SUSTAINABLE PRODUCTION SYSTEMS WITH AI AND EMERGING TECHNOLOGIES: A MODERATOR-MEDIATION ANALYSIS

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Abstract:

Sustainable production systems are crucial for mitigating the environmental impact of industrial processes and promoting sustainable development. The integration of artificial intelligence (AI) and emerging technologies has the potential to revolutionize production systems, enabling more efficient resource utilization and reducing waste. However, the factors that influence the effectiveness of AI and emerging technologies in promoting sustainability outcomes are not well understood.
Moderator-Mediation Analysis is done in this research paper for the evaluation of related factors among the variables with the help of Python programming Language. Aim and objectives are specified with the relevant analysis and constructions. Moderator-Mediation Analysis is done with proper methods and strengths and weaknesses are described accordingly. This research contributes to the understanding of how AI and emerging technologies can be effectively integrated into production systems to promote sustainability. The findings suggest that organizational factors and mediating variables are crucial in harnessing the potential of AI and emerging technologies for sustainable production. The study provides insights for practitioners and policymakers seeking to leverage AI and emerging technologies for sustainable development. Further research is recommended to explore additional factors and contexts that may influence the relationship between AI, emerging technologies, and sustainable production systems.

Keywords: s*ustainable production systems, artificial intelligence, emerging technologies, moderator, mediation, process innovation, eco-efficiency, environmental performance, organizational factors, top management support, employee engagement.*

I. Introduction

"Moderator-Mediation" analysis research paper on a dataset that includes data on energy consumption in production processes within the industry, has aimed to be performed. The purpose of constructing the analysis is to evaluate the sustainable measurement required in the production within the industry. This specific analysis aimed be performed to investigate the relationship between the dependent and independent variables within the dataset. The significance of this analysis is to evaluate the factors that create the strength and weaknesses among the variables of the production factors. These two statistical analyses has aimed to be performed to evaluate the possible factors in structuring the sustainable production system.

With the help of this research paper can be satisfied with the construction of different objectives relevant to the analysis. Therefore, the objectives are structured to achieve the goal of this research paper.
To estimate the methods and process of moderation-mediation analysis.
To construct an effective analysis of the variables of production.
To analyse the strengths and weaknesses among the variables.
To evaluate potential factors responsible for a sustainable production system.

Unsustainable patterns in product consumption and production cause different crises of loss of biodiversity, pollution, and changing climate. Overall, discussion on the potential issues can be referred to the lack of proper knowledge, technology, poor monitoring and evaluation system, misperception of financial and economic factors, and leadership control. These are the potential barriers to a sustainable production system. Therefore, an evaluation of such factors that can be implemented to achieve a sustainable environment in the production and consumption section of the industry has aimed to be structured within the report.

II. Literature Review

The research paper is based on the sustainable production system with AI and emerging tools, hence here researcher provides the information that which process has been implemented. According to the founded data AI technology is also used in environmental developments along with different types of economic setting and their context.

Applications in Moderator-Mediation Analysis

The **Moderator-*Mediation Analysis*** describes the most developed and also technology mechanisms, and beneficial platforms which are recently general in the software growth industry. The phrase is sometimes countered with the bleeding advantage which also guides to the new type of technologies so cannot able to ready for mass advocacy [1]. AI is believed the key tool for performing compelling functional modification in the context of modern firm structure since Artificial Intelligence technology is appearing in several types of forms. Artificial Intelligence can also process the ability which is connected to the perspective of useful machines to assume and also perpetrate comparable kinds of tasks to humans. It is the process where an unbiased outsider helps the detachments to a claim to define their debates and difference of idea resulting in a meeting of minds. It is the specific concept of ***Artificial Intelligence*** that was commenced in the forenamed days but this application can also gain valuable velocity in the current times.

Figure 2.2.1. Cutting-Edge Technology

The firms are infusing multiple parts in enhancing the interpretation of the Information technology boosting the applications to generate intra-firm efficiency for closing improvement. It is expected that the excessive computing procedure will be capable of reviving the tasks

served by the appliance ***learning technology.*** Another type of ***cutting-edge*** tool like the ***blockchain*** emanates usefulness to the production management strategy and nurses in the operating sustainability of the company. This valuable technology is considered helpful to push most values to the industries since it can solve issues that help in the process of supervision to the surface of documents and also authentication of user individuality.

Implementation Process of Sustainable Production Systems with AI and Emerging Technologies

There are so many advanced technologies in the recent market like artificial intelligence, IoT, Deep Learning, Machine Learning, Intrusion Detection, and many more. Technologies help to achieve the work faster with more efficient and accurate results.[2] These technologies are used all over the world to improve work quality and increase the quantity in the same or less time. Artificial intelligence makes suggestions from understanding, studying, or analyzing the data provided. AI brings a great revolution in the Sustainable Production System making sustainable optimization and environmental effects reduce. Reduction of risks, and prediction of natural disasters like hurricanes, floods, and earthquakes can be possible with the help of AI. Sustainable Production Systems can be implemented with recycled materials reducing the carbon effects on the environment. Replacing human abilities and intelligence artificial intelligence is used greatly to enhance the system.

The Internet of Things is used to help to know companies with user interaction with the product, user preferences, and service optimization. Prediction of demand and supply, maintenance schedule, and signs of abnormalities are done by Machine learning. Human intelligence is mainly stimulated by machine learning and analysed after that. Predictions are made with a view to this stimulation and this procedure makes a great impact in the world of Sustainable Production Systems.

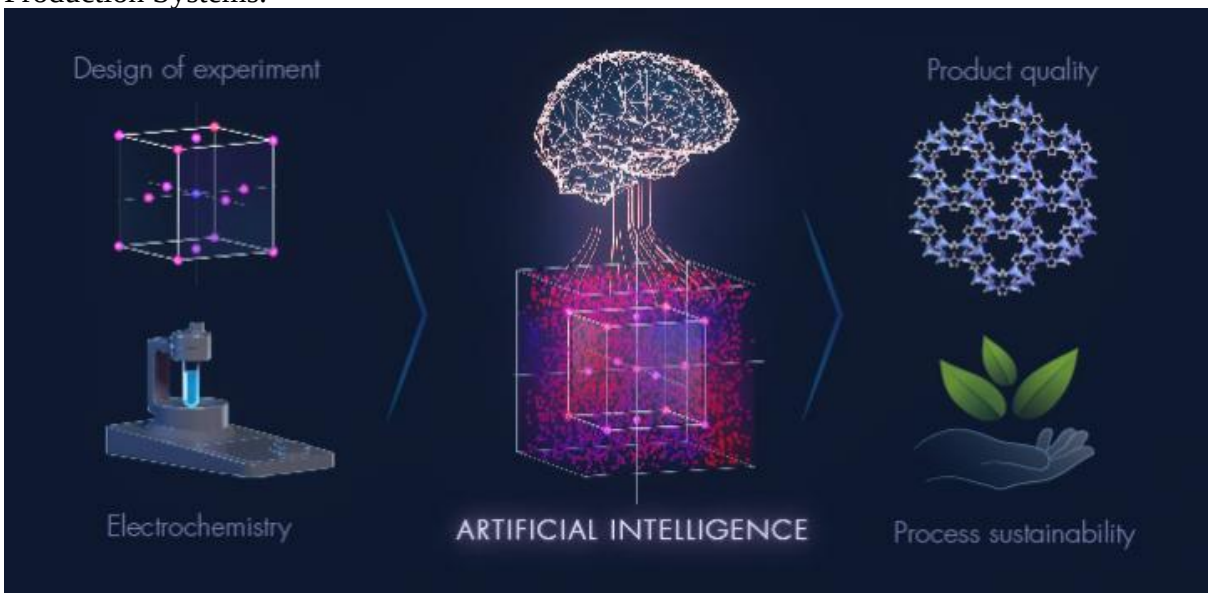

Figure 2.2.2. Sustainable product system with Artificial Intelligence

Advantages of AI Technology to Moderator-Mediation Analysis

AI allows one to grow in a smart and tolerable reaping higher, manner and more profitable outcomes while utilizing fewer aids. Artificial Intelligence certainly can power the following revolution. The governments and AI experts ought to work in a duo to ease AI assuming[3]. It is a clone of the mortal intelligence into devices to do items that people would usually depend

on individually. There are three primary types of ***Artificial Intelligence*** based on its capacities- Weak AI, Super AI, and Strong AI.

- Weak AI - Concentrates on individual tasks and also cannot conduct beyond its constraints.
- Super AI - Exceeds human intellect and can perpetrate any scheme finer than a human
- Strong AI - It can comprehend and discover any academic task that a person can.

There are several kinds of advantages in Artificial Intelligence.

1. Reduction in Human Error. It is always one of the best Benefits of AI which can quite reduce blunders[9]. The determination of AI in every step is resolved by the Facts which are earlier gathered.

2. ***More accurate.*** Artificial Intelligence is very much authentic whether the predictions can also able to optimize efficiency to establish the mediation analysis.

3. ***New Inventions.*** AI is the main operating passion behind the multiple innovations which resolve and support humans in determining the valuable plurality of difficult issues.

2.3 Linkage to aim

The main object of this research paper is to create a sustainable production system with the help of this ***artificial intelligence***, and many other technologies like ***IoT, Deep Learning, Machine Learning,*** and ***Intrusion Detection. Sustainable Production Systems*** are the development of a thing or product with the help of pollutant-free substances[4]. Artificial intelligence brings a revolution to the ***Sustainable Production*** industries making the work easy and efficient. Artificial intelligence helps computers to see and understand situations, understand written languages, study data, create suggestions, and many more. The literature review helps with the research paper by gaining knowledge of previous experiences with the latest technologies.

III. Methodology

Analysis process done with the Python language, hence Researcher has been choosing the particular method which is essential for the development process. The researcher chooses the ***"Moderator-Mediation Analysis"*** method, these processes analyse mechanisms. According to the data, the process analysis of the independent variables provides an effect on the dependent variable, this analysis process continues via intervening variables. Hence this moderation analysis has analysed the conditions which contain the relationship between independent and dependent variables. These analysis processes determine whether the relationship can be dependent on the value of the third variable or not.

Secondary data for the analysis process and also provide the ***"moderation meditation analysis".*** The researcher has been conducting their investigation using the Python programming language, thus Researcher has chosen the specific approach that is crucial for the development process[8]. The moderator analysis method was chosen by the researcher, and this process analyses mechanisms.

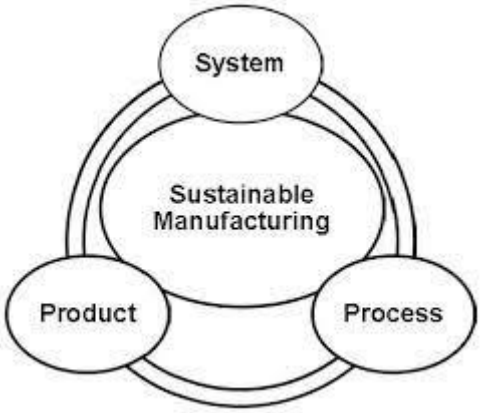

Figure 3.2.1. Life cycle of Sustainable Manufacturing

The results show that the dependent variable is affected by the independent variables' process analysis, which is furthered by intervening factors. As a result, the circumstances that contain the link between the independent and dependent variables have been examined in this moderation study. These analytical procedures establish whether the relationship is susceptible to variation in the third variable's value or not. The researcher has chosen the secondary data for analysis and the developer also makes stratify which has been provided in the process of the implementation.

Justification and Support of Choice

"Moderated mediation analysis" has an essential technique for analysis method, researchers used this method in this analysis. It has been a valuable method or process which describes the indirect effect dependent on the importance of moderating variables. Researchers choose a data frame that has been providing the power consumption data, and based on this researcher used the moderation method [6]. Hence these techniques provide the relationship between an independent variable and the dependent variable.

Figure 3.3.1. Sustainable materials

Chosen data frame varied the 9 columns which are containing the crucial data or information which has been essential for the analysis process. Moderators' analysis helps to judge external validation of the particular study and identify the limitations of the relationship which has been maintained by the independent and dependent variable. The moderation and mediation process has been maintaining some testing processes and it also recommends examining a series of particular models. Most of the time this analysis method has been known as the piecemeal approach and it has been focused on the overall outcome of the pattern. Hence these mediated

agreements help to solve procedural and interpersonal issues which are not essentially exposed to lawful resolution. The developer has been choosing the ***"secondary data"*** for their research along with their mentioned strategy containing specific processes.

Data Collection

The researcher used secondary data for their analysis process, this secondary analysis provides the utilization process of providing data. It also helps to find those question and answer which is different from particular work. The secondary data analysis process could be used large-scale data analysis process, or it is also known as part of personal research.

Figure 3.4.1. Data Collection Method

Secondary data has been found in various resources such as the internet, different libraries, articles and reports, web information, and many more. Hence researcher has chosen a power consumption data frame, according to the data frame containing 9 columns, and all columns has contained the essential data for the research method. This data frame has been used for personal research and this development process research using the ***"mediation analysis"*** process[16].

Validation

A researcher has used the power consumption data frame which is considered various information which has essential. Hence this data frame has been containing the datetime, temperature, humidity, wind speed, diffuse flow various essential information. Hence their researcher has used a particular analysis method and developed a model which has essential for the research method. Researchers employed the "moderated mediation analysis" technique, which is a key technique for analysis methods[7]. A useful strategy or procedure for describing indirect effects that depend on the significance of moderating variables has been developed. Researchers employed the moderation method after selecting a data frame that had been supplying data on electricity consumption. Here used data updated with the present situation and there are all information is original as per the data analysis.

IV. Result and discussion

Moderated mediation, also known as dependent indirect results, happens when the therapeutic effect of an autonomous variable on an output variable through an intermediate variable varies depending on groups of a leader variable. The "mediated moderator" standard concentrates on the moderating influence and the "moderated mediator" prototype process on the mediating

influence. Both samples can be studied using techniques identical to those for stretching mediating leverages. Each type of design, however, also consists of an accessory action to test mediating effects.

The main objective of using mediation and moderation investigation is the invariant inclusion of mediating and moderating processes which can pledge to enhance the quantity of knowledge. The outcomes from the analyses of the effects through developing approximate interventions and testing [8]. Consider breaking down the absolute section to can more implement the actual goal of analysis through Artificial Intelligence. Many types of issues also require consideration and these are

1) Insufficiency of awareness of proportions error.
2) Variable diffusions are inferred to comprise the full scope of feasible values.
3) Unequal pieces across moderator-based types.
4) Preliminary statistical capacity.
5) Artificial classification.

The definition of moderation is assessments related to founded measures and ideals that are fair, impartial, and also accurate. The techniques are uniform, dedicated, and established within the task rejoinder evaluated work. Mediators are also part causal course of an outcome, and how or why a development takes place through Artificial Intelligence.

Evidence of practical work

Practical work refers to the method of understanding and also training activity that can interest the procedure of skill in keeping and controlling real objects, and materials. The whole work is based on the Jupiter notebook where the Python code is running which is also related to the Mediation Analysis. The independent and independent variables are implemented in the Jupiter platform and evaluate the relation between these. Practical work conditions with the tools and tasks that will be demanded to use. Practical work is very much important for any kind of research paper [9]. The practical task also helps to reflect the details of the assignment and done by the Practical work an idea can be more improved than the approach of hearing.

Awareness and Solution to the technical challenges

There are some technical challenges faced during the time of ***Sustainable Production Systems*** implementation with the help of ***artificial intelligence, IoT, Deep Learning, Machine Learning, and Intrusion Detection.***

- Artificial intelligence runs on data and there can be a challenge if the data is insufficient or irrelevant to the topic.
- Challenges can arise with the lack of proper knowledge or experienced personnel.
- Data privacy and data security are also a problem in this research paper as there are chances of user privacy violations[10]. AI mainly runs from analysing data from users which can affect user privacy greatly.
- IoT is defenceless to cyber threats and attacks and IOT devices can be hacked and misused by the hacker raising a great concern to this research paper.
- Python language is used in this research paper which also is not an easy language to code. Sometimes the output results varied and it needs a great level of concentration to make it desired output.

These are the challenges faced during the research paper and to avoid these challenges the research paper needs to be done with proper attentiveness and time. Data deficiency levels can be avoided by feeding more data as fresh and new data is the most effective way of increasing

the quality of the technology. Cyber-attacks can be avoided to great content by securing the data[17].

Novelty

Referring to the novelty of this model implementation it can be stated that the entire implementation process and integration of techniques are applied in an improved way. Previous works in this context applied different techniques for evaluating the outcomes of this particular analysis. However, an advanced technique has been implemented aiming at the achievement of actual outcomes. Thus, it can be stated that the entire research paper work and model implementation is novel to this purpose[11]. Reliability and accuracy of the research paper work refer to the evaluation of significant relations among the variable in the context of sustainability measurement from the dataset.

Interpretation of result

```
data = pd.read_csv('powerconsumption.csv')
data.head()
```

Temperature	Humidity	WindSpeed	GeneralDiffuseFlows	DiffuseFlows	PowerConsumption_Zone1	PowerConsumption_Zone2	PowerConsumption_Zone3
6.559	73.8	0.083	0.051	0.119	34055.69620	16128.87538	20240.96386
6.414	74.5	0.083	0.070	0.085	29814.68354	19375.07599	20131.08434
6.313	74.5	0.080	0.062	0.100	29128.10127	19006.68693	19668.43373
6.121	75.0	0.083	0.091	0.096	28228.86076	18361.09422	18899.27711
5.921	75.7	0.081	0.048	0.085	27335.69620	17872.34043	18442.40964

Figure 4.5.1. Data importing

The “power consumption” data has been imported which reflects nine different columns. Each of the columns holds significant values. “Data. Head ()” has been used for reviewing the first significant rows of the dataset. This dataset holds different data on temperature, humidity, date and time, wind speed, diffuse flows, power consumption zone 1, power consumption zone 2, and power consumption zone 3.

```
# NULL VALUE CHECK
data.isnull().any()
```

```
Datetime                  False
Temperature               False
Humidity                  False
WindSpeed                 False
GeneralDiffuseFlows       False
DiffuseFlows              False
PowerConsumption_Zone1    False
PowerConsumption_Zone2    False
PowerConsumption_Zone3    False
dtype: bool
```

Figure 4.5.2. Null value check

This figure represents the obtained outcome of checking the null values within the dataset. It can be observed that there is no presence of any null values as it resulted in false. Null value mitigation is one of the most important operations while performing any analysis[5]. These null values are responsible for generating unusual errors while providing results against the analysis.

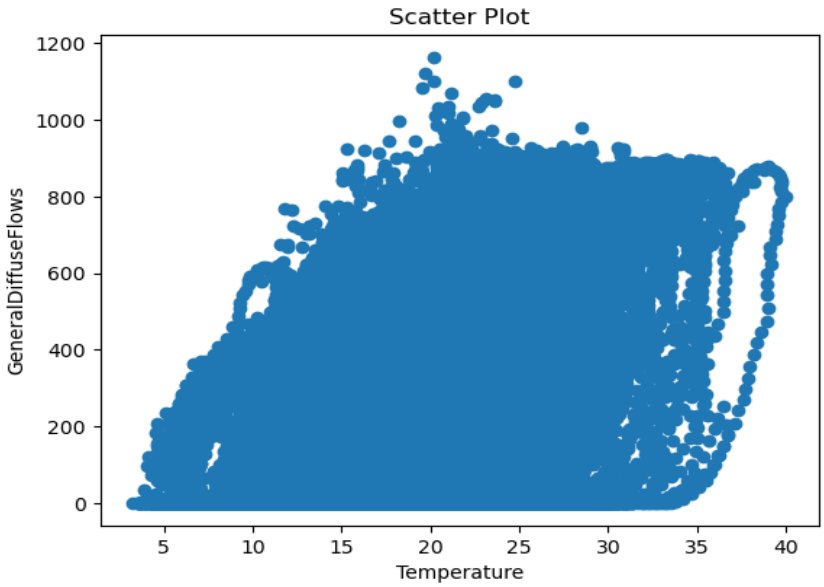

Figure 4.5.3. Scatter plot

The scatter plot has been generated on obtaining the relation between temperature and the general diffusion flow. The analysis has been performed to evaluate the dependency of the variables on each other[14]. It has been observed that the variables are closely related to their natures. The plot depicts that the variable "general diffuser flow" is highly correlated to the variable "temperature". Extensive close presentation of the plots are reflecting highly related variables of the dataset.

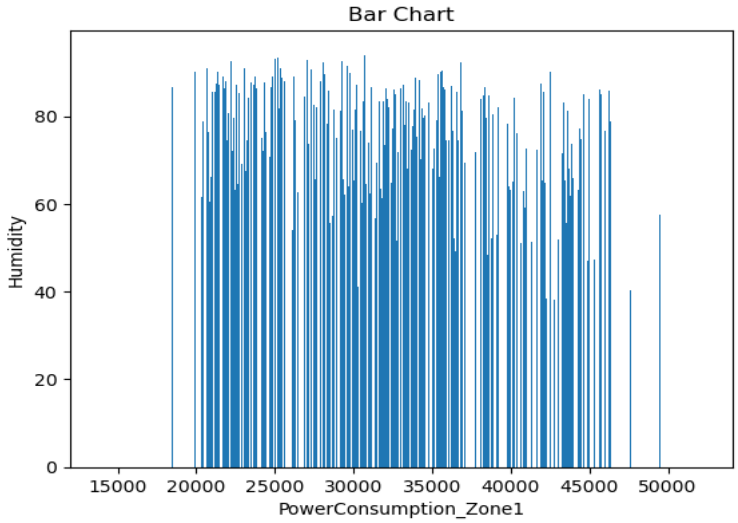

Figure 4.5.4. Bar plot

This bar plot has been obtained by evaluating the analysis of the variables “power consumption zone 1”, and “humidity”. This plot reflects the high relation and effect of humidity on this significant power consumption. The graph represents humidity and power consumption zone 1 in the y and x axis respectively. Bar plot helps in revealing the information segments from the dataset.

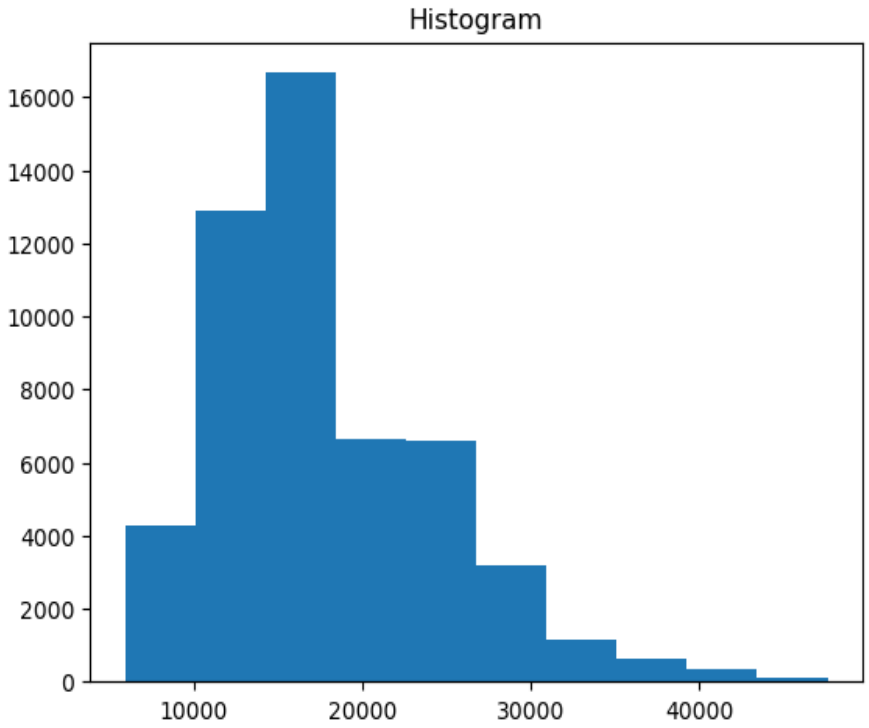

Figure 4.5.5. Histogram Analysis

The variable “power consumption zone 3” has been plotted through histogram analysis.

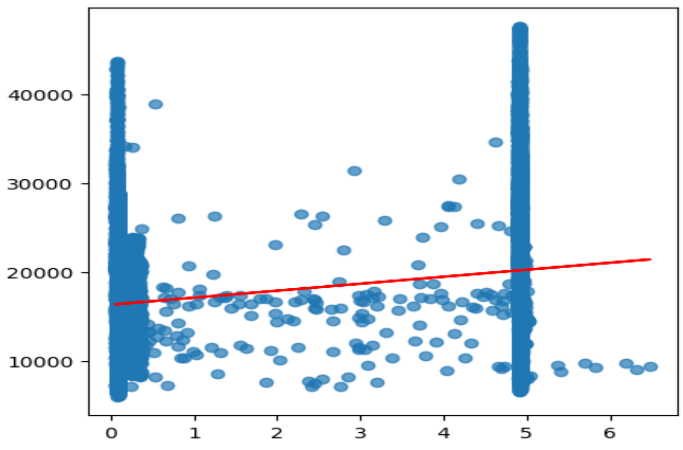

Figure 4.5.6. Scatter plot of Linear Regression

The scatter plot of linear regression has been represented in the above figure. The predicted value of x and y has been plotted through the red line shown in the graph. The linear regression formula “y = [16296.08358483] + [[785.5735576]]*x” has generated by the model.

```
from sklearn.metrics import r2_score
print("r_square score: ", r2_score(y, y_head))
```

```
r_square score:  0.07764056586447743
```

Figure 4.5.7. “R-Square” value of Linear Regression

A linear regression model that has been constructed based on the dataset has provided the r-squared value of 0.077.

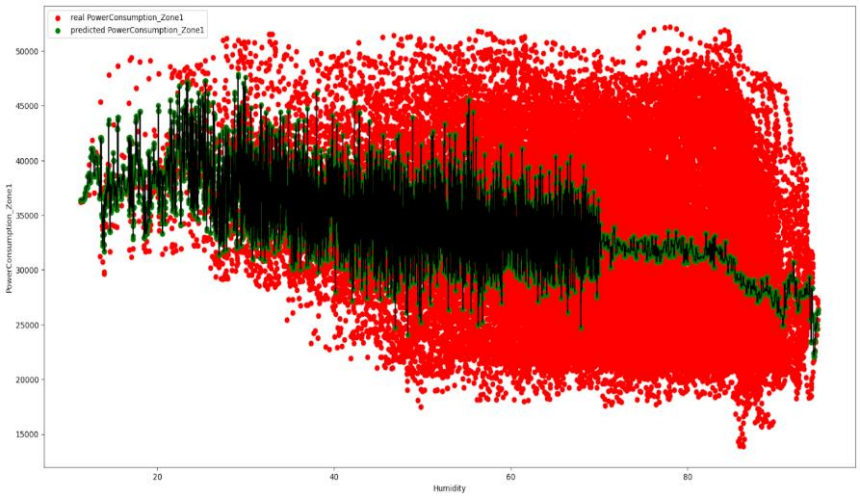

Figure 4.5.8. Scatter plot of Random Forest Regression

This figure is representing the plot obtained from the random forest regression model. The actual and predicted value of the random forest regression has been obtained through the applied codes. These values are then integrated to generate the graph. The red dots represent the real value of the specific variable and the green dots are representing the predicted values of that significant variable. The graph reflects that the real values and predicted values are different with wide values.

```
from sklearn.metrics import r2_score

y_headrf = random_forest_reg.predict(x)
print("r_score: ", r2_score(y,y_headrf))

from sklearn.model_selection import cross_val_score
```

```
r_score:  0.15925959576200566
```

Figure 4.5.9. “R-Square” value of Random Forest Regression

The "R-square value" of this analysis has been obtained from this significant regression. It provides a value of about 0.159. In a comparison of these two models, the random forest regression provides more accuracy than the linear regression.

Use of Tools and Techniques

Jupiter notebook is used as a main tool in this research paper. Jupiter Notebook helps to allow users to compile all data in a single place to show the whole research paper to the audience. Jupiter Notebook also helps to create data visualizations and other parts for the user. Input sources can be allowed to control by the user and feedback is provided directly to the user[13]. The main object of Jupiter Notebook is to keep the requirements of every research paper out-of-the-way of equally the system and each other. Jupiter Notebook is user-friendly, accurate, easy to use, and easy to visualize and this is the reason why Jupiter Notebook is preferred.
Moderator-Mediation Analysis is used mainly as a technology in this research paper. ***Moderator-Mediation Analysis*** is an important process method for evaluating whether a secondary outcome is restricted to the values of a moderating variable. The relation between two variables is not constant but it partially depends on variable number three, called as Moderator variable. The relationship between the two variables constructed and the change in the variable strength is mainly done with the help of the moderator variable. A moderation plan is created first and the collection of data, analysis of that data, interpretation, and review is followed after that. ***Moderator-Mediation Analysis*** simplifies the research paper to a great extent and that is the reason why ***Moderator-Mediation Analysis*** is used as a technology in this research paper[1].

V. Conclusion

Sustainable development goals can be performed through ***Artificial Intelligence*** if it was a valuable dispute that also can substitute for person intelligence and capabilities. Machine learning and Machine perception are also petitions to the sustainable Development Goals. Moderate Mediation is recommended for scrutinizing a series of dummies and also looking at the overall decor of results. The report critically considered all all-possible categories related to the Mediation analysis through Artificial intelligence.

Summary of Achievements

The mediation Analysis quantities which are extent-specific variables in the transmittance form a cause to its effect. The whole report describes the research queries that have to be solved. Possible evidence of Practical work is also mentioned in the discussion section and all types of solutions are specified in different approaches. Moderated mediation standards are especially useful when there is an attraction in the process of comprehending both why and under what specified constraints variables are described to one another.

Reflection

Moderation primarily describes a condition in which the connection through all the perspectives of AI between two constructs is not endless but pivots on the worths of a third mercurial, referred to as a leader variable[16]. I used Jupiter Notebook for Python code implementation for better mediation analysis. We all know that Mediation analysis can pull off with the help of Artificial Intelligence.

Research Recommendation

The whole report describes many risks and also many types of issues in the discussion section. All types of risks and issues have to be solved for better mediation analysis. Some specific types of Experimental designs are more accurate and also appropriate for the process of mediation to meet the perspective requirements for considering a specific mediator[15]. The moderation also can be sampled by the influential exchange between the moderating mercurial.

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