.صفوان الراوي

كلية الادارة والاقتصاد-جامعة الموصل

م.م نور صباح عيسى

كلية الادارة والاقتصاد-جامعة الموصل

م.م مأوى ربيع احمد

كلية الادارة والاقتصاد-جامعة الموصل

Abstract:

The current study aims to diagnose digital manufacturing and its role in enhancing environmental sustainability through a field test and a case study at the Northern state Cement Company/Badoush Cement Plant Expansion. The researchers developed a virtual model using theoretical literature on this topic. Hence, in order to emphasize the correlation and the nature of the influence between the two variables, this study adopts digital manufacturing and its role in enhancing environmental sustainability, as the study relied on the extent of its direct impact on enhancing environmental sustainability and focusing on the ninth goal related to industry, innovation, infrastructure, and at the level of the cement industry factory - Badoush Expansion - In Nineveh Governorate. Therefore, the research framework is to determine the extent to which the laboratory management uses digital manufacturing technologies such as 3D printing and advanced robotics, enhancing production processes, reducing waste, and promoting sustainable and customized manufacturing. To achieve this goal, the Quality House has been adopted as a measure that determines the extent of the impact of digital manufacturing in achieving quality. In manufacturing and production, according to a matrix represented by the Quality House, which publishes the quality function in the researched company and identifies the main reasons for the failure to achieve quality according to the FTA (fault tree analyses) by directly asking questions about the most important reasons for failure in digital manufacturing and knowing the extent of its impact on quality and thus its reflection on achieving development. Sustainability in general and environmental sustainability in particular.

Keywords: digital manufacturing, environmental sustainability, Badoush Cement Factorybstract

1. Literature review

1-1:digital manufacturing

Digital manufacturing is a process of making products digitally, which has completely changed the way products are made traditionally through factories and machines. This integration of technologies such as robotics, artificial intelligence, and advanced materials to production line systems has led to minimizing costs while increasing effectiveness like never before seen. This paper dives into this world: what is digital manufacturing These questions will be answered along with discussions on various technologies involved including their benefits illustrated through different industry applications automotive, aerospace, consumer electronics among others demonstrating how customized products can be achieved at lower costs due to its adoption. These platforms act like OSs: digital manufacturing systems that provide an array of applications plus services, allowing the data collected on the shop floor to be made accessible to various software applications **(Lin, L., Kollipara, P. S., & Zheng, Y. (2019)** Through these platforms, business intelligence applications obtain insights from operational state data and information about machining processes which in turn helps optimize manufacturing processes not just for efficiency but quality and flexibility too Chen, **(Z., Li, J., & Zheng, Y. (2021)**The role played by digital manufacturing in enabling application scenarios as well as ICT-based digital extensions for physical assets is instrumental: it leads cloud-based design integration with production (manufacturing) systems, thereby fostering innovation while also driving collaborations among different departments within an organization (or even among different companies) with advanced technologies being adopted thanks due their identification during such reviews By promoting collaboration through cloud-based design work and driving advancements at system levels (including materials & procedures) identified ... In response to the integration challenges, companies can achieve the greater efficiency in their manufacturing operations by implementing Computer Integrated Manufacturing Systems (CIMS) **(Kimmig, J., Zechel, S., & Schubert, U. S. (2021)** The establishment of IoT and CPS technologies along with CIMS has broadened the horizons of the integration phenomenon in production which leads to a more coordinated and connected system at a wider level through machines and devices within the manufacturing process Through digital means, manufacturing is capable of functioning as a single well-coordinated entity where all components involved are continuously tuned for optimal performance and output. This includes control facilitated by automation over such equipment as industrial robots and CNC-machines that adapt their operations based on real-time conditions ensuring both effectiveness and efficiency **[. Kurapati, et. (2023)** A standardized approach for achieving collaborative sharing and utilization of manufacturing resources must reach systemized planning and control not only at different levels but also across varying locations, underscoring the need for a coherent framework to foster efficiency in digital manufacturing systems The future holds promise for distributed manufacturing through Cyber-Physical Systems (CPSs) as a supportive arm of flexible manufacturing operations, signaling waves of innovation on efficiency within the manufacturing industry As an illustration, DMG Mori is using CELOS. This is a system that enables the control and operation of machines in a digital manufacturing environment because it is application-oriented it has been tailored for processes that take place digitally [Other platforms such as ADAMOS (an open network and digital market) target the machine construction industry specifically within digital manufacturing and are built on Microsoft Azure's strong foundation **(Chang, et. (2018).** Through adoption of these core technologies, firms can revamp their manufacturing abilities; make processes more nimble, easier to go through, yet effective with higher output; and adaptability in the increasingly digitalized manufacturing landscape. The introduction of digital manufacturing has changed the automotive industry significantly by providing an all-encompassing platform that integrates different functions plus software services towards efficiency enhancement and production processes optimization shop floor data at your fingertips. Accessibility for applications like production planning or quality management, among others: this facilitates easy coordination between different departments, leading into streamlined operations with enhanced performance capabilities altogether The way these platforms work is that they merge both functions **(Winkless, L. (2015)** and software services together; this creates interfaces whose implementation provides operational state plus machining process data for business intelligence applications, which would otherwise not be available with any other source of information about production and overall equipment effectiveness (OEE) The digital manufacturing platforms in the automotive industry are able to expose such services through IT standard interfaces like API Rest or OT standards such as

OPC-UA. This leads to the establishment of an application developers' ecosystem: an innovative environment that allows continuous improvement to take place **(Challagulla, et. (2020).** Recent developments of nanomaterial applications in additive manufacturing: a brief review. *Current Opinion in Chemical Engineering*, *28*, 75-82.. What makes these platforms even more interesting is that they paint a complete picture of the manufacturing context from the product itself down to the workers involved in the production line. They also ensure a holistic approach towards production optimization and efficiency by taking into consideration all related aspects within the value network The primary goal behind services offered by

1-2:sustainable development

Says the French folk wisdom "Qui veut voyager loin menage sa monture" in the sense of wanted to travel must save his energy to reach his goals, this wisdom carries with it a definition of the term sustainable development, as the concept of sustainable development appeared for the first time during the work of the Scientific Committee for Environment and Development organized by the United Nations in 1983 in the report issued by the former Prime Minister of the State of Norway, which was published in 1987 entitled "The future for all "Nortre avenir a tous" as this report touched on the concept of Development and taking into consideration the situation Present and future generations At the Earth Summit held in Rideau Janeiro, sustainable development was adopted as a policy to which all countries are committed so as not to cause damage to the environment or to human health and the economy as a result of the irrational exploitation and wastefulness of natural resources (**Nassima and Jamal, 172,2021).**

There have been many definitions of sustainable development, but they all agree on achieving interaction in the social, economic, accounting, and environmental dimensions, and that its goal is to create integrated and compatible environmental development. It is possible to present a set of viewpoints for a number of writers if they define it (**Zhou & etal, 2015, 1133**) as an organizational principle that maintains limited The resources necessary to meet the needs of future generations in order to continue life on this planet .

It was described by(**Manea, Rocsana, 2015, 31**) from the perspective of the various human sciences. From the perspective of sociology, sustainable development closely maintains social relations and society. From the economic perspective, it ensures that the per capita income of future generations is not less than the per capita income of the current generation. From the environmental perspective, it preserves biodiversity, essential ecosystems and environmental processes,

(**Romiguer 2011, 6**) sees sustainable development as a term applied to economic and social development, allowing practitioners to meet the needs of the present without compromising the ability of the leading generations to provide for their needs. It seeks to achieve integration and interconnection between its economic, social and environmental dimensions at the same time without compromising any of them. With the ability to continue and communicate from the perspective of its exploitation of natural resources. (**Al-Zibari, 40, 2021**)

1-3:The concept of environmental sustainability

Since 2000, environmental sustainability has become one of the Third Millennium Development Goals (MDG).

The seventh goal, as environmental sustainability is considered the deeply buried roots that connect the three systems (the economic system, the social system, and the ecological system) in sustainable development, as the beginnings of interest in environmental sustainability were implicitly among the concerns about the necessity of sustainable development, which is based on three pillars:

Economy, society, and environment. An environmentally sustainable system should maintain a stable base of natural resources

It avoids excessive depletion of renewable resources, including agricultural land productivity and air balance, and environmental sustainability was part of the development of sustainable development (**Israel, 2005, 131**).

It has been defined (as making decisions and reducing the negative impacts of human activities, in addition to taking measures to use non-renewable resources wisely, fairly and equitably for the current generation and the future generation. **Yuan, 2013, 177**)) (**Morelli, 2011, 23**) added that environmental sustainability It can be defined as a condition of balance, flexibility, and interconnectedness that allows the needs of human society to be met, provided that these needs do not exceed the capacity of the ecosystems supporting them, and work continues to renew the services necessary to meet those needs.

(Moldan, et.al, 2012, 15) pointed out that environmental sustainability is maintaining natural services at required levels because there is a relationship between these services and human well-being, and the tangibility of this relationship is the basic characteristic of supporting and preserving environmental systems, maintaining the quality of these natural services. It involves caring for life-supporting ecosystems globally (concerning for the services provided by nature means caring for nature itself). Therefore, environmental sustainability depends on responsible management of natural and human resources that works to maintain the needs of current generations and preserve the interests of subsequent generations. This challenge facing individuals and societies requires making great efforts to educate the population about this problem.

Sustainability means protecting natural resources from human pressures, avoiding excessive use of fertilizers and pesticides that pollute surface and groundwater, and overexploiting forests and fisheries at unsustainable levels (**Mohamed et al., 2015, 349).(Al-Talibi and Hussein, 2018,361**)agree that environmental sustainability is a strategy that places the environment among business priorities in all activities and events carried out by society and companies to achieve optimal use of environmental resources and ensure their sustainability for the benefit of future generations.

1-4:The importance of environmental sustainability:

Companies contribute to maintaining the integrity of the vital environment by reducing resource consumption and reducing the generation of waste and pollution, as well as their effects on ecosystems, land, water, and air. This contribution has positive effects on the organization’s performance, maintaining its reputation, and reaching optimum use of raw materials. Energy, water, and protection from exposure to fines through the possibility of renewing (using) the product and environmentally friendly products (**Rebitzer, et al., 2004, 713)**.

The importance of environmental sustainability is highlighted in protecting natural resources necessary to ensure the protection of humans, such as water, air, land, and biological diversity, so that it does not lead to their significant deterioration through pollution, carbon dioxide accumulation, the elimination of the ozone layer, and the elimination of natural habitats that allow...

By ensuring biodiversity, this is done by combating pollution, reducing energy consumption, and protecting non-renewable resources. This dimension is translated into the concept of caring for the environment or taking care of it, and they attribute this to achieving what is called environmental efficiency, which leads to creating value, achieving quality of life, caring for the environment, and improving the quality of goods, services, and sustainable consumption. For continuity, development, and cleanliness of operations and distribution (**Smouts, 2005, 5).**

1-5: Requirements for achieving environmental sustainability:

The requirements for achieving environmental sustainability are as follows: **(Khudari, 83, 2014,)**

1- The use of non-renewable resources should be paid for the purpose of increasing renewable resources.

2 - The rate of consumption of non-renewable resources should not exceed their growth rate.

3- The rate of consumption of non-renewable resources should not exceed the ability to replace them with new materials.

4 - The rate of pollution should not exceed the environment's ability to deal with this pollution.

5 - The rate of production of inorganic materials should not exceed nature's ability to decompose them.

1-6: Dimensions of environmental sustainability:

Sustainable development is only achieved by achieving integration and close interrelation between three basic elements, which are: the economic, social and environmental aspects of development. Ignoring the social or environmental dimension negatively affects the economic dimension.

First: the economic dimension

This dimension focuses on achieving economic growth in a sustainable manner without harmful impact on the environment and natural resources. This dimension includes **(Mind, 209, 2021):**

- **I.** Sustainable growth: achieving economic growth in a way that ensures its long-term sustainability without depleting resources or creating an unsustainable environmental impact.
- **II.** Resource Efficiency: Improving the effectiveness of the use of economic resources with an emphasis on innovation and technology to improve the productivity of operations.

III. Promoting financial inclusion :Providing economic opportunities for all segments of society, including vulnerable groups, and improving the equitable distribution of wealth.
IV. Striking a balance between economic growth and environmental preservation is an essential part of a sustainable development strategy.

Second: The social dimension

The social dimension of sustainable development focuses on improving the quality of life of communities and ensuring balance and social justice. This dimension includes: **(Mohamed et al., 2015, 342-344)**

I. Social justice: ensuring that opportunities and resources are distributed fairly within society, and reducing gaps between different classes.
II. Improving the quality of life: providing basic services such as education, health, and housing, and ensuring human rights and community participation
III. Promoting diversity and inclusion: supporting cultural diversity and mutual respect among members of society, and enhancing the participation of all segments of society in decision-making.
IV. Focusing on these aspects aims to achieve sustainable social development that works on the well-being and improvement of the lives of all members of society

Third: The environmental dimension

This dimension focuses on protecting the environment and preserving natural resources in a way that allows current and future generations to benefit from them. This dimension includes (**Mind, 219, 2021**)

I. Biodiversity conservation: Maintaining biological and biotic diversity in ecosystems to ensure the sustainability of plants and animals.
II. Natural resource management: using natural resources sustainably and efficiently, and developing techniques to reduce unsustainable consumption.
III. Pollution reduction: Taking action to reduce and prevent environmental pollution and maintain air and water quality.
IV. Climate Change Adaptation: Planning for the impacts of climate change and developing strategies to adapt communities to these challenges.
V. Climate Change Adaptation: Planning for the impacts of climate change and developing strategies to adapt communities to these challenges.

VI. This dimension aims to maintain the health of the environment and ensure the sustainability of ecosystems, which contributes to creating a sustainable environment for life on Earth.

1-7: Sustainable development goals

The United Nations sought to follow a purposeful and comprehensive strategy that combined economic development, social integration, and environmental sustainability, through several sustainable development goals consisting of (17) goals and (169) targets, which were approved on September 25, 2015 for the period 2015 - 2030 to be stable foundations. To achieve sustainable development throughout the world as follows **(Al-Sabaawi, 2022, 43-44) (Shalihi, Touati, 72-75, 2017), (Masoudi et al., 205, 2019) (United Nations report 2017):**

I. Poverty eradication: Providing a sustainable source of livelihood and eliminating poverty in all its forms and types in all countries.

II. Total eradication of hunger: ending hunger, achieving food security and improving the level of nutrition while promoting and developing sustainable agriculture.

III. Good health and well-being: Ensuring a good healthy life and promoting well-being for everyone, of all ages and genders, and reducing child and maternal mortality.

IV. .4. Quality education: Increasing access to education at all levels and ensuring comprehensive and equal quality education while enhancing learning and knowledge opportunities permanently and for all.

V. Gender equality: achieving gender equality and justice, empowering all women and girls, and supporting women.

VI. Clean water and sanitation: Ensuring permanent abundance and sustainable management of water and health, and providing sanitation services for all.

VII. Clean and affordable energy: Universal access to sustainable new energy services at affordable prices that suit everyone.

VIII. Decent work and economic growth: Promoting comprehensive and sustainable growth and creating and making decent work opportunities available to all working-age members of the population.

IX. Industry, innovation and infrastructure: Establishing a resilient infrastructure, encouraging and stimulating comprehensive industrialization, and supporting and encouraging innovation.

X. Reducing inequalities: Reducing and reducing inequality between countries and within a single country.

XI. Sustainable cities and communities: Making cities and human settlements inclusive, resilient and sustainable.

XII. Responsible consumption and production: ensuring sustainable production and consumption patterns.

XIII. Climate action: Working to address climate change and its effects on countries.

XIV. Life under water: preserving seas, oceans and marine resources.

XV. Life on land: combating desertification, managing forests sustainably, protecting terrestrial ecosystems and stopping their degradation.

XVI. Peace, justice, and strong institutions: creating peaceful societies, providing justice for all, and building effective, accountable, and comprehensive justice and accountability institutions at all levels.

XVII. Establishing partnerships to achieve goals: Supporting and enhancing the means of implementing and revitalizing the global partnership in order to achieve development goals.

It is clear from the above that the sustainable development goals related to the environment are as follows:

I. . Clean water and sanitation: ensuring permanent abundance and sustainable management of water and health, and providing sanitation services for all.

II. . Clean and affordable energy: Universal access to sustainable new energy services at affordable prices that suit everyone.

III. . Sustainable cities and communities: making cities and human settlements inclusive, resilient and sustainable.[1]

IV. . Responsible consumption and production: ensuring sustainable production and consumption patterns.

V. . Climate Action: Working to address climate change and its effects on countries.

VI. . Life Underwater: Preserving seas, oceans and marine resources.

VII. . Climate Action: Working to address climate change and its effects on countries.

VIII. . Life Underwater: Preserving seas, oceans and marine resources.

IX. . Life on land: combating desertification, managing forests sustainably, protecting terrestrial ecosystems and halting their degradation

2- Methodology

The field of study was a case study at Northern Iraqi Cement Company .It is a company established in the Northern Cooperative for Cement after the merger of the Rafidain National Cement Company, which was established in 1953, with the governmental Hammam Al-Alil Cement Authority, and it was named Mosul Cement Company as an administrative and political result. And the economic changes over the past decades, the company has witnessed several administrative changes as a result of adding production lines or annexing or separating other productive factories from its management.

The study relies on qualitative research to obtain in-depth knowledge from the participants. The studyers gathered information by conducting interviews with members of the cement plant's management team. The study's validity is dependent on the management team's experience and expertise. Based on the views of respondents, a fault tree analysis (FTA) was used to provide possible key explanations for failure of each matrix at House of Quality. Samples of 5 respondents in the cement factory included as shown in table (4.1):

The Quality House has been adopted as a measure that determines the extent of the impact of digital manufacturing in achieving quality in manufacturing and production, and according to a matrix represented by the Quality House, which specializes in spreading the quality function in the researched company and identifying the main reasons for the failure to achieve quality in digital manufacturing and what digital manufacturing will add to it according to the tree of errors, thus reflecting This helps achieve sustainable development in general and environmental sustainability in particular.

Table (4.1) Respondents of the study

Respondents	Role	Education	Experience
Respondent (1)	factory manager	Bachelor	22 years
Respondent (2)	Purchases Manager	Bachelor	13 years
Respondent (3)	Store manager	Bachelor	21 years

Respondent (4)	manager of Marketing	Bachelor	11years
Respondent (5)	maintenance manager	Bachelor	15years

The data collection method based on the following steps shown in the figure (4.1)

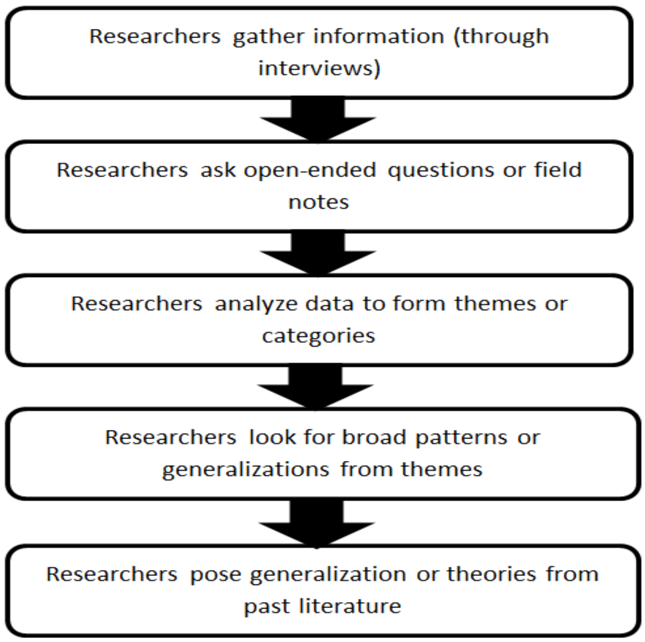

Figure 4.1: inductive logic of study in qualitative study (Creswell, 2009).

Following data analysis and identification of key possible failure events, studyers constructed FTA in each HoQ matrix and estimated average weights for each of the basic failure events based on respondent opinion.

Finally, for each of the House of Quality matrices, the probability of occurrence of a top event that leads to system failure as well as system reliability can be determined using the following equations (Ericson, 1999):

- OR Gate
  $P(Q) = A(Q) + B(Q)$ (1)
- AND Gate

P (Q) = A (Q). B (Q) (2)

- R = 1 – P (Q) (3)

2-1:Results and Discussion

Based on data obtained through interviews with Cement plant staff, and after studying and analyzing these data, Fault Tree Analysis was constructed for each of HoQ matrices, estimated average weight of failure of basic event, Probability of failure and Reliability were also calculated for each matrix, as shown below:

2-1-1Customer Requirement

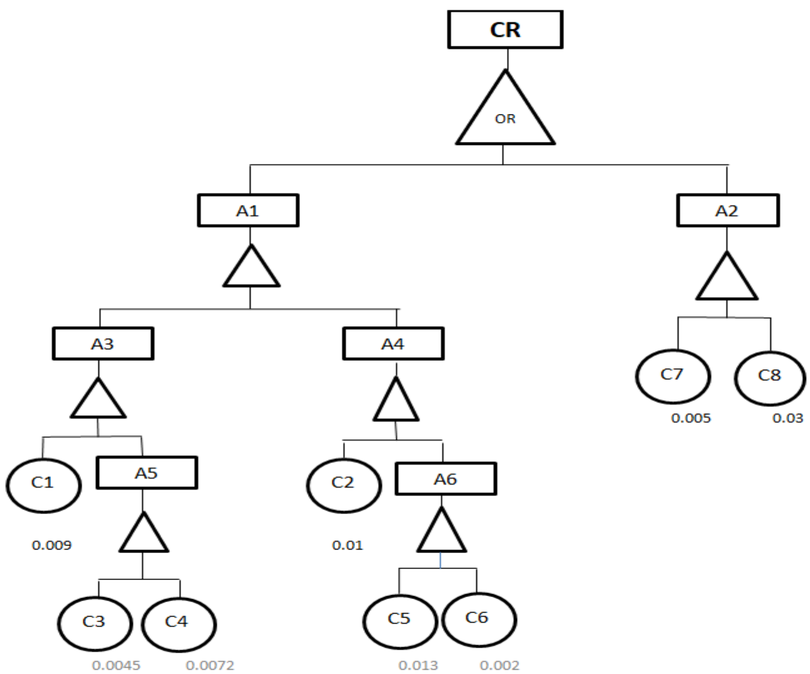

Figure (5.1): FTA of customer requirement

Table (5.1) Codes of events

code	Events	Code	Events
CR	Customer requirements	C1	Quick response digital failure
A1	Failure in defining customer's requirement	C2	Suitable Price failure
A2	Failure in digital survey	C3	Unprofessional employees

A3	Services failure	C4	Ethical problem
A4	Product specifications failure	C5	Fail to mix materials in correct proportions
A5	Customer treatment failure	C6	Raw materials failure
A6	Quality failure	C7	Lack of experience
		C8	Misleading information

P (Q) = A1 + A2

P (Q) = A3 + A4 + C7 + C8

P (Q) = C1 + A5 + C2 + C6 + C7 + C8

P (Q) = C1 + C3 + C4 + C2 + C5 + C6 + C7 +C8

P (Q) = 0.0807

R = 1 – 0.0807 = 0.9193 = 91.93%

It is noticed from the FTA that p =0.0807. R== 0.9193

This indicates that the customer's voice has an important role in this company and is mainly adopted in determining product specifications

It was found through (FTA) that C6 the failure is the most influential in the matrix, which has the effect of determining the specifications that go into the design and composition of the product.

2-1-2:Competitive Assessment

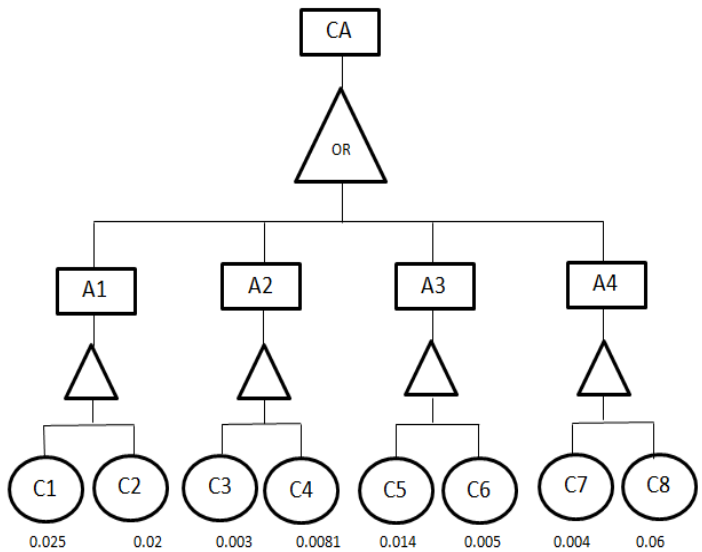

Figure (5.2): FTA of competitive assessment

Table (5.2)

Code	Basic events	Code	Basic events
CA	Competitive assessment Failure	C3	Reign accessibility &Strategy failure
A1	Customer requirement failure	C4	E-marketing failure
A2	Marketing failure	C5	Failure in adapting new technologies
A3	Technology failure	C6	Lack of experience
A4	External environment failure	C7	Adapting new rules and regulations failure
C1	Product Specifications failure	C8	Failure in responding to economy change
C2	Services failure		

P (Q) = A1 + A2 + A3 + A4

P (Q) = C1 + C2 + C3 + C4 + C5 + C6 + C7 + C8

P (Q) = 0.1391

R = 1 – 0.1391 = 0.8609 = 86.09%

It is noticed from the FTA that $p = 0.1391$. $R = 0.8609$

It is noticed through (FTA) that (C3), which means that failure to define or plan a Reign accessibility &Strategy failurehas a great impact on the failure of this matrix in general, which plays the primary role in marketing the product in light of competition in the market.

2-1-3:Relationship Matrix

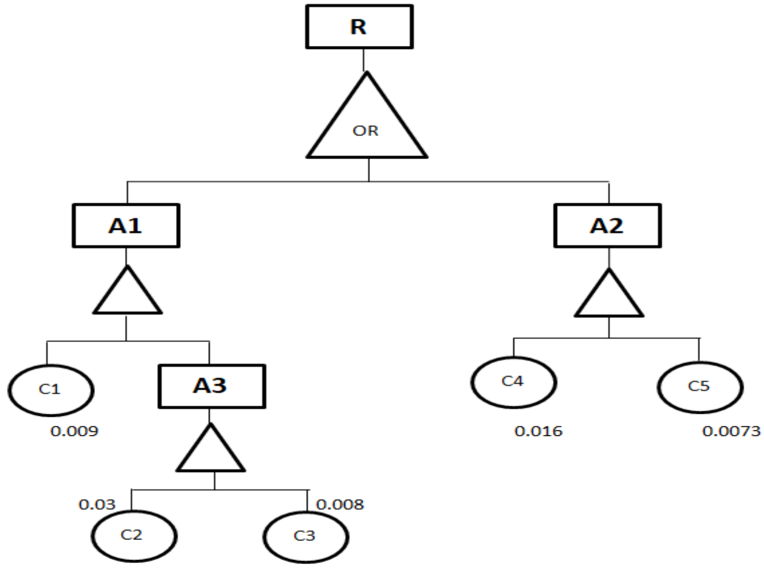

Figure (5.3): FTA of Relationship matrix

Table (5.3)

Code	Events	Code	Events
R	Relationship failure	C1	Disqualification digital skills
A1	Failure in Customer needs survey	C2	Complicated
A2	Failure in personal experiences	C3	Changeable
A3	Requirements are unclear	C4	Lack of skills
		C5	Lack of knowledge in new digital forms

P (Q) = A1 + A2

P (Q) = C1 + A3 + C4 + C5

P (Q) = C1 + C2 + C3 + C4 + C5

P (Q) = 0.0703

R = 1- 0.0703 = 0.9297 = 92.97%

It is noticed from FTA that p =0.0703. R= 0.9297

It is noticed through (FTA) that (C5), which means that Lack of knowledge in new digital forms has a significant impact in determining the reasons for failure to employ customer requirements in the manufacturing process as a whole

2-1-4:Technical Assessment

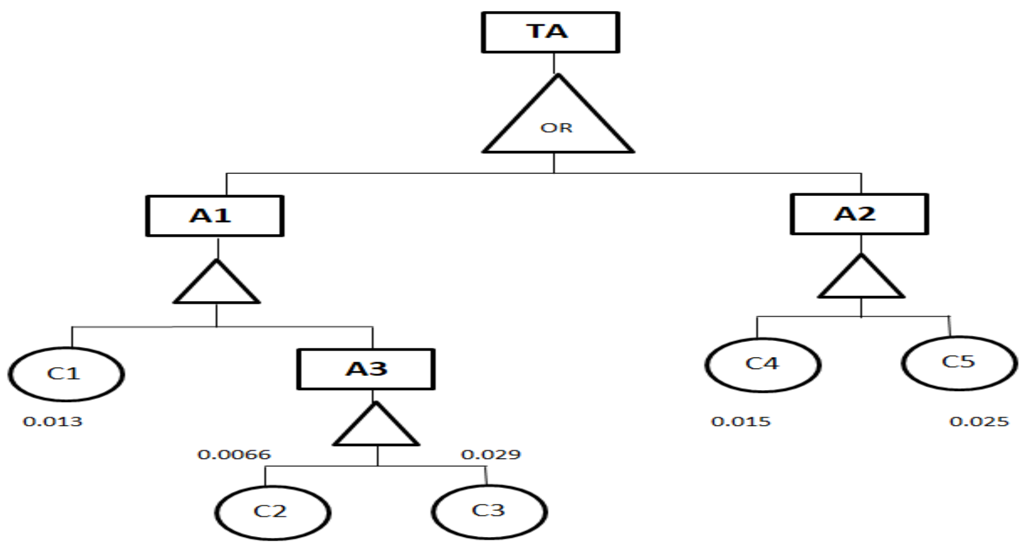

Figure (5.4): FTA of technical assessment

Table (5.4)

Code	Events	Code	Events
TA	Technical assessment Failure	C1	Product performance indicators
A1	Failure in Determine the indicators	C2	Time
A2	Failure in Competitive analysis	C3	Services
A3	Reliability	C4	Market researches
		C5	Product characteristics of competitors and the company

P (Q) = A1 + A2

P (Q) = C1 + A3 + C4 + C5

P (Q) = C1 + C2 + C3 + C4 + C5

P (Q) = 0.0886

R = 1 – 0.0886 = 0.9114 = 91.14%

It is noticed from FTA that p =0.0886. R= 0.9114

It is noticed through (FTA) that (C2), time is the most reliable cause of failure in product preparation and placing it on the market

2-1-5:Engineering Specifications

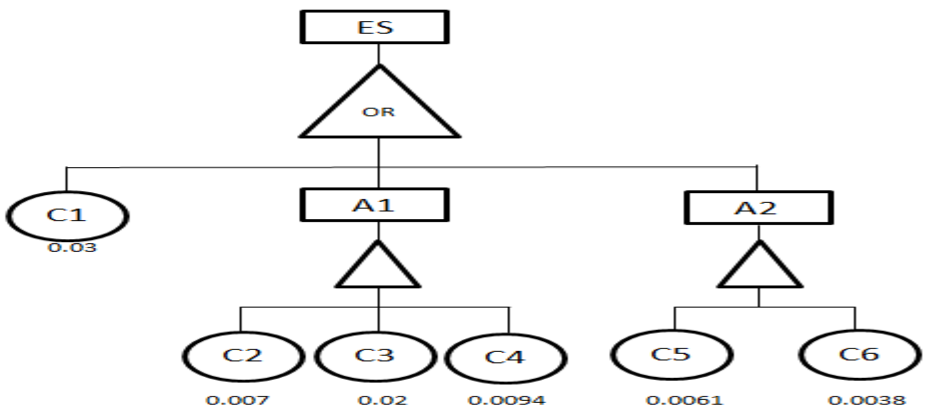

Figure (5.5): FTA of engineering specifications

Table (5.5)

Code	Events	Code	Events
ES	Engineering specifications failure	C3	Lack of maintenance
A1	Failure in machines	C4	Wrong use of machines
A2	Lack of experience	C5	Lack of training
C1	Failure in safety system	C6	Random employment & specialization in new digital technic
C2	Environmental failure		

P (Q) = C1 + A1 + A2

P (Q) = C1 + C2 + C3 + C4 + C5 + C6

P (Q) = 0.0763

R = 1 – 0.0763 = 0.9237 = 92.37%

It is noticed from FTA that p =0.0763. R= = 0.9237

It is noticed through (FTA) that (C6) is the main cause of failure to translate the customer's voice into engineering specifications that are included in his design, due to Random employment & specialization in new digital technic.

2-1-6:Trade Off

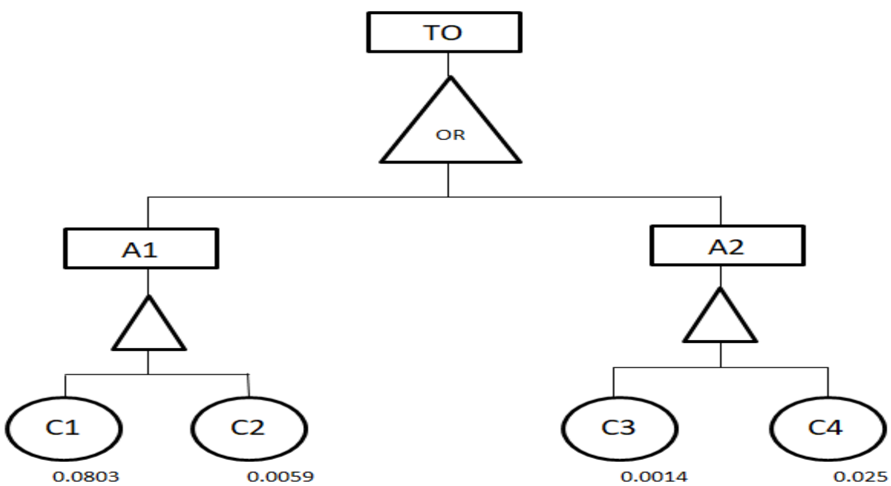

Figure 5.6: FTA of trade off matrix

Table (5.6)

Code	Events	Code	Events
TO	Trade off failure	C1	Customer's requirements failure
A1	Product planning failure	C2	Engineering properties
A2	Failure in changes	C3	Digitally experience
		C4	Product specifications

P (Q) = A1 + A2

P (Q) = C1 + C2 + C3 + C4

P (Q) = 0.1126

R = 1 – 0.1126 = 0.8874 = 88.74%

It is noticed from FTA that p =0.1126. R= = 0.8874

It is noticed through (FTA) that (C3) the Digitally experience has a great impact in determining the causes of failure to make changes in the product in accordance with the customer's voice

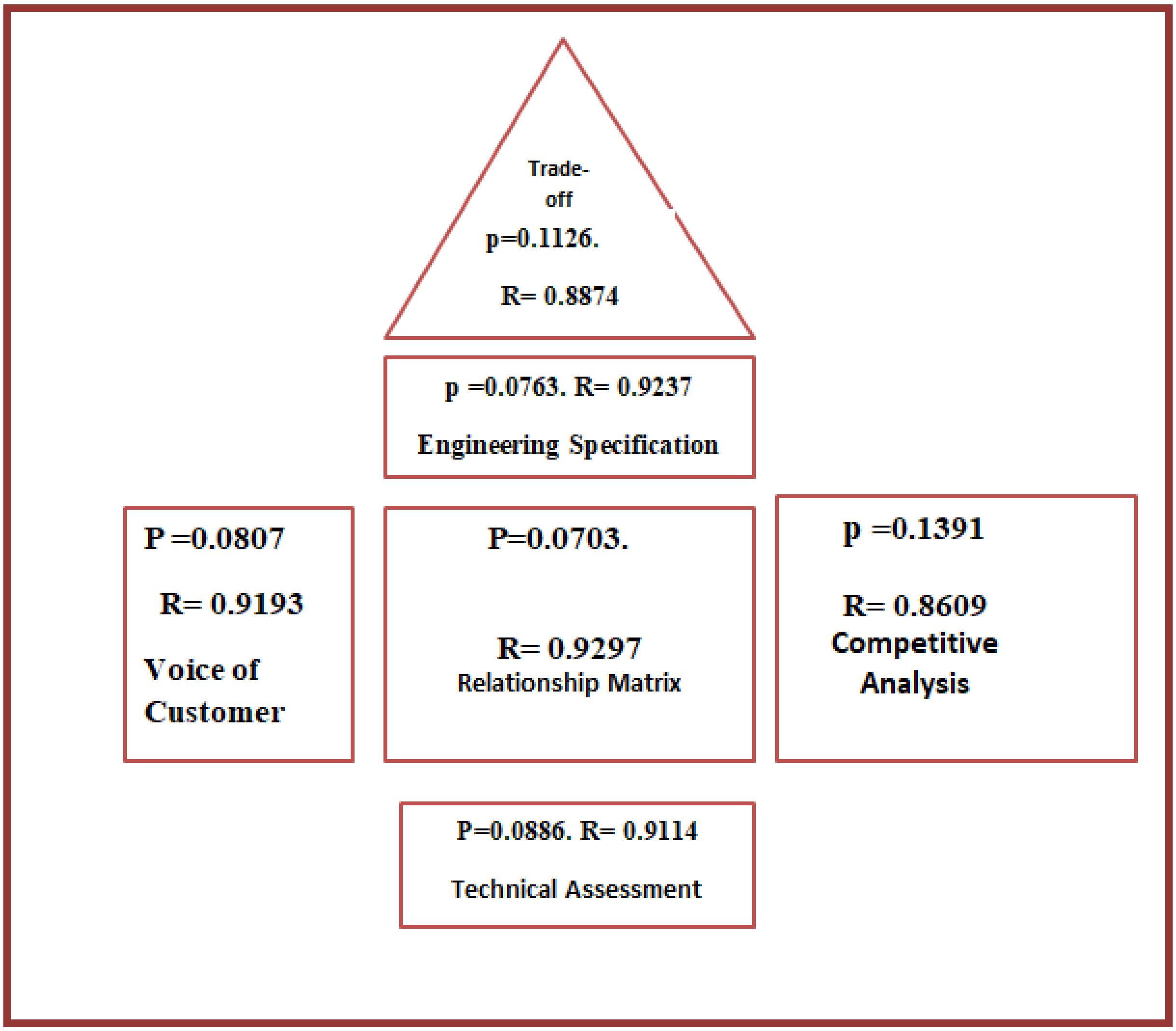

Figure 5.7: HoQ

It is noted from the Quality House that (R) is the largest in the (relationship matrix) = 0.9297. This indicates the importance of adopting digital in the good relationship between translating the customer's voice into engineering and technical specifications that enter into the formation of the company's final product. In other words, the necessity of addressing the causes of digital failure, which It avoids the use of digitalization in manufacturing processes and creates a quality worthy of the company's outputs for the sake of sustainable development and a sustainable environm

3-Conclusion

This study has effectively contributed to finding and examining the causes of failure in each of the company's quality management matrices and answering the questions raised by the study, which also contributed to the focus of managers and stakeholders in the Northern Iraq Cement Company and increased interest in it in terms of digitalization in the company and how to achieve it. To ensure the presence of quality in all manufacturing processes of the product, and according to the Quality House, it was designed according to the fault tree tool. The causes were diagnosed in each matrix, which has a role in shaping the failure in each of them, which helped the company in general to build strategies and adopt long-term solutions for its success and build a house. Quality, which seeks to achieve the main goal of listening to the voice of the customer in order to provide a sustainable environment that contributes to achieving the goals of environmental sustainability.

The results of this study are consistent with the study of Martin et al. This study is entitled (Developing a High-Quality Functional Plan Planning Risk Interactions in Project Planning, 2016)

Which concluded that there is a gap in risk assessment tools available to project planners. There are no effective tools to assess risks in a way that can be easily diagnosed, find the appropriate solution and reduce them.ent.

4-Sources:

1. Al-Khodari, Abdel-Jalil, Saadi, Abdel-Haq, Alwan, Mohamed Lamin, 2020, Environmental Accounting and its Impact on the Dimensions of Sustainable Development in Algerian Economic Institutions, "A Field Study on a Sample of Economic Institutions," Namaa Journal of Economics and Trade, Volume 4, Issue 2, Algeria.

2. Al-Sabaawi, Riyad Ahmed, 2022, Renewable energy and its role in achieving sustainable development, a study in a selected sample of developed countries with special reference to Iraq," unpublished master's thesis, College of Administration and Economics, University of Mosul - Iraq.
3. Al-Talbi Ahmed Abdel-Sattar, Hussein, Alia Ibrahim, 2018, "Elements of green innovation and their impact on defining environmental sustainability: An exploratory study in machinery manufacturing companies. In the private sector in Mosul," Cihan University Journal, Issue 2, Part B - Cihan University Erbil Scientific
4. Al-Zibari, Khano Shaaban, 2021, "Small projects and their role in achieving sustainable development in Iraq as a model 1990-2019," unpublished master's thesis, College of Administration and Economics, University of Mosul, Iraq.
5. Baghdad University of Economic Sciences, Scientific Complex of the Scientific Conference.
6. Challagulla, N. V., Rohatgi, V., Sharma, D., & Kumar, R. (2020). Recent developments of nanomaterial applications in additive manufacturing: a brief review. Current Opinion in Chemical Engineering, 28, 75-82.
7. Chang, J., He, J., Mao, M., Zhou, W., Lei, Q., Li, X., ... & Zhao, X. (2018). Advanced material strategies for next-generation additive manufacturing. Materials, 11(1), 166.
8. Chen, Z., Li, J., & Zheng, Y. (2021). Heat-mediated optical manipulation. Chemical reviews, 122(3), 3122-3179.
9. Khudari, Muhammad, 2014, The role of human development trends in developing social development (a cross-country study), College Journal
10. Kimmig, J., Zechel, S., & Schubert, U. S. (2021). Digital transformation in materials science: A paradigm change in material's development. Advanced Materials, 33(8), 2004940.
11. Kurapati, S. K., Mahendar Reddy, N., Sujithra, R., Kola, R., Ramesh, G. V., & Saritha, D. (2023). Nanomaterials and nanostructures in additive manufacturing: properties, applications, and technological challenges. Nanotechnology-Based Additive Manufacturing: Product Design, Properties and Applications, 1, 53-102.

12. Lin, L., Kollipara, P. S., & Zheng, Y. (2019). Digital manufacturing of advanced materials: Challenges and perspective. Materials Today, 28, 49-62.
13. Masoudi, Muhammad, Masoudi, Ali, Ibrahim, Qaid, 2019, “The relationship between the dimensions of technological development, an analytical framework,” Forum, International Trends in International Trade and Development Challenges, Working Towards Promising Future Visions That Are Beneficial to All, December 2-3, 2019
14. Special issue of the Second International Scientific Conference of Cihan University - Erbil in Administrative and Financial Sciences, June 27-28, 2018, (cIc_ADFS18
15. Winkless, L. (2015). Is additive manufacturing truly the future?. Metal Powder Report, 70(5), 229-232.