The research on the applications of nanotechnology in textile industries

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Abstract The basic aim of this research study is to describe the application of nanotechnology in textile industries. This research study is based on secondary data analysis for determining the research used E-views software and generated different results. This research study depends upon quantitative analysis and the data collected from different websites and annual reports of textile industries. The descriptive statistical analysis, correlation coefficient analysis, the regression analysis also explains the total equality test analysis of application nanotechnology in textile industries used for determining the research study. This research study is also theory-based and presents some theoretical models related to nanotechnology research showing the application of nanotechnology. According to the overall research, nanotechnology plays a vital and informative role in textile industries.

Keywords nanotechnology (NT), Textile Industries (TI), E-views;

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DOI: 10.47750/RAA/11.1.05

1.Introduction

Nanotechnology constitutes one of the major scientific horizons. It includes several approaches for tweaking particles' molecular characteristics to produce new properties with a wide range of applications. Regularly alluded to as the analysis or manipulation of material with a size between one and one hundred nanometers. Several industries, including electronics, coatings, cosmetics, textiles, and medicine, use engineered nanomaterials. These compounds feature toughness, susceptibility to water, capacity to block UV light, and improved transmission. Nanotechnology has been linked to claims about dramatically better commodities and ground-breaking advances in different fields. It is anticipated to lead to more sources of energy manufacturing and improved welfare. [1]

Therefore, nanoscience is conducted in a variety of fields, such as biochemistry, electronics, biological science, and physical sciences. At the same time, nanotechnologies are being created for use in various fields, such as the food, pharmaceutical, medical and textile industries, domestic products, computation, informatics, programming, and energy. The three primary mechanisms by which distinctive features appear at the Nanoscale are the existence of subatomic particles, an increase in the surface-to-volume, or the capacity for novel molecular configurations. [2]

Despite the immense promise of manufactured nanomaterials and applications of nanotechnology, there are still concerns about their safety, which creates several risk management and regulatory issues. Due to systemic and structural complexity, nanoscale physical properties, and the toxicity of each Nanomaterial, determining the toxicity of nanomaterials is difficult. The lethality of generated nanoparticles is not always predictable due to the instability of the basic materials in the large or cell biology phase. [3]

Although research on the hazards of various manmade nanoparticles is expanding, questions remain regarding their use in the future, how they will be exposed, and how they may ultimately impact the environment and health impacts. The uncertainty around the potential negative effects of nanomaterials is worsened by the absence of approaches for characterizing, quantifying, and reviewing nanoparticles. [4]

Sometimes in academia, the still-emerging field of nanotechnology is compared to biochemistry in the 1980s and information technology in the 1960s. The creation and use of materials, tools, and processes with fundamentally unique capabilities and attributes because of their nanoscale (1-100 nanometer) structures are referred to as "nanotechnology." It entails atomic, molecular, and supramolecular material structures being altered and/or created at the Nanoscale. Particularly below 10–20 nanometers, the features of matter can be significantly altered due to properties including the

DOI: 10.47750/RAA/11.1.05

preponderance of subatomic particles, confining effects, molecular recognition, and an increase in relative surface area. [5]

Nanoscience, the result of multidisciplinary cooperation between physics, chemistry, biology, material sciences, and engineering, focuses on studying the groupings of atoms and molecules. Nanotechnology demands the synthesis of numerous scientific, engineering, and technical disciplines more than other industries do. Applications of nanotechnology will alter practically every aspect of human life, including communication, health, employment, mobility, housing, leisure, and food, as well as the legal, fiscal, philosophical, and climatic landscape. Like other developing technologies, Nanotechnology raises concerns about potential risks and unintended effects as well as hopes and expectations for new scientific and technological advancements, creative applications, and economic opportunities [6].

The textile business has always met a variety of customer needs. The clothing production still uses natural fibers like wool, velvet, and woolen more than synthetic materials like nylon and polyester. Most synthetic fibers are used in home and commercial settings, including flooring, tents, tiers, cables, harnesses, housekeeping cloths, and pharmaceuticals. Both organic and synthetic cloths frequently have distinctive properties that make them perfect for clothing. As was previously mentioned, nanotechnology presents the opportunity to combine the advantages of natural and synthetic fibers, enabling the creation of innovative fabrics that enhance the beneficial features of each particular fiber.

One of the many industries that nanotechnology has aided the most is the textile industry, according to a current edition. Nanotechnology's application in the textile sector has helped materials become far more comfortable, hygienic, and durable while reducing their operating costs. In terms of economics, energy efficiency, environmental friendliness, controlled substance release, packing, sorting, and storing materials on a tiny scale for future use, as well as improved bioavailability, nanotechnology has a number of advantages over traditional approaches.

Researchers and scientists have been drawn to the textile sector by the unique and ground-breaking characteristics of nanotechnology, which has increased the usage of nanotechnology in clothing. This might be the case as one of the best industries for advancing nanotechnology is the textile sector. When a sizable surface area is offered for a given weight or volume of fabric, textile textiles offer the finest bottoms. The energy of the surrounding macromolecules or supermolecules drastically changes as a Fibre transitions from wet to dry. The textile industry and nanotechnology collaborate in this wide interfacial zone [7].

Adding nanoparticles to textile materials to produce finished fabrics with different functional qualities has been the subject of several investigations.

DOI: 10.47750/RAA/11.1.05

Performances. Due to their enormous surface area and high surface energy, which increase their affinity for fabrics and longer the intended textile function, nanoparticles can significantly increase the longevity of processed fabrics. The biggest determinant of how effectively they adhere to fibers is their molecular structure. It is logical to assume that while the larger particle agglomerates will be quickly removed from the Fibre surface, the tiniest particles will penetrate further and adhere tenaciously to the inside of the textile. By creating nano whiskers out of hydrocarbons that are three orders of magnitude smaller than a regular cotton fiber, water repellence can be added to textiles. To simulate peach hair, nano whiskers are woven into the cloth. Similar to the Lotus effect, individual whiskers have intervals between them that are larger than water molecules but smaller than water drops. This creates a strong surface tension that keeps the water on the surface. By consuming gases, the whiskers keep their breathing capacity. Incorporating gel-forming chemicals into the fabric or covering it with a nanoparticulate layer to create 3D surface structures can also help a fabric repel water [8].

2. Literature review:

Research shows that using advanced materials in textile industries provides great applications. Using nanoparticles and polymers for manufacturing various textile-related products improves the functioning of textile fabric. Smart textile is the latest technology-based methodology that produces textile products using nanotechnology [9].various research-related studies predicted that smart textile provides advanced functionalities to the textile industry. Smart textile performs multiple tasks and provides application in the health field by providing real-time monitoring of several physiological needs. Smart textiles also provide the health status of the wearer using nanotechnology-based sensors. The use of Nano-sensors in textiles provides the textile industry with information about the requirements to maintain textile comfort and longevity [10].researches claim that for maintaining the process of sustainable manufacturing of textile products, sustainable Manufacturing Adsorption Method is used in textile industries. Using the SM adsorption method in textile industries ensures the production of eco-friendly textile products [11].researches shows that for controlling global warming and other environmental issues, eco-friendly materials are now being employed in textile-related engineering industries. The use of biodegradable materials has replaced non-biodegradable materials at the industry level. The biodegradable material used in textile industries includes bio-Nano based material that is potentially more eco-friendly than other materials used in textile industries. With the recent progress of nanotechnology in textile fields, the production of bio-based nanoparticles from cellulose, banana fiber, and form jute fiber has become more common in the textile industry [12].researchers claim that the trend of improving traditional clothes is growing in the world. For manufacturing multi-functioned and durable textiles, nanoparticles are employed in the manufacturing process of textiles. Using nanotechnology in

DOI: 10.47750/RAA/11.1.05

the textile industry has resulted in developing new and functional fabric with additional features of self-cleaning and self-healing [13].studies explained that using nanotechnology in the textile industry improves the efficiency, durability, and fabric of textile products. Substituting the conventional textile methods with the new ones using nanotechnology provides a framework for producing high-quality Nano products. Nanotechnology has resulted in the advanced use of nanofibers in non-woven by electrospinning technique. researchers claim that nanotechnology provides applications in the textile industry, thereby increasing the market value of textile products. Also, utilizing nanomaterials for enhancing the character of textiles is done in the textile industry. Smart textile holds great value in the textile industry because of their excellent working mechanism and immense economic worth [14].studies explained that consumers of the present world prefer to use upgraded versions of clothing to improve the quality of their lifestyle. Comfort, as well as durability, are the crucial features that a wearer looks for in a garment fabric.to meet these requirements of customers, nanotechnology is used in textile industries. Nanotechnology in the textile field offers the production of high-performing textile fabrics. The textile industry's cotton properties can be enhanced using nanotechnology in the cotton production process [15].research studies claim that nanotechnology has revolutionized the industries of the present world by providing immense applications in several fields. The manufacturing of products by small-scale and large-scale industries depends mainly on the use of nanomaterials in these industries [16].research studies prove that using cellulose as a plant-based product in the textile industry by combing it with nanoparticles results in the production of Nano based cellulose matrix. This Nano cellulose provides high strength and stiffness to the surface of textile fabric. These features of Nano cellulose, like electrical conductivity and less expensiveness, make it suitable to use in several textile industries [17].studies explained that nanotechnology provides its applications for removing and recycling the textile industry's waste. Recycling and reforming textile waste using nanotechnology and nanoparticles reduces the environmental impact of textile waste and makes it safe to be discharged into the environment [18, 19].Research shows that combining nanotechnology with biotechnology provides promising results to the field of the textile industry. The copper-oxide-based nanoparticles produce through the biosynthesis process provide services in the bioremediation process of textile wastewater. These copper oxide-based nanoparticles used in wastewater bioremediation possess high antimicrobial activity and remove heavy metals from the textile dyes. Removing heavy metals from textile waste using copper oxide-based nanoparticles is a cost-effective and easy-to-handle process [20].studies claim that the biodegradation of contaminated wastewater using immobilized nanoparticles on bacterial strain proves to be a Novel Environmental Method [21] .recent studies by research scholars predicted that one of the biggest causes of environmental pollution is textile dye waste. the problem of phototoxicity in most green vegetation is because of the textile dye

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waste in vegetation water. for resolving this effect of the phototoxicity of textile dyes on vegetation, nanotechnology is used in this regard [22].studies explained that using Nano cellulose and Cellulose Nano whiskers (CNWs) in textile fabric act as reinforcing fillers in the textile fabric .scholars predict that free and immobilized, as well as purified lipases used in the textile process, are produced using Gelatin-Coated Titanium Nanoparticles. The wool used in the textile process is first dried, and then its color strength is improved using partially purified and immobilized lipase enzymes [23].various studies aimed at explaining the use of copper oxide nanoparticles in the Biochemical Oxygen Demand photocatalytic degradation process. Studies also explain that the process of BOD removal is performed effectively when a 0.05 g/L dose of nanoparticles is used in the textile process [24].researchers claim that the surface functionalization feature of Nano cellulose is used in textile industries for coating textiles. The plastic coating conventionally used in the textile coating process is replaced using the cellulose nanocrystal in the coating process [25].researchers claim that for carrying out the dying process in textile industries, magnetic iron-based nanoparticles are used. The magnetic feature of iron oxide-based nanoparticles causes the unique coating process in textile industries. moreover, in the textile sector, electrospinning is used to develop magnetic spin or properties in nanoparticles [26].Research studies highlighted that using Nano coloration technology in the textile dying process is a green and sustainable method because it releases less textile waste [27].furthermore, in the textile industry Multilayer Nano Coating is done using greener and bio-based nanoparticles [28].

3. Research methodology:

This research study describes applications related to nanotechnology in textile industries. This research study is based on secondary data analysis for this purpose, data collected from different websites related to the nanotechnology and textile industries. For measuring, the research study used E-views software and generated informative results related to the nanotechnology and textile industries' performance. This research study is also based on theoretical analysis research that represents that application related to the textile industries.

Research Tools, Techniques, and methods:

This research study is based on quantitative data analysis to determine the research study used of E-views software and run results. The descriptive statistic, unit root test analysis, variance analysis, equality test analysis, histogram, and state analysis also present that graphical analysis relates to nanotechnology in textile industries.

Application of Nanotechnology in the Textile Industry

The industrial revolution brought new phases of doing business. The changing nature of technology, from very large devices to minute ones, changed the

DOI: 10.47750/RAA/11.1.05

whole scenario of business. Nanotechnology, with its ability to use as small-size technology with more benefits in hand, is revolutionary. All the sectors of the economy found its ways into Nanotechnology; the textile industry is no exception. The versatile nature of the textile industry needs new dimensions from the inception of cloth making to the final product. Nanotechnology has changed the physical and biological properties of textile products and synthesizes itself using new techniques. The molecular structure of the fabrics can be changed using Nanotechnology. The new versions of antimicrobe deal with making cloths that remove the bacterial and fungus infections that are widely needed by humans. The clothes with fire resistance in it are helpful in protecting humans from the adverse effects of fire. Moreover, the durability, softness, and clothes that can repel water from the surface are essential in the modern-day world. The Sportswear textile helps in manufacturing breathable suits and changes the chemical structure of fabrics. The making of Nanofibers in the textile industry has many applications. Moreover, electrospinning is a new technology for making various sorts of material. It will help in making the Nanomaterial that is permeable and enlarging the surface area of the materials, which is helpful in the application of advanced technology. Special additional materials can be added to produce the more advanced form of electrospinning. The textile of the Nanomaterial consists of Nanofibers and Nanomembranes. These materials help in generating products that have high biological, physical, electrical, and magnetic qualities because they have more specially designed structures. The clothes made of Nanotechnology are used by the military and other high-command officials. The structure of the textile industry is built on the material inception from farms. The growth of the cotton industry, which is the raw material for the textile industry, can be increased by deploying the nanomaterials such as Nano pesticides, Nano fertilizers, and Nano seeds. The actual and increased growth of the textile cotton enhances the growth of textile fabrics. Nanotechnology helps in making fabrics with antibacterial qualities, is easy to clean, and can help in the repulsion of water from the surface. The water-repellent quality of the Nano material is easily created by using the Nano whiskers. It compresses the fabric quality to $1/100^{th}$ Nm and is helpful in making the surface zero-permeable. These water-repellent gels will help in decreasing the absorption of dirt as well. This quality enhances the trust in the use of cotton fabrics with more repulsion to water and dirt. The UV rays can be distracted from the cotton by using Nanotechnology. The inorganic blockers of UV are successful in distracting the UV rays from entering fabrics. For this purpose, a small layer of titanium will be added to the cotton fabric; it will help in protecting the fabrics from UV protection. The inculcation of antimicrobial factors is already in practice in the textile industry, which includes organosilicons, phenols, and organo- metallics. But with Nanotechnology, nano-sized silver, zinc, and titanium oxide create the properties of the antimicrobials in fabrics. These are the best microbial technologies in the present day. The use of Nanotechnology will reduce the antistatic effect as compared to the conventional methods of manufacturing

DOI: 10.47750/RAA/11.1.05

cloths. The static charge is usually produced in Synthetic and Nylon fabric. There is a bad performance of antistatic charge in the synthetic fabric; it is important to create and develop the antistatic charge in cloths. The Nanomaterial of Titanium oxide and zinc oxide provides antistatic properties to the cloths. These materials are very helpful in releasing the charge from the surface of the fabric and make them more antistatic. Moreover, the silicon gel has also the properties of antistatic charge to be provided on the fabrics that are able to absorb the excess moisture from the cloths.

Another important application of Nanotechnology is that it helps in providing wrinkle-free fabric. In the conventional method, the resin is used for wrinkle-free fabric. There are many drawbacks to using the resin, such as that it decreases the strength of the fabric with more water absorbency and decreases the permeability of the fabric. The research has found to use the of titanium oxide and nano-silica for cotton and silk cloths, respectively. In the textile industry, cotton fabric plays a very vital role from the view of its easiness, softness, and breathability. But the commercial and non-commercial usage of cotton is limited because there are less strength and flammability. The opposite to it is synthetic fabric which is more durable, water-repellent and has more strength. Nanotechnology is being employed to combine synthetic and cotton fabric qualities to make them more desirable to wear and use. In textile manufacturing, there are more concerns about the final look of the fabric. The finished products must have nice color tones, texture, structure, and other qualities. Nanotechnology has been working to provide a good texture for the fabric's finished product and make the surface of the fabric appropriate to use with coating. The Nano beads are used as a coating to protect the fabric by creating a favorable molecular structure to the Nanoscale. The cotton fibers are applied as a layer on the synthetic surface known as the synthetic fiber core for protecting the fabric. Last but not least, many Nanostructures are being developed on the surface of the fabric to protect them from wetness. Further, Nanotechnology is applied to get wrinkled-free clothes. In the busy days of life, people need easiness for their clothes as well. The art of Nanotechnology is to provide clean, antibacterial, anti-fungus, wrinkle-free, and UV-protected clothes.

Numerical analysis:

Descriptive statistical analysis:

	NT	PTI
Mean	2.224543	3.112951
Median	1.982325	3.262355
Maximum	4.335610	5.673200
Minimum	1.093200	1.223900
Std. Dev.	0.969777	1.348749
Skewness	0.479963	-0.155074
Kurtosis	2.003802	1.885731

DOI: 10.47750/RAA/11.1.05

Jarque-Bera	1.913871	1.337787
Probability	0.384068	0.512275
Sum	53.38902	74.71083
Sum Sq. Dev.	21.63074	41.83986
Observations	24	24

The above result describes that descriptive statistic analysis the result presents mean values, and median values also describe the minimum and maximum rates. The result shows that standard deviation, skewness values, probability values, and a sum of square deviation. The first variable is nanotechnology; its present mean value is 2.2245 the median value is 1.98. according to the result, its minimum value is 1.09, and the maximum value is 4.33, respectively. The result presents that a probability value is 0.38 shows that 38% significant level between them. The result also describes that the sum value is 53.38 and the sum of the square value is 21.63; this research study is based on 24 observations related to nanotechnology in the textile industries. The second indicator is the performance of the textile industry; its mean value is 3.112 shows a positive average value of the mean, the median value is 3.26, its maximum value is 5.67, and the minimum rate is 1.223, respectively. The result represents that the probability value is 0.51 showing that there is a 51% significant level between them. The result presents that the sum value is 74.71 and the sum of the square value is 41.83, respectively.

COINTEGRATION:

Sample (adjusted): 3 24				
Included observations: 22 after adjustments				
Trend assumption: Linear deterministic trend				
Series: NT PTI				
Lags interval (in first differences): 1 to 1				
Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		**Trace**	**0.05**	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None	0.262821	9.083653	15.49471	0.3577
At most 1	0.102344	2.375308	3.841466	0.1233
The trace test indicates no cointegration at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

The above result represents that the cointegration analysis result represents that linear deterministic trend; the result presents that eigenvalues, trace statistics, and 0.05 critical values also explain probability values. According to the result, its eigenvalue is 0.262 and 0.1023; the trace statistic rate is 9.083 and 2.37, respectively, showing that positive trace values are related to the application of nanotechnology in textile industries. The result presents that 0.05 critical values are 15.49 and 3.84, respectively, showing positive rates between them. The probability value describes that 0.3577 and 0.1233 show 35% and 12% significantly.

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UNIT ROOT TEST ANALYSIS:

Null Hypothesis: NT has a unit root			
Exogenous: Constant			
Leg Length: 0 (Automatic - based on SIC, maxlag=5)			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.149083	0.2288
Test critical values:	1% level	-3.752946	
	5% level	-2.998064	
	10% level	-2.638752	
*MacKinnon (1996) one-sided p-values.			

This research study represents that unit root test analysis related to nanotechnology in textile industries. The result presents that t statistic values also that probability values the rate of t statistic is -2.149083 its probability value is 0.22 shows that 22% significant values between them. The critical test values represent that 1% level, 5% level, and 10% level show that -3.7529, -2.998, and -2.6387 shows negative values of all variables. The result describes a significant unit root test analysis between them.

Augmented Dickey-Fuller Test Equation				
Dependent Variable: D(NT)				
Method: Least Squares				
Date: 02/02/23 Time: 00:19				
Sample (adjusted): 2 24				
Included observations: 23 after adjustments				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
NT(-1)	-0.360348	0.167675	-2.149083	0.0434
C	0.817325	0.412020	1.983704	0.0605
R-squared	0.680282	Mean dependent var		0.000187
Adjusted R-squared	0.641248	S.D. dependent var		0.821345
S.E. of regression	0.761131	Akaike info criterion		2.374919
Sum squared resid	12.16573	Schwarz criterion		2.473658
Log-likelihood	-25.31157	Hannan-Quinn criteria.		2.399752
F-statistic	4.618558	Durbin-Watson stat		1.970221
Prob(F-statistic)	0.043441			

The above result represents that augmented dickey fuller test equation result describes that coefficient values, and standard error values, also present t statistic values and probability values. The result shows that coefficient values are -0.360, and 0.817 its standard error values are 0.16, and 0.41 respectively. The t statistic value shows that -2.149 and 1.9837, the probability value present that 0.04 and 0.06 mean 4% and 6% significance level between them. The result describes that the R square value is 0.68 showing that 68% model fit for analysis. The adjusted R square value is 64% its S.E of regression analysis is 0.76, representing the 76% error of the regression. The overall probability value is 0.04 shows that 4% means a 100% significant level between them. The result also presents that the F statistic values, its rate is 4.618, the mean dependent

DOI: 10.47750/RAA/11.1.05

variance value is 0.000187, and its standard deviation dependent variance present that 82% respectively shows positive deviation rates between nanotechnology in textile industries. The overall result shows that nanotechnology plays a vital role in textile industries.

EQUALITY TEST ANALYSIS:

Test for Equality of Means of NT			
Categorized by values of NT and PTI			
Sample (adjusted): 1 24			
Included observations: 24 after adjustments			
Method	**df**	**Value**	**Probability**
Anova F-test	(10, 13)	15.51361	0.0000
Analysis of Variance			
Source of Variation	**df**	**Sum of Sq.**	**Mean Sq.**
Between	10	19.95829	1.995829
Within	13	1.672452	0.128650
Total	23	21.63074	0.940467

The above result describes the equality test between nanotechnology and the performance of textile industries; the result describes the values and probability values of different analyses. The ANOVA F test shows that the value is 15.51361; its probability value is 0.0000 showing that there is a positive and 100% significant link between them. The result represents that the variance analysis source of variation shows that the sum of square values is 19.95829 and 1.67245; its total value is 21.63074, showing that positive sum of square values. The mean square values are as between value 1.9958 the within the values 0.12 shows that total value 0.940 shows that 94% variance rates.

Sample: 1 24			
Included observations: 24			
Method: Holt-Winters No Seasonal			
Original Series: NT			
Forecast Series: PTI			
Parameters:	Alpha		0.7500
	Beta		0.0000
Sum of Squared Residuals			13.96420
Root Mean Squared Error			0.762785
End of Period Levels:		Mean	1.247303
		Trend	-0.008801

The above result represents results related to nanotechnology in textile industries. The alpha value is 0.7500 its beta value is 0.000, showing that 100% rates. The sum of the squared residual value is 13.96; also, the root mean squares error value is 0.76, showing 76% squared average values. The mean value is 1.24; also, the trend value is -0.008801, showing negative rates between them. The result presented significant trend values between the nanotechnology and performance of textile industries.

DOI: 10.47750/RAA/11.1.05

Nanotechnology is receiving a great deal of interest since it is thought to have a significant amount of potential for a wide range of end uses. Because of their significant economic potential, corporations have begun to take an interest in the novel and extraordinary properties of nanomaterials as well as academics and scientists. Nanotechnology for the textile sector has real economic potential, particularly since the traditional methods used to give diverse characteristics to the textiles do not frequently result in lasting difficulties and will lose their functions after wearing or washing. The nanoparticles have a high surface energy and a big surface-area-to-volume ratio, which enables them to provide high durability for textiles. This improved affinity for the fabrics leads to a rise in the function's longevity. Furthermore, the tactile feel or breathability of materials coated with nanoparticles will not be compromised.

4. **Conclusion**:

This research study describes the application of nanotechnology in textile industries. This research study is based on secondary data analysis for measuring the research study using E-views software and running results. The descriptive statistic, the test of equality, and trend analysis, also explain cointegration analysis and dickey augmented analysis for measuring the results. This research study also defined applications related to the variables. The overall research concluded that positive and significant impact of nanotechnology in textile industries. Self-cleaning fabrics, improved color compatibility, flame retardancy, UV and antistatic protection, antibacterial, wrinkle resistance, dirt resistance, and water repellency are just a few of the textile properties that utilize nanotechnology. Among these, significant uses are briefly outlined. Nano-Tex has introduced the most recent wrinkle-free treatment based on nanotechnology, which offers an improvement over the old abrasive methods while maintaining the integrity and strength of the fabric. There are some fabrics and clothing that are wrinkle-free textiles, which are well-known and suited for time-constrained consumers. Tensile and flexural, and fabric tears are lowered by processing and chemical treatments. Due to the improvement of technology for the manufacture of nanomaterials, a customized product may now be produced more quickly and with the required features. It is now simpler to use textile nanoparticles for cutting-edge applications. The use of nanotechnology in cutting-edge textile applications is already well-known in the textile industry. The textile sector has a bright future for nanotechnology and will use it significantly.

Sometimes textiles are over-engineered or toughened up to withstand the fiber deterioration brought on by the conventional wrinkle-free methods. In both cases, the wrinkle-free chemistry's destructive properties force the shop or brand to invest additional costs in order to accommodate the technology's limitations on all materials. The nanoscale molecular structure of Nano-innovative Texas's Fortify DP technology can improve wrinkle-free performance by permeating the fiber more effectively. Additionally, it uses a

DOI: 10.47750/RAA/11.1.05

longer, more flexible cross-linking chain, which lowers the suspense stress on the fibers and decreases the significant loss of strength associated with conventional wrinkle-free chemistry.

5. Recommendations:

As an enabling technology, nanotechnology improves the effectiveness and efficiency of the present applications. Nanomaterials have a huge future potential since they have the ability to be employed for a variety of cutting-edge applications across many industries. The firms are now concentrating on producing nano-textile goods that have conventional qualities and conform to global standards for safety, health, and the environment. Given the increased consumer interest in nano-textiles and the stringent environmental regulations, it is crucial for textile producers to maintain high ethical standards in these goods. Technology has historically been incorporated into textiles, as is apparent. For example, efforts have been made to enhance clothes with sensing capabilities further. Companies are also working on developing textile-based nano-sensors, which opens up a wide range of opportunities for the nano-textile, including the development of clothing that is easily adaptable to changing weather conditions, monitoring wearers' vital signs, and creating specialized healthcare systems. One of the issues with the development of nano-textiles is the high expenses of the technology. Thermos- or temperature-regulated clothing is a regular appearance in the garment industry, but buyers avoid it because of the high cost. Despite certain drawbacks, nanotechnology has a wide range of benefits, including the capacity to provide textile items with improved corrosion-resistance capabilities while also making them more durable, lighter, and stronger. The future of nanotechnology in the textile industry is looking bright, according to research that focuses on enhancing its prospects or developing exceptional textile functionalities.

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