ASSESSING ECONOMIC IMPACTS OF ENERGY CONSERVATION IN SMALL AND MEDIUM TEXTILE FIRMS OF FAISALABAD

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CERTIFICATE

This is to certify that this thesis entitled: **"Assessing Economic Impacts of Energy Conservation in Small and Medium Textile Firms of Faisalabad."** submitted by **Mr. Muhammad Mohsin Junaid** is accepted in its present form by the School of Economics, Pakistan Institute of Development Economics (PIDE), Islamabad as satisfying the requirements for partial fulfillment of the degree in Master of Philosophy in Economics.

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Author's Declaration

I Mr. Muhammad Mohsin Junaid hereby state that my MPhil thesis titled **"Assessing Economic impacts of Energy conservation in small and medium textile firms of Faisalabad"** is my own work and has not been submitted previously by me for taking any degree from Pakistan Institute of Development Economics or anywhere else in the country/world. At any time if my statement is found to be incorrect even after my Graduation the university has the right to withdraw my MPhil degree.

Date: September 11, 2024

Signature of Student

Muhammad Mohsin Junaid

Dedication

Dedicated to my beloved Parents, Siblings, Aunt Dr. Humera Iqbal and a Best Friend Usama Ihsan.

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Abstract

The underlying research has threefold objectives: (i) to explore the energy conservation status of the textile sector SMEs in Faisalabad, (ii) impacts of the energy conservation on firms' energy productivity, and (iii) to identify what are the major challenges these firms are facing? To estimate aforesaid objectives, primary data has been collected by conducting a survey to the SMEs of weaving and finishing sector. Basically, energy conservation is the concept of engineering field, and there are different measures to conduct energy audit of the firms, which is quite hard for a student of economics to conduct it. Nonetheless, after getting the training and expert opinion, we designed a questionnaire related to the energy conservation through energy audit, and containing the questions pertaining to the motor efficiency, lightening efficiency, and firm's awareness. In addition to energy audit, to explore its economic impacts, we obtained information of capital and labor employed, wages, electricity consumption, firms' output, and total cost, and problems they face regarding achieving energy efficiency. Energy productivity is measured by dividing the output with electricity consumption (in units)—it is per unit output. The data is collected from 204 textile sector SMEs in Faisalabad by using cluster random sampling technique—first stage, two clusters are formed: (i) weaving, and (ii) finishing, while at stage, firms are selected randomly based on proportionate to size sampling. For empirical purpose, situational analysis and regression based analysis (OLS estimation) is conducted.

The findings of the study obtained through situational analysis demonstrates that on the whole, 46 percent of the sampled firms contain supper efficient motors, around 26 percent firms comprise motors which are meeting standard criterion of efficiency, while around 27 percent of the sample firms have least efficient motors. Likewise, sector level analysis indicates that weaving sector is relatively more efficient than finishing sector. Moreover, in terms of lighting efficiency, around 76 percent firms are using energy efficient lights while 24 percent firms are found using inefficient lights. In addition, the OLS estimation demonstrates that those firms who are using energy efficient motors and lights are yielding higher per electricity unit output as compared to those firms which are inefficient. Further analysis reveals that both capital and labor significantly contribute to energy productivity, emphasizing the significance of strategic investments and efficient utilization of resources. Firm- specific features such as age, category also plays important roles, with older firms and those in specific categories representing higher energy productivity. The findings highlight the critical role of targeted investments in capital and labor, the adoption of energy efficient technologies. The survey results further show that rising electricity prices, taxes, costly raw material, and increasing cost of production are the key challenges which SMEs of textile sector in Faisalabad are facing, and even these factors are forcing some firms to shut down their units. These insights are valuable for policymakers and industry stakeholders targeting to promote the sustainable measures and improve competitiveness of textile sector.

Keywords: Energy Conservation, Weaving & Finishing, Motor & Light efficiency, Cluster Random Sampling

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Abbreviation

SME: Small and medium enterprises

AGE: Firm Age

ME: Motor Efficiency

MC: Motor Condition

LE: Lighting Efficiency

FC: Firm Category

EP: Energy Productivity

OLS: Ordinary Least Squares

RR: Random Sampling

GDP: Gross Domestic Product

R&D: Research and Development

CAP: Capital

LAB: Labor

Chapter 01

Introduction

1.1 Background

Energy conservation is crucial in today's world, where the depletion of natural resources and environmental degradation pose serious threats to our planet's future. Beyond the immediate reduction in operating costs, energy conservation also offers long-term financial benefits. Investments in energy-efficient technologies and practices often result in lower maintenance costs and longer equipment lifespans. Moreover, many governments and organizations offer incentives, rebates, and tax credits for businesses that adopt energy-efficient measures.

The leading export sector of Pakistan is textile sector. which contributes 61% in FY2022. Pakistan large scale manufacturing sector is textile. Textile and clothing are energy intensive units. Spinning consumed 34%, weaving consumed 23% and wet & chemical processing consumed 38% energy 5% for miscellaneous purposes (Malik , Mustafa, & Zia, 2023). Energy is mandatory for production process. Developing economies needs huge investment to meet the energy needs. One way to reduce the energy cost is energy conservation (Deshmukh & Patil, Energy Conservation and Audit, 2013).

Basically, energy conservation is the decisions and practices of using less energy. Energy conservation can be achieved by the efficient use of energy and effort of reducing wasteful energy consumption by utilizing fewer energy services. The electricity demand decreased with the energy conservation techniques and energy efficiency appliances/equipment/tools or with the changing of behavior of individuals (Mirza, Bergland, & Afzal, 2014). Numerous studies conducted on the energy conservation in different industries such as iron and steel industry, petroleum industry, cement industry, small and medium scale industries, and manufacturing industries.

There many analytical studies on industrial, commercial and residential sector regarding energy conservation (Chan, Yang, Lee , & Hong, 2009). The continuous use of machines and inefficient operations in textile sector causes massive energy bill. The energy conservation programs executed in textile sector and gained wide range of acceptance in this sector to overcome rising cost of energy (Khude, 2017).

The major input in the process of making textile products is electrical energy. The cloth making process is energy intensive as a result there is much opportunities of conservation (Singh & Gupta, 2011). Textile sector also consumed and having potential of energy conservation. Energy conservation can also have significant social benefits, particularly in terms of employee engagement and comfort. Energy-efficient buildings and workplaces can provide a more comfortable and healthier environment for employees (Gruber & Brand, 1991). For instance, improved lighting, better temperature control, and enhanced air quality can contribute to a more pleasant and productive working environment. Furthermore, companies that prioritize energy conservation often foster a culture of sustainability and corporate responsibility, which can enhance employee morale and engagement. The textile industry utilized energy for machinery, air conditioning, air compressor system, lightening system, spinning frames, dyeing machines, pumps, fans and looms (Hong G.-B. , Su, Lee, Hsu, & Chen, 2010).

Electricity saving is possible through the energy conservation and energy management techniques (Zafar, Fiaz, Ikram, Khan, & Qamar, 2021). The textile industry in Pakistan is regarded as an energy-exhaustive sector, and by applying environment friendly energy-saving techniques, an expected minimum of 10% to 15% of energy may be saved in this sector (Nadimuthu, et al., 2021). In textile sector, small and medium-sized enterprises (SMEs) play a pivotal role, especially in the weaving and finishing segments.

However, these SMEs face numerous challenges, one of the most pressing being energy efficiency. Improving energy efficiency is critical not only for reducing operational costs but also for enhancing competitiveness and sustainability in the global market. This comprehensive analysis explores the current state, challenges, and opportunities for improving energy efficiency in SMEs in the weaving and finishing sector of Pakistan's textile industry (Ayyagari, Beck, & Kunt, 2003). Energy efficiency refers to using less energy to perform the same task or produce the same output. In the context of the textile industry, it involves optimizing processes to reduce energy consumption while maintaining or improving product quality.

Energy-efficient production processes can enhance the competitiveness of Pakistani textiles in international markets. With growing environmental regulations, improving energy efficiency helps companies comply with national and international standards (Bravo & Iturralde, 2022).

SMEs in the weaving and finishing sector consume significant amounts of energy, primarily in the form of electricity and thermal energy. Key energy-consuming processes include spinning, weaving, dyeing, and finishing. According to various studies, the energy consumption in these SMEs is often inefficient due to outdated machinery, poor maintenance practices, and lack of awareness about energy management. These challenges are exacerbated by several factors. Many SMEs still use old and inefficient machinery that consumes more energy than modern equipment. There is a general lack of awareness and expertise in energy management practices among SME owners and workers. Upgrading to energy-efficient technology requires significant capital investment, which many SMEs cannot afford. Additionally, there is limited access to technical and financial support from the government and financial institutions, which hinders the adoption of energy-efficient practices (Deshmukh & Patil, Energy Conservation and Audit, 2013).

Despite these challenges, there are substantial opportunities for improving energy efficiency in SMEs in the weaving and finishing sector. These opportunities can be categorized into technological, managerial, and policy interventions. Technological interventions include modernizing equipment, energy-efficient lighting, automation, and heat recovery systems. Investing in modern, energy-efficient machinery can significantly reduce energy consumption (Dixon, McGowan, Onysko, & Scheer, 2010). For instance, replacing old looms with new ones that have variable speed drives can lead to substantial energy savings. Upgrading to LED lighting in factories can reduce electricity consumption and improve working conditions. Implementing automated systems for controlling and monitoring energy use can help identify inefficiencies and optimize energy consumption. Installing heat recovery systems can capture and reuse waste heat from processes like dyeing and finishing, reducing the need for additional thermal energy (IEA, 2015).

This can include optimizing natural lighting, improving airflow, and reducing the distance that materials need to be transported within the facility. By incorporating energy efficiency into the design phase, textile manufacturers can create facilities that are inherently more energy-efficient and sustainable (Deshmukh & Patil, Energy Conservation and Audit, 2013).

The adoption of energy-efficient technologies is another critical strategy for energy conservation. This can include everything from energy-efficient lighting and HVAC systems to advanced manufacturing equipment and automation technologies. For example, using variable frequency drives (VFDs) to control motor speeds, implementing high-efficiency boilers and furnaces, and adopting heat recovery systems can all contribute to substantial energy savings. Additionally, textile manufacturers can explore renewable energy options such as solar, wind, and biomass to reduce their reliance on fossil fuels and further decrease their environmental impact (Dixon, McGowan, Onysko, & Scheer, 2010). Employee training and engagement are also essential components of a successful energy conservation strategy. By educating employees about the importance of energy conservation and providing them with the tools and knowledge they need to identify and implement energy-saving measures, textile manufacturers can foster a culture of sustainability. This can include training programs, awareness campaigns, and incentive programs to encourage employees to participate in energy conservation efforts (Khude, 2017).

Regular maintenance and upgrades are also important for ensuring energy efficiency in textile manufacturing. Equipment that is well-maintained operates more efficiently and consumes less energy. This includes routine maintenance tasks such as cleaning, lubrication, and calibration, as well as more significant upgrades such as replacing outdated equipment with newer, more energy-efficient models. By keeping equipment in optimal condition and investing in modern technologies, textile manufacturers can achieve continuous improvements in energy efficiency.

In terms of value addition, the wet processing industry occupies a significant place in the textile value chain. The downstream business of apparel and made-ups is strongly dependent on the processing industry for the supply of textiles and materials with added value. Many small and medium sized units engaged in this process. 1) Bleaching of fabrics 2) Dyeing 3) Printing and finishing of fabrics. (Shah, G.Syed, & Shaikh, 2014). This export-oriented sector which is main source of earning foreign exchange. The cotton and cotton yarn are famous in the world with the name of Pakistan. (Khan & Kazmi, 1998). The textile sector of Pakistan is also competitive in global market because of its textile products (Abbas, Hsieh, Techato, & Taweekun, 2020).

The other way to tackle this problem in a good manner is energy conservation. Industrial sector utilized the 35% of overall energy production. Energy prices and crises effects the economy of Pakistan. The electricity shortage influences the textile sector of Pakistan negatively.

The study found that electricity supply and unstable policies effect the revenues of the firm badly. It has been calculated that 24 % of revenues losses due to the 1 hour of outage (Mirza, Bergland, & Afzal, 2014). The higher the energy prices worsen the economic conditions of the sector which causes the layoff, inflation and economic stagnation. Energy is an important input in many business procedures (Zafar, Fiaz, Ikram, Khan, & Qamar, 2021). The unreliability of supply can upset the firm's productivity. Pakistan textile sector is also facing the energy crisis, that's why Pakistan textile sector is now suffering from these worse conditions (Yasmeen, Shah, Ivascu, Tao, & Sarfraz, 2022).

1.2 Statement of the Problem

The industrial sector in Pakistan plays a fundamental role in the country's economy, with the textile industry being the leading contributor to exports and GDP. However, small and medium-sized textile firms, particularly in Faisalabad, face significant challenges due to rising energy costs, inefficient electricity usage, and frequent power shortages. These issues are intensified by high tariffs, expensive raw materials, and inconsistent economic and political policies, all of which have led to fluctuations in the sector's performance. As global trends shift towards energy conservation, it becomes imperative for these firms to adopt more efficient energy practices to enhance their competitiveness and to be more productive. This study aims to assess the economic impacts of energy conservation measures on small and medium textile firms in Faisalabad, focusing on their effects on energy productivity, labor energy efficiency, and capital utilization. By exploring these opportunities, the research seeks to provide actionable insights that can help revive and sustain the textile sector in this key industrial hub.

1.3 Research Questions

According to above discussion, this study aims to answer the two major question regarding energy conservation in textile sector.

- Is there any energy saving potential in small and medium textile firms in Faisalabad?
- What is magnitude of energy saving?
- Which subsector is wasting energy?
- How much energy conservation influences the energy productivity of textile firm?

1.4 Objectives of the Research

- Identify energy conservation through energy audit in small and medium textile firms.
- Evaluate the energy conservation effect on firms and energy productivity of small and medium textile firms of Faisalabad.

1.5 Significance of Research

There is a noticeable lack of thorough research that specifically examines the relationship between energy conservation initiatives and firm's energy productivity in the literature. There are few studies led in the context textile industry of Pakistan. The area of textiles for energy conservation in the industrial sector needs attention. Rest of the world moved towards the energy conservation and its implication. Textile industry requires research in this area. This study is a contribution in the literature in context of small and medium textile firms and energy conservation conditions.

1.6 Structure of the study

This study is consisting on 05 chapters. First chapter describes about the background and introduction of the study. Second chapter gives in depth literature review of the study. The third chapter described about the data and methodology used in the study. The forth chapter describes the results and discussion of the research. The last and fifth chapter is about conclusion and recommendations provides the key findings and its implication in research. After these chapters' references includes the complete list of the references of the study. In the end, questionnaire used for the data collection is attached in appendix.

Chapter 02

Literature review

In the discussion of "energy conservation," the first step is what it truly means, because it has different meanings in different contexts. A simple definition of it is "Saving energy" without giving any further information. The economist most frequently used definition is increase in energy productivity (calculated by the variations in energy consumption to Output produced), which is also accomplished by the technical methods (i.e. a growth in Conversion efficiency), or Behavioral alterations. Engineer defines energy conservation as an increase in conversion of efficiency, which measured as the ratio of output energy (power out) to energy input (power in) (Cooper, 1996).

Energy conservation means that reducing the energy demand the consumption of Energy efficient equipment/appliances/tools or through behavioral changes in individuals (Bhattacharyya, 2011). Energy conservation is change in the behavior of individual to consume less energy. The low-priced Kw/h is that you didn't consumes. Energy conservations means using less energy by human voluntary effort to save it (Bilgen & Sarıkaya, 2018). The improvement in energy efficiency is a type of energy generation. It raises the per capita energy utilization (Rajput, Wadhwani, & Singh, 2021).

In any nation small and medium enterprises plays a main role in the economy. They are treated as engines of the economic growth. Energy is important input in any SME. Their role for country's Gross domestic product (GDP) and quantity of employment it creates are significant. Their efforts to grow as large industry can't be ignored. (Naik & Mallur, 2018).

Small and medium sized firms are the central part of the Economies globally; it provides the 60% of employment. Energy efficiency improvements can offer significant value for the economies, societies and SME’s themselves, but efficiency investment is lagging due to shortage of information, technical expertise, funding and resources (IEA, 2015).

2.1 Economic Impacts of Energy Conservation

Nationally, increasing energy conservation and energy efficiency in every sector is considered one of the leading instruments for reducing the trade deficit, energy imports and environmental effects (Dixon, McGowan, Onysko, & Scheer, 2010).

There is trade off connection between energy efficiency and economic performance, mainly the developing countries needs heavy energy consumption to outgrowth their economies. The betterment in the energy efficiency causes the less energy cost and improve the firm’s competitiveness. Competitiveness of firm will help firm to enhance output. Energy is an important factor of development of human accomplishments. Certainly, supply of energy is major determinant of social and economic aspects of a country. The industrial activities need more energy to keep the country on track of development. The energy produced by the fossils which are limited on the earth. Pakistan is the country who is facing the energy shortfall from 2018. The country faced the major gap in the demand and supply of the energy (Electricity) and natural gas. The industrial sector of Pakistan consumes more than 37 % of the primary energy. While most of the energy wasted in many industrial processes resulting the industrial operational productivity (Hassan, 2021).

Energy conservation in industries impacts the economic growth of the country on the other hand it decreases energy intensity of the firm and shooting up the competitiveness of the industry. Improving the condition of the energy in the textile sector is cost effective measure to lower the energy cost and energy demand with the losing the output of the firm. It’s doable through the policy support and energy efficiency programs, capacity building of the labor in the industry and through trainings. Use global forum to target all decision makers. Meetings of the organizational experts specially on energy conservation. (UNIDO & Energy , UNIDO and Energy Efficiency; A low-carbon path for industry, 2009).

Increasing energy efficiency in small and medium enterprises result in rise of profitability and competitiveness. By reducing energy cost, firms can uplift product quality, lower risks and liabilities, and unlock new business opportunities. Furthermore, energy conservation aligns with wide range policy goals, including job creation, growing the market for energy efficient products and services, develop energy security and reduces greenhouse gas emission and local air pollution. It empowers firms to deferring investment in extra power generation (Henriques & Catarino, 2016).

2.2 Role of energy efficiency in small and medium firms

Efficient utilization of energy in large scale industries is obvious due to regular basis energy audit and energy efficient practice in the giant firms. Large scale units in the Europe are obligated to conduct an energy audit but small and medium sized firms do it voluntary. Although, government in Europe implemented energy and environment policies to support energy audits in small and medium sized firms (Lisauskas, Kveselis, Dzenajavičienė, Masaitis, & Perednis, 2022). In the literature, agreement occurs concerning the gains of extraordinary capital intensity in the industrial growth (Bhat, 2014, Rath, B.N & Jagam, B.P, 2020, Soni, S & Subrahmanya, 2020). Rise in capital intensity creates a solid increase in energy demand that has environmental and economic implications (Repetto, R. & Austin, D. , 1997).

As the small and medium firms are back bone of economy so, that a UNIDO study also emphasizes on the energy efficient techniques in the textile sector. Industrial energy efficiency programs help industries to lower its energy cost. Energy management system and energy efficient industrial equipment and appliances can also reduce the energy consumption.

Energy efficiency knowledge and awareness of the employs in the industry helps to achieve the goals of energy conservation. These steps taken by any industry make its energy cost affordable and industry energy efficient (UNIDO, UNIDO Energy Programme; Sustainable Energy for Inclusive Development and Climate Action, 2015).

Energy management system or the energy efficient techniques are the finest ways of addressing the systematic issues of energy conservation in the firms. By implementing the energy efficiency techniques in the firm, we can reduce the energy consumption of the firm, energy cost of the firm, and increase the performance of the firm (de Macedo, Cantore, Barbier, Matteini, & Pasqualetto, 2020). There is a positive impact of energy efficiency in the Latin America on economic performance of firms (P.Motalbano & S. Nenci, 2018). In the Europe, the Europe's energy efficiency directives requested to do the energy audits of 280 firms. These high quality and cost efficient energy audits among the small and medium scale firms across the Europe finds the potential of 20 % of energy savings in the Europe (Fresner, Morea, Krenn, Uson, & Tomasi, 2017).

2.3 Measurement and indicator

Energy intensity is an important indicator of energy efficiency and it is created as the amount of energy consumed per commercial output. This is commonly used for comparing and monitoring energy efficiency between countries. Energy intensity varies depending on various factors like energy consumption, GDP, and technology (Sener & Karakas, (2019)). Energy audit is main systematic approach for decision making in the area of energy management and energy conservation. It tries to find out the total energy inputs with its uses and tries to find out the energy streams of the firm (Deshmukh & Patil, 2013). Energy auditing is a survey, inspection and analysis of the firm energy flows to conserve energy and reduce the amount of energy input without negatively affecting the output of the firms (Sharma, 2012).

The major objective of energy audit is to find opportunities for energy saving and also provide some basis of more effective use of energy in organization. Energy audits are classified into two kinds (Patravale , Tardekar , Y. Dhole , Morbale, & Datar, 2018).

1. Preliminary Energy audit
2. Detailed Energy audit

In preliminary energy audit the energy data is gathered through the survey of the facility and questioned asked to the managers, owners of the factory and key stakeholders. Questions included about the energy consumption, raw material, capital, production process, machines and equipment. This is the way of easily assessing the energy saving techniques for the firms. Identify the main energy saving areas and improvement loopholes (Patravale , Tardekar , Y. Dhole , Morbale, & Datar, 2018).

In the detailed energy audit there are three phases of the energy audit. A detailed energy audit is comprehensive in nature and aims to perform the actual energy performance of the end users and processes. Detailed energy audit results are summarized in the report form of every area of the firm. This audit has three phases to held in industry.

- Pre-audit phase
- Audit phase
- Post-Audit phase

In the pre audit phase the raw data is collected and in the audit phase the auditor and his team connect some devices to machines and firm's equipment to collect data to make report. The post audit phase told the after checks of the energy audit.

2.3.1. Benchmarking of energy efficiency

In the small and medium firms of different industries there is a need of identifying the simple and fair, energy efficiency benchmarking tool. A comparison is needs to be accurate and on disaggregated level, between processes and tools of firms but this need more energy data. This type of comparison needs more resources and great deal of time to assess the small and medium industries (Adityaa, et al., 2017). On the other hand, the industrial SME's have no direct benefit from the benchmarking of the energy performance, especially at firm's performance level and benchmarking is only used for the get knowledge about the energy efficiency potentials. The other way to calculate the energy efficiency in the firms is specific energy consumption (SEC), get by dividing the energy use by the produced outputs (Ahmet Çay, 2018). The main concept of benchmarking is to evaluate the energy performance of the facility against the reference point. Benchmarking has been to be a suitable analysis methodology and management tool to increase the energy efficiency and energy performance in different areas of life (Bhattacharyya, 2011). industrial energy efficiency benchmarking is used for assess the energy performance of an individual industry firm against reference plant or sector. Another method is used for getting the reference point is average energy efficiency value for the energy efficiency comparison, this can be from the population or from the relevant sector of industries in general. While the benchmarking to an average value examined that benchmarked unit is better or worse than the average, energy efficiency aims in benchmarking program can be set to a higher level for comparison, e.g. first quartile (Bravo & Iturralde, 2022).

2.4 Technological Innovations and Adoption

(Dasgupta, 1999) showed in his research that cotton dyeing and manmade textile SMEs in India using traditional machines, with little modification. If the organization adopt the energy efficiency technologies and measures there was potential of energy saving 20-25%. (Thiruchelvam, kumar,s, & Visvanathan,C, 2003; Chan, Liang, Yang, Hsu, & Bing, 2003; Price & Hasanbeigi, 2012) have investigated in their studies in textile (SME's) that energy efficicent motors, ligtings and suitable insulation of boilers brings a lot of benefits. They decreased the dust generation by 50 percent. In these studies they found the economics of these replacements and get that 16 months would be the payback period of this technological adoption. (Naik & Mallur, 2018) found that firms prevents their compressor air leakages and use variable speed drive motors can effect energy saving. Futhermore if the firm have proper insulation, boiler properly maintained and use invertors can play a major role in reduction of energy consumption.

2.5 Barriers and Challenges

Small and medium sized firms are normally less energy efficient than the larger firms (Cango, Trucco, Trianni, & Sala, 2010) indicated that there is large potential of energy saving in small and medium sized firms than large. Another research proposes that investment barriers are issue for small scale industry (Gruber & Brand, 1991).

2.5.1. Financial barriers

Energy efficient technologies promises to reduce the energy cost of the firms and households and also reduce the financial cost related to the environmental damages. But these technologies are not adopted by the businesses and the individuals to fill the gap of energy efficiency because of the financial barriers (Gerarden , Newell, & Stavins, 2015).s For the small and medium sized firms' financial barriers might be higher as banks are biased in favor of large scale firms and there is no fast pay back in case of small scale firms (Nagesha & Balachandra, 2006; Thollander, Danestig, & Rohdin, 2007). Firm have limited technologies due to the size of the firm and greater capital limitation (Cango, Trucco, Trianni, & Sala, 2010).

SME's in the economy don't carry the possible investments due to not accessability of needed investment capital on a suitable low interest rate and high returns to pay back of that investement (Kostka, Moslener, & Andreas, 2013). Small and medium sized firms in europe are not implementing the energy efficient measure in the industry because of the financial barriers (Fresner, Morea, Krenn, Uson, & Tomasi, 2017).

2.5.2. Informal barriers

As well as the firm have little knowledge of energy efficiency due to the smaller staff size of the small units than the larger units. Entrepreuners in SME's have many roles at a time in the firm and this is the reason no single person is not in charge of energy efficiency in the firm. Management devoted little time for the cause of energy efficiency in small and medium sized firms (Trianni & Cagno, Dealing with barriers to energy efficiency and SMEs: some empirical evidences, 2012) (Trianni, Cagno, Thollander, & Backlund, 2013).

Small firms have high transaction cost in method of collecting, assessing, and implementing information about energy saving potentials and relevant technologies. Studies shown that firm did not apply cost effective measures due to fewer employs. If SME's have managers but they are often uninformed of technologies or they did not recognizes the saveing potential in the fims and failed to calculate the energy consumption systemmatically (Kostka, Moslener, & Andreas, 2013). (Schleich & Gruber, 2008) and (Schleich, 2009) also researched that information barriers are significant for small and medium units in Germany and concluded that SME's have lack of knowledge about energy consumption patterns and this is the main factor for not adopting the energy efficient tools and measures. Markets have a wide range of energy efficient technologies with ralatively low payback time but the SME's are unknown to them (Pathirana & Yarime, 2018). Small and medium sized firms accounting for the fact that they have no proper knowledge about the energy efficiency and not aquiring the proper energy efficeincy measure that requires less efforts and zero capital investment with high rates of return (König , Löbbe, Büttner, & Schneider, 2020).

2.6 Literature gap

A number of studies held on the topic of energy conservation for diverse industrial units like as iron and steel industry, cement industry, petroleum industry, small and medium scale industries, manufacturing industry and textile industry. Many other studies showed that improvement in energy efficiency via energy conservation techniques (Hong G.-B. , Su, Lee, Hsu, & Chen, 2010). There are ways to improve the textile sector energy management which contributes in the competitiveness and profitability of the sector. The textile industry is not adopting the cost-effective measures of energy conservation generally due to lack of information. The information about the energy conservation should be disseminated in the industry to aware people (Bravo & Iturralde, 2022).

Chapter 03

Data and Methodology

This chapter discussed the research methodology. It contains data source and its description, method of data collection, sampling design, variable construction, Theoretical framework and econometric specifications.

3.1 Data source and its description

The study relies on primary data collected from firms through survey. We collected data of energy conservation and firms' other characteristics. Data of energy conservation indicators in a firm is collected through the preliminary energy audit. Questions added about firm's other characteristics and energy conservation indicators in the survey. A survey conducted in textile industry, where the managers, and industry stakeholders provide us the relevant information.

3.1.1. Sampling design

3.1.1.1. Unit of Analysis

The unit of analysis for this study is small and medium firms of textile industry. The main challenge in the survey is criterion selection of a SME's. commonly used the criteria of SME's are no of employees, total net assets, sales and level of investment. However, the most commonly used criteria is no of employees. So there is a cut of range for SME's with 0-250 employees in the firm (Ayyagari, Beck, & Kunt, 2003). Our main indicator for SME's is no of employees. We focused on the SME's in textile sector specifically weaving and finishing firms. Each data point in the dataset represents the individual firm.

3.1.1.2. Locale

The target area to conduct this research is province Punjab located in the eastern side of Pakistan. In Punjab province we focused on the city Faisalabad. It is third largest city of Pakistan with total acquiring area of 59,113,587 Sq. Km. Faisalabad is situated in the flat plains of north east Punjab, between longitude 73°74 east latitude 30°31.5 north. Faisalabad is second most populous district in Punjab province. Basically, it is an agri-industrial district, which contributes in approximately $5 billion to the national GDP with its textile exports (Punjab, n.d.). Although Karachi and Lahore also have significant number of textile firms but Faisalabad is hub of textile products manufacturing. By focusing on Faisalabad city, we targeted Pakistan's main exporting sector of the economy. There is yarn and cloth market where hundred and thousand meters' cloths purchased and sold on daily basis. Faisalabad exported yarn and cloths to rest of the world. Faisalabad is called Manchester of Pakistan because of its extensive textile production. We choose Faisalabad because of most of the weaving firms situated in this city. Weaving firms produced raw fabric for further value addition its sent to other cities. The selection of Faisalabad is due our own to convenience and ease to accessing the firms. Table 3.1 shows the total population of textile firms according to categories and location.

Table 3.1: Total population for different categories of firms

Categories of firm	**West**	**East**
Weaving	2023	1673
Garment	293	86
Dyeing	190	18
Printing	55	104

Source: Punjab Employees social security institution (PESSI)

Table 3.1 showed the categories of the firms in east and west of the Faisalabad city. Faisalabad has 3696 number of weaving firms in west and east of the block. West block contains 2023 weaving firms and 1673 firms are in the east corner. 293 garment firms are situated in the west and 86 in the east. 190 unit of dyeing situated in the west and 18 units in the east. Printing firms having 55 units in the west and 104 firms in the east.

3.1.1.3. Sampling method

In our study we used 2 stage cluster random sampling technique. Two stage cluster random sampling is a complex but effective sampling technique used in the statistics to obtain a representative sample from the population widely spread over the large area. It is too large for the single stage sampling method. This is beneficial method of sampling while engaging with the heterogeneous population where direct sampling is unfeasible or costly.

The process starts with selecting the clusters. Which are naturally arising in grouping from the population, such as geographical areas, category, or some other traits. The first stage involves the randomly selecting the preset number of these clusters. Once the clusters are chosen, the second stage involves randomly sampling the units involved in each cluster.

When we design the survey, it is not feasible and cost effective to select a simple random sample because of the difficulty of compiling a sample frame that list all firms' in the entire population. The broadly dispersed population can also make it costly to select sample. So, in this situation, it is easy to make a group or clusters of firms. On first stage we made two clusters of the sampled firms in the population having same traits. i) Weaving and ii) Finishing.

A random sample of these cluster can be drawn from each of clusters. This is hierarchical, in order to select from listed clusters. Firms are selected randomly based on the proportionate to size. We did sampling with probability proportional to size (PPS). When the sizes of the population are known, it can be shown that a two stage cluster sample in which the clusters are chosen with PPS. By focusing on the specific cluster (regions), it reduces the cost of data collection. Two stage Cluster sampling significantly reduces the resources needed as compare to simple random sampling of complete population.

3.1.1.4. Sample size determination

The population of the textile firms are 4225 in east and west of the Faisalabad city. This number includes the weaving firms, Garments, dyeing and printing units in textile sector. It includes all small medium and large enterprises of textile. While determining the sample size of the two stage random sampling and getting the list from the Punjab employees social security institution (PESSI) we found the three identifier in the list.

- Name of firms
- Sector of firms
- Address of firms

For sampling, we used random clustered sampling technique. we collected data from cluster of 100 sample size categorized into 2 types of units weaving, and finishing. We targeted our sample size to 250 firms. 26 firms refused to give data and 20 firms were shut down, when we contact them for data collection. This study consists of 204 sample size of firms. As the weaving firms are larger in proportion so, that we increased the sampled from weaving firms. Firms are selected randomly based on the proportionate to sample size.

3.2 Questionnaire design

The questionnaire design is an important element of the data methodology in the research. In this research we use the closed ended and open ended questions. A well-structured questionnaire ensures the collection of reliable and valid data. Which is necessary for analyzing the research hypothesis. The questionnaire prepared based on the literature and expert consultation. To construct this questionnaire, we met National energy efficiency and conservation authority (NEECA), Islamabad. We included the demographic questions such as name, age, and questions about energy efficiency indicators. Indicators of energy efficiency such as motor efficiency, motor condition, machine usage, lighting efficiency, type of light, Air conditions, and awareness. The questionnaire designed to be clear, concise and un ambiguous to reduce respondent burden and avoid confusion. The questionnaire used for this study attached in **Appendix**.

3.3 Variable construction

3.3.1. Energy conservation

In the discussion of energy conservation, the main concern is what it means? The word "Energy conservation" used in different context. The usual definition of energy conservation is "saving the energy". Energy conservation and energy efficiency are the terms that used interchangeably. In the literature of the energy economics the most widely used definition of Energy conservation is generally related to the reducing energy consumption per unit of output. In the next section we debate on the energy efficiency.

3.3.1.1. Energy Efficiency

Energy efficiency guides us that what measures we will take to conserve more energy. Energy conservation is a broader term in the literature. Energy efficiency is measured by the series of indicators to quantify the energy efficiency in the facility. In generic terms, energy efficiency states that using less energy and producing same amount of the services and useful output. For example, in the industries, energy efficiency can be calculated by the amount of energy required to produce a ton of product and how much energy is being used by the firms actually. Energy intensity is one the indicator mostly used in the literature (Sener & Karakas, 2019). Some of energy efficiency indicators are discussed below which used in this study.

Motor efficiency: To measure energy efficiency of the firms, motor plays a vital role in it. Motor is key energy consumption unit in the firms. Motors are most commonly used in the textiles firms. The construction of the motor efficiency variable is an important step in this research.

It serves as the primary energy effectiveness variable in the firms. This variable is constructed through input power used in the process of making the output.

$$Efficiency\ \% = \frac{output\ power}{input\ power} \times 100$$

This percentage efficiency is used as proxy of energy efficiency variable. In which the output is mechanical power of motors, typically measured in horse power (HP). Input power is electrical power used in motors usually measured in kilowatt (kw). For extracting this information, we used name plates of motors fixed on it. After measuring the percentage efficiency of motors we categorized it into three categories least efficient, standard efficient, and super-efficient. We took these standards from the institute of electrical and electronic engineering (IEEE). In this study we considered the least efficient is below 65 %, 65-75 % standard efficient and above 75 % are called super-efficient motors.

Motor condition: The motor condition is a key variable in the preliminary energy survey. Motor condition serving as an indicator of whether firms are using motor in original condition or rewind. This variable is constructed through the primary data collected survey, and important for finding impact of motors condition on energy productivity. This variable takes the value 1 if firms reported that they are using original motors and 0 if they reported that firms using rewind motors. This dichotomous variable helps in understanding the energy efficiency relationship with energy productivity.

Lighting efficiency: Lighting efficiency is a main variable of preliminary energy audit. The lighting efficiency dummy variable is defined as the binary indicator reflecting the implementation of energy efficient lighting systems with in firms. The survey included the question regarding the lighting efficiency in the firms like, efficiency and inefficiency, kind of lights, tube lights, energy savers, and LED lights.

We assign the codes to lighting variable 1 if the firms reported that they implemented the energy efficiency lights. 0 if firms reported that they relying on the traditional bulbs, tube light, halogen bulbs and inefficient lighting technologies.

3.3.2. Energy productivity

Energy productivity variable has many names in the literature. Energy intensity is used as the indicating variable in the studies (Sener & Karakas, (2019)). Many studies named it specific energy consumption (SEC). it is used for the calculation of the energy data. Basically engineers used this terminology in the literature more often (Ahmet Çay, 2018).

$$SEC = \frac{EC}{AP}$$

Where EC is monthly average Energy consumption and AP is average production in number of pieces. This is another indicator used in the studies to measure the energy consumption and production for calculating their performance. Economists used to calculate the progress of the firms through the energy productivity.

The construction of energy productivity variable is a pivotal aspect of this study, designed to measure the output manufactured per unit of energy consumed. Ratio calculation from the following formula.

$$Energy\ productivity = \frac{Economic\ Output}{Energy\ input}$$

Energy productivity variable constructed through this formula. Energy input data includes the total energy consumption of entities under study. Energy input data sourced from total electricity units consumed, electricity bills. Economic output measured as the total monetary terms such as sales.

3.3.3. Firm's other characteristics

3.3.3.1. Capital

The variable of capital is defined as the stock of physical and financial assets that are used in the manufacturing of goods and services. This includes the tangible assets such as machinery, buildings, and equipment. We collected the data of current machines prices and the number of machines in the firm. After multiplying the machine price and number of machines, we get the value of capital implied.

3.3.3.2. Labor

The labor data is collected from the firms. In which we included the headcount of the firms. The working hours of labor. Data about the working shifts and training time. The salaries firms disbursed to their human resources. Knowledge and awareness of energy efficiency in the labor of the firms.

3.3.3.3. Age of firm

In the survey of firms, we asked about the established time of firm. The primary data point for the construction of this variable was when the firm established. We calculated the age of the firm with this formula.

$$\text{Firm Age} = \text{Survey Year} - \text{Year of Establishment}$$

After knowing the age of the firms we created categories of age groups. We made five age groups of the firms. Age group variables are included as the dummy variables in the regression analysis.

3.3.3.4. Category of firm

In the survey, while data collection we considered the sector of the firm. We engaged in the two sector of textile. Weaving and finishing/Garments sector considered as our area of research.

The firm category is included due to analyze and draw a comprehensive insight from across sector comparison. This variable gives the targeted recommendations based on the firms' characteristics and category. This variable is also helpful in the situational analysis.

Table 3.2: Variable Description

Variables	Description	Unit
Motor efficiency	Indicates whether the firms uses high efficiency motors (1) or not (0).	Binary
Motor condition	Indicates condition of motors, where (1) represents original condition and (0) represents rewind.	Binary
Lighting efficiency	Indicates the presence of energy efficient lighting system, where (1) means efficient lighting and (0) means in efficient lighting.	Binary
Firm category	Represents the type of the firm, such as weaving (1) or finishing/garments (0).	Binary
Age of firm	The number of years since the firms was established.	Years
Capital	Represents the financial amount of investment in machinery, equipment and in infrastructure.	PKR
Labor	The total number of employees working in the firm.	Headcount in firm
Energy productivity	It is calculated as the ratio of output to energy input.	Ratio (Output/input)

Source: Primary data survey

3.4 Theoretical framework

The production function is fundamental concept in economics, which describes the relationship between the firm's inputs and its output. it is important to understand that how the firms transform the inputs into goods and services. By analyzing the production function, economists and firm's managers can get to know the valuable insights into efficiency and productivity of the firms, the return to scale and role of technological progress. A production function specifies the maximum output a firm can produce with the given quantities of the inputs. The general production function can be expressed as:

$$Y = f(K, L) \tag{3.1}$$

Where:

- Y is the output,
- K is the capital input,
- L is labor input,
- f represents the functional relationship between the input and output.

This is generic form of production function in equation (3.1). This shows that firms include inputs, such as capital and labor, and use them to produce goods that sell to household and markets. This general structure applies to most growth models; it is convenient to start our analysis by using a simplified setup. The next step we will do is make a cobb doulas function of the eq (3.1).

$$Y = AK^{\alpha}L^{1-\alpha} \tag{3.2}$$

In equation (2) Y stands for output, f stands for relationship in between the input and output. A represents efficiency of production, K shows capital input and L denotes for Labor input. α and $1-\alpha$ are output elasticities of capital and labor respectively, which measures the responsiveness of output to change in each input. As we know about the assumption of cob Douglas production function. The function assumes that if all inputs are increased by a certain proportion, the output will increase by the same proportion. Mathematically, if capital (K) and labor (L) are doubled, the output (Y) will also double. Positive but diminishing marginal returns of the function. The model assumes that there is perfect competition in the market. Technology is treated as the constant in the production function.

Labor intensive model of production.

$$\frac{Y}{L} = f(\frac{K}{L})$$

$$\text{y}=f(\text{k}) \tag{3.3}$$

we get equation (2) by dividing the labor on both side to make the function labor intensive.

Energy transformation in Neoclassical production function.

$$Y = f(K, L, E) \tag{3.4}$$

Here, we introduce the energy transformation in basic production function. Other inputs are same in production function as above.

Energy intensive model.

$$Y = f(K, L, E)$$

Dividing by energy eq (3) on both sides.

$$\frac{Y}{E} = f(\frac{K}{E}, \frac{L}{E}) \tag{3.5}$$

Where $k = \frac{K}{E}$ and $\mathrm{l} = \frac{L}{E}$ we assumed the capital energy ratio with k and labor energy ratio with l. in the left side of the equation (3.5) there is output divided by the energy that describes output energy productivity. The higher value indicates that more efficient energy use. As the objective of the study is calculating the energy impacts on firm production. By this we will able to find that energy productivity of firm, energy productivity of capital and energy productivity of labor. So, we include in our final model energy and firm's other characteristics.

$$EP = f(k, l, EE, FC) \tag{3.6}$$

In this equation on left side there is energy productivity, which is function of the capital, labor, energy efficiency and firm characteristics. This is our final model of energy productivity.

3.5 Econometric specification

The econometric specification of the energy-intensive production function model can be expressed as a log-linear regression equation, allowing for the estimation of the elasticities of output with respect to capital, labor, and energy inputs. In the model 01 output is treated as dependent variable. K denotes Capital, L denotes labor. This is simple econometric representation of model. Further we will introduce log transformation.

$$\ln y = \alpha_0 + \beta_1 \ln k + \beta_2 \ln l + \varepsilon_i \quad (3.7)$$

We introduce energy in ours baseline model to estimate energy productivity. Since our objective was to estimate the energy productivity of firms.

$$ln\frac{Y}{E} = \alpha_0 + \beta_1 \ln\frac{K}{E} + \beta_2 \ln\frac{L}{E} + \varepsilon_i \quad (3.8)$$

The equation (3.5.2) represents the model of energy productivity. In which energy output ratio, capital output ratio and labor energy ratio used to analyze the model. The objective is to estimate the impact of energy conservation on energy productivity. For that we included variable of energy conservation.

$$\ln y = \alpha_0 + \beta_1 \ln k + \beta_2 \ln L + \beta_3 \mathrm{EE} + \varepsilon_i \quad (3.9)$$

In the equation (3.5.4) after log transformation in the equation we included the variable of energy efficiency which captures the impact of energy conservation on energy productivity.

To capture the firm level heterogeneity, we included the age of firm, sector of the textile firm.

$$\ln Y_{is} = \alpha_0 + \beta_1 \ln K_{is} + \beta_2 \ln L_{is} + \beta_3 EE_{is} + \sum \beta_{4i} \mathrm{Age} + \beta_5 \mathrm{Sector} + \varepsilon_i \quad (3.10)$$

Dividing by energy factor on both sides. We get the final model for estimation.

$$\ln(\frac{Y_{is}}{E}) = \alpha_0 + \beta_1 \ln(\frac{K_{is}}{E}) + \beta_2 \ln(\frac{L_{is}}{E}) + \beta_3 EE_{is} + \sum \beta_{4i} \mathrm{Age} + \beta_5 \mathrm{Sector} + \varepsilon_i \quad (3.11)$$

Where ln stands for natural log of the terminologies. $\frac{Y_{is}}{E}$ is denoting the energy productivity in the model. α_0 is an intercept of the model. $\frac{K_{is}}{E}$ it indicated the capital energy ratio used for the production in the firms. EE_{is} is stands for the energy efficiency variables included in our model. Age is the variable of the firms age. Sector is stand for the industrial sector of the firm weaving or finishing. ε_i this is error term of the model. “is” with each variable, i stands for the firms and “s” stands for the sector of the firm in the industry.

This econometric model estimated by the ordinary least square (OLS) technique. Ordinary least square regression is broadly used method to estimate the relationship between the dependent variable and one or more independent variable. However, OLS technique relies on several assumptions about the data. Robust analysis techniques are used to address the potential issues and enhance reliability of the OLS results.

Chapter 04

Results and discussion

This chapter discusses about the situational analysis of the firms, graphical representation of the data, descriptive statistics, and the results of regression analysis of this study.

4.1 Situational analysis

Situational analysis is a comprehensive approach to get the insight of internal and external factors influencing this research study. By systematically collecting and analyzing the data, identifying the fundamental issues, and developing planned recommendations, you can make a well-informed foundation for decision making and planning.

4.2 Categories of firms

To conduct this research, we selected firms from textile sector of Faisalabad. We choose weaving and finishing units for this research. There is Finishing(Garments) and wet processing category. Which represents the 38 % of total data. The major chunk of the data described by the weaving firms. The data indicates the weaving category contains 62 % of total firms. The total number of firms considered for survey are 204.

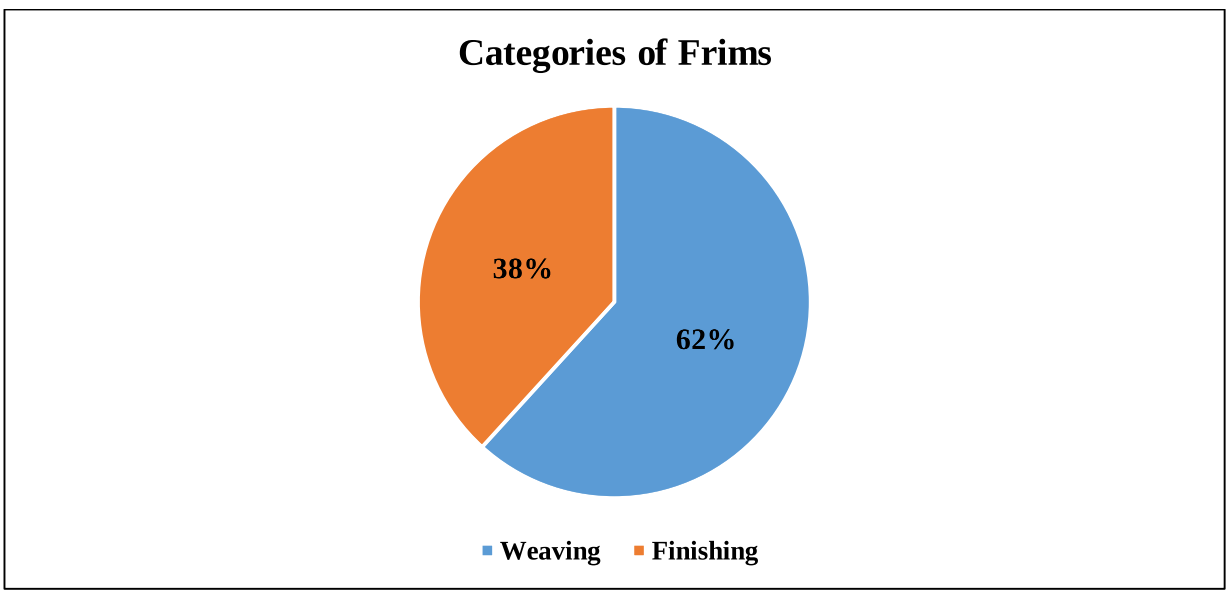

Figure 4.1: Categories of firms.

Figure 4.1 describe the survey data on the distribution of firms across weaving and finishing. The weaving holds big shares in the pie because of the dynamics of the industrial site.

4.3 Electricity source

This variable is classified the primary energy source of the firms in two categories. Collecting data on this variable normally involved utility bills and this guides us about the exact utilization of the energy patterns with in the study scope.

Table 4.1: Electricity source of firms

Electricity source	Percentage
Grid	89
Solar	11

Source: Authors own calculation.

Table 4. showed the source of electricity in the small and medium firms of textile in Faisalabad. In the table 89 % firms solely dependent on source of grid electricity and 11 % firms used solar and grid electricity. These firms have some advantage of cheap electricity for utilization. The data indicates that majority of electricity is sourced from grid, which is used about nine times out of ten. Solar power, less common but significant portion of firms moving towards solar energy.

4.4 Motor Efficiency

Motor efficiency is very important factor in the textile firms. All kind of textile firms relies on the motors. It is the key element in measuring the energy efficiency of firms. It tells us how effectively the motor converts the electrical energy into mechanical energy.

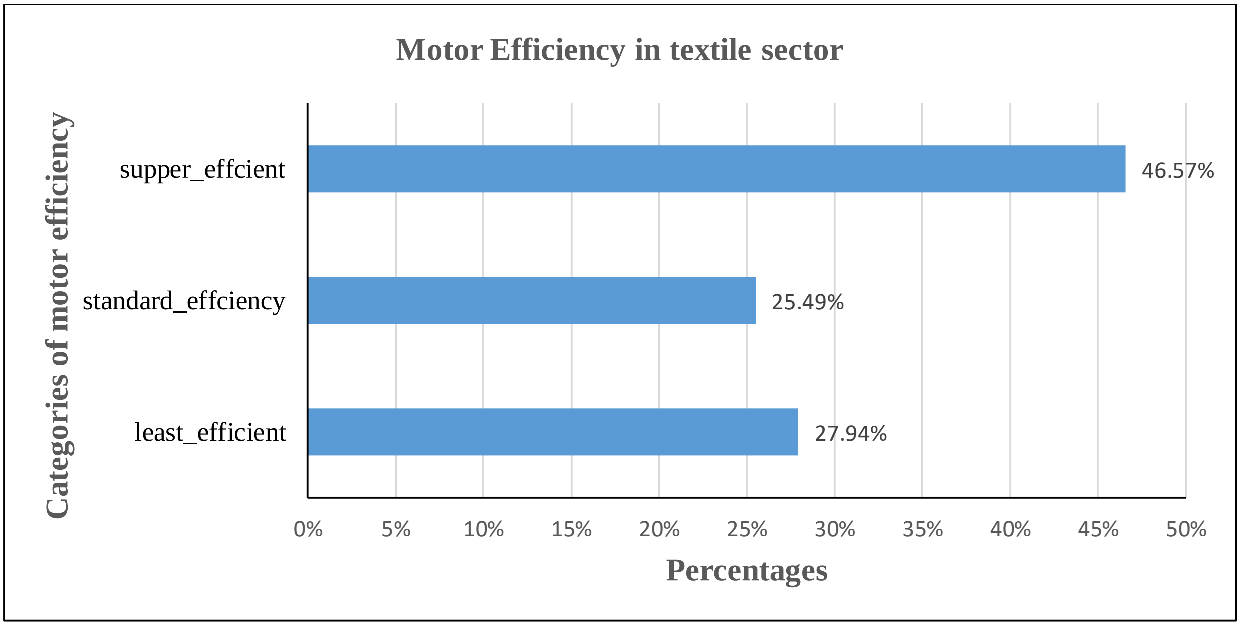

Figure 4.2: Motor efficiency in textile sector.

Figure 4.2 elaborates the categories in the variable of motor efficiency we have 3 categories which explains the efficiency of the motors. Least efficient motors that works bellows 65 % and consuming more electricity than other categories. This is the reason of the inefficiency of the firms. 27.95 % firms using least efficient motors. 25.49 % motors are standard efficient in the firm's data. 65 % to 75 % efficiency decided as standard efficiency. 46.57 % motors are super-efficient in the industry. These motors consume less energy as compare to least and standard efficient motors. A major chunk of motors lies in this category. This suggest that majorly firms have super-efficient motors in the industry.

4.5 Motor condition percentage

Motor condition percentage is a critical measure the operational health of motors and energy efficiency of electric motors. Motors in their original condition exhibits the highest efficiency as they are manufactured and designed to that optimal requirement. However, over the time, motors require rewinding due depreciation. Which can affect its efficiency.

Rewound motors still functions but often shows decline in the performance and energy efficiency. Its due to winding patterns and materials used during winding motors.

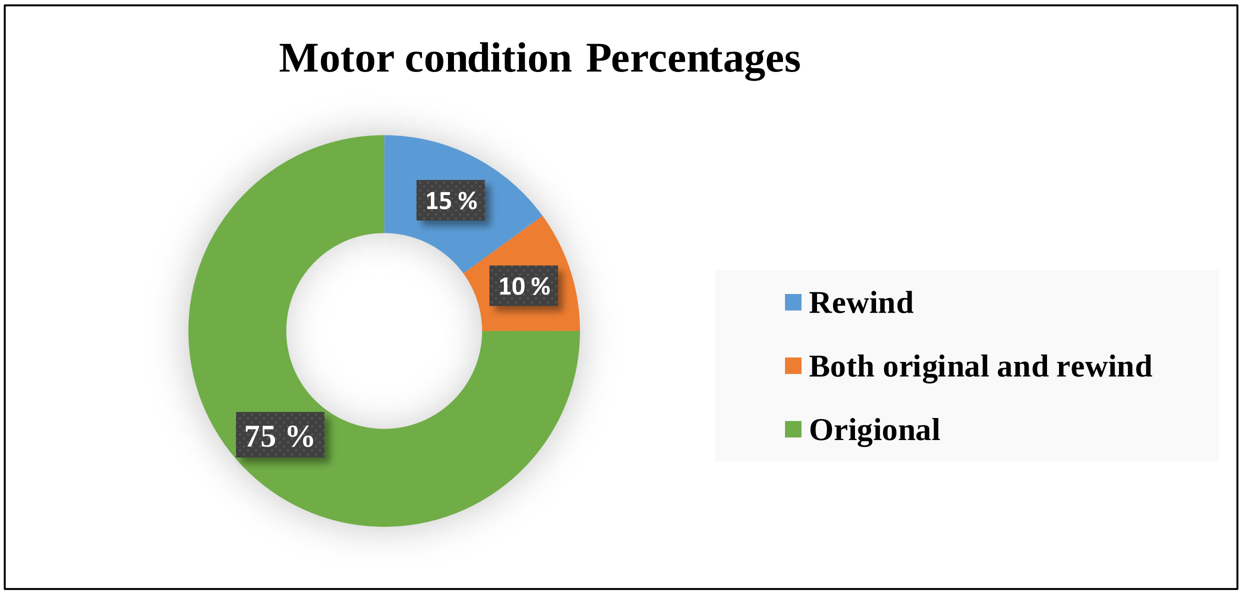

Figure 4.3: Motor condition percentages.

Figure 4.3 depicts the percentage of motor condition in both sector. There are 75% original motors used in the small and medium textile firms. The use of original motors increases the energy efficiency of firms. Only 15 % firms used rewind motors. Using rewind motors badly effects the efficiency of the firms. 10 % of firms used both original and rewind motors. By analyzing the motor condition percentage, we can quantify the efficiency losses in the sector.

Table 4.2: Energy efficiency of firms

Motor				
Indicators		Total %	Weaving %	Finishing %
Efficiency	Least efficient	27.94	16.67	46.15
	Standard efficient	25.49	31.75	15.38
	Super-efficient	46.57	51.59	38.46
Condition	Original	75.49	76.98	73.08
	Rewind	14.71	14.29	15.38
	Both original & rewind	9.80	8.73	11.54
Type	Ac	70.59	80.95	53.85
	Dc	29.41	19.05	46.15
Machine service	Weekly	33.82	26.19	46.15
	Monthly	46.57	49.21	42.31
	On fault	19.61	24.60	11.54
Note: This table presents 4 indicators for motor performance and maintenance across two different sectors: Weaving and Finishing.				

Source: Author's own Calculations.

Table 4.2 provides a detailed analysis of motor performance and maintenance practices across two sectors in the textile industry, Weaving and Finishing. By examining different indicators such as efficiency levels, motor history, motor type, and duration of machine service, we can derive valuable insights into energy efficiency practices within these sectors. The data reveals differences in motor efficiency between the Weaving and Finishing processes. In total, 46.57% of motors are classified as super-efficient. However, this percentage varies significantly between both sectors. 51.59% of motors are super-efficient in Weaving firms, indicating a high-efficiency motors. 31.75% are standard efficient and 16.67% are least efficient motors in weaving firms.

On the other hand, finishing firms have only 38.46% of motors are super-efficient,15.38% are standard efficient motors. While 46.15% are least efficient, suggesting that there is substantial room for improvement in this sector.

The prevalence of least efficient motors in the Finishing sector highlights a critical area where targeted interventions can enhance energy efficiency. By upgrading or replacing inefficient motors, the Finishing sector could achieve significant energy savings.

4.6 Motor condition

The majority of motors are original, with 75.49% overall, and slightly higher percentages in Weaving (76.98%) compared to Finishing (73.08%). 14.71% of motors have been rewound, with almost similar proportions in both sectors. A small percentage (9.80%) of motors have been both original and rewind in total, weaving firms have 8.73%. The number is slightly higher in the Finishing sector (11.54%).

The type of motors used varies significantly between the weaving and finishing sector. AC motors are mostly used in both sectors, with 70.59% overall. Weaving has a higher reliance on AC motors (80.95%) compared to Finishing (53.85%). DC motors mostly used in the Finishing sector (46.15%) compared to Weaving (19.05%). DC motors are generally more efficient for textile operations. Finishing or garment sector don't need much heavy motors so, that this sector use Dc motors. Machine Service frequency plays an essential role in maintaining motor efficiency.

Weekly service conducted more frequently in the Finishing sector (46.15%) compared to Weaving (26.19%). The most common service interval overall (46.57%), with similar rates in both sectors is monthly. More common in Weaving (24.60%) compared to Finishing (11.54%).

Regular servicing is important for ensuring motor efficiency. The higher rate of on-fault servicing in the Weaving sector suggests a reactive maintenance approach, whereas the Finishing sector's higher weekly service rate indicates a more proactive maintenance strategy. Adopting more proactive maintenance practices in Weaving could lead to better motor performance and energy efficiency.

4.7 Lighting efficiency

Lighting efficiency in small and medium sized textile firms have an important role in energy cost and energy efficiency of firms.

Textile firms requires significant and continuous light in the facility to ensure the quality of the fabrics. However, traditional lighting systems can be highly energy intensive and most important factor of increasing energy cost. Recent research suggests that adopting energy efficient lighting such as LED lights. Which consume significantly less power than traditional lights and have longer lifespans as compared to conventional incandescent or fluorescent bulbs. Lighting efficiency is an important indicator of energy efficiency. **Figure 4.4** below indicates about the lighting efficiency of small and medium textile firms in Faisalabad.

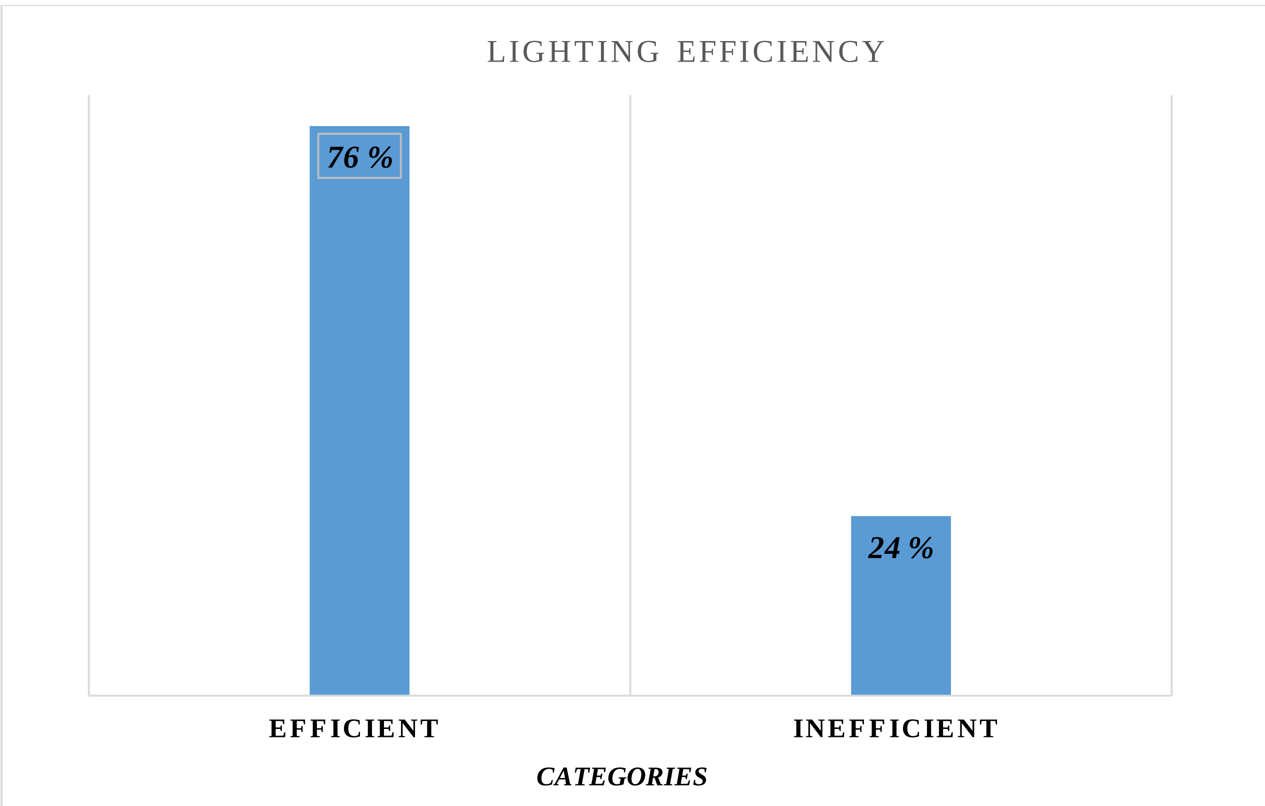

Figure 4.4: *Lighting Efficiency of textile sector*.

In the **Figure 4.4** we can see that most of the firms implemented the efficient lighting. 76 % lighting is efficient in both sectors. Which shows that industry have awareness about the lighting efficiency. 24 % of firms still using the inefficient lighting.

Lighting is an important factor of energy survey. Efficient lighting use reduce the energy consumption. Even though investing the efficient lighting is higher in the beginning. In the long term, it's the reason of reduction in the cost of energy bills. Energy efficient lighting system provide the better quality of the lighting. This can enhance the labor productivity and work environment.

Table 4.3: Lighting and Air conditions

Lighting				
Indicators		Total %	Weaving %	Finishing %
Efficiency	Inefficient	24.02	36.51	3,85
	Efficient	75.98	63.49	96.15
Light kind	Tube light	25,49	36.51	7.69
	Energy saver	24.51	11.11	46.15
	Led light	50	52.38	46.15
Unused lit area	Yes	6.86	8.73	3.85
	No	93.14	91.27	96.15
Air condition				
Indicators		Total %	Weaving %	Finishing %
Ac	No Ac	88.24	92.86	80.77
Type of Ac	Conventional ac	2.94	4.76	0.00
	Inverter ac	8.82	2.38	19.23
Note: This table provides insightful data on the efficiency and type of lighting and air conditioning used in weaving and finishing firms. It reveals that the finishing units has a higher percentages of efficient lighting and uses more inverter AC units as compared to the weaving units. The data highlights the importance of targeted interventions to enhance energy efficiency, especially in weaving units where there is a higher rate of inefficient lighting and a greater percentage of unused lit area.				

Source: Author's own Calculations.

Table 4. shows an in-depth look at the lighting and air conditioning efficiency within the Weaving and Finishing sectors of textile firms. The data is divided into efficiency levels, types of lighting, unused lit areas, and the presence and type of air conditioning. By analyzing these indicators, we can identify key areas for improvement and highlight successful practices that enhance energy efficiency. The data indicates a significant disparity in lighting efficiency between weaving and finishing sector. Overall, 24.02% of the lighting is inefficient. However, this figure is much higher in the Weaving sector 36.51 % compared to the Finishing sector 3.85 %.

On the other hand, 75.98 % of the lighting is efficient, with the finishing sector achieving an impressive 96.15% efficiency rate, while the weaving sector lags at 63.49 %. This suggests that the Finishing sector has successfully implemented more efficient lighting solutions. The Weaving sector, with its higher rate of inefficient lighting, presents a clear opportunity for targeted interventions to upgrade lighting systems in weaving firms.

Different types of lighting are used across the sectors, impacting overall efficiency. Tube light used more in the weaving sector 36.51 % compared to the finishing sector 7.69 %. Energy saver mostly used in the finishing sector 46.15 % compared to weaving 11.11 %. LED light the most efficient option, used by 50 % overall, with slightly higher usage in the weaving sector 52.38 % compared to finishing 46.15 %. The high use of LED lights in both sectors is encouraging, but there is room for increasing the adoption of energy-saving bulbs in the weaving sector.

Unused lit area managing unused lit areas is critical for energy efficiency and an important factor in measuring lighting efficiency. Unused lit areas present in 6.86% of the total areas, with a higher prevalence in the weaving sector 8.73 % compared to the finishing sector 3.85 %. 93.14 % of the areas are efficiently managed with no unused lit areas, higher in the finishing sector 96.15 % than in weaving 91.27 %. The weaving sector should focus on reducing unused lit areas to improve overall energy efficiency.

Air Conditioning Efficiency is the presence and type of air conditioning also play a critical role in energy efficiency. The majority of the areas do not have air conditioning, with 88.24 % overall, and higher in the weaving sector 92.86 % than in finishing 80.77 %. Very limited use of conventional AC overall 2.94 %, with slightly higher usage in the Weaving sector 4.76 %. More energy-efficient and inverter AC used by 8.82 % overall, predominantly in the Finishing sector 19.23 %, with minimal use in Weaving 2.38 %.

The Finishing sector's higher use of inverter ACs suggests an advanced approach to energy-efficient cooling, while the Weaving sector can benefit from transitioning from conventional to inverter AC units. This analysis emphasizes the gap in energy efficiency practices between both categories of firms weaving and finishing. There is need of upgradation of inefficient lighting.

The Weaving sector should prioritize replacing inefficient lighting with more efficient options, such as LED lights. Encourage the adoption of led lights and energy savers rather than using bulbs in weaving sector to enhance energy efficiency. Reduced unused lit areas and implement plans and policies to minimize unused lit areas in weaving sector. Promote the use of inverter air conditioning units in the weaving firms to improve energy efficiency.

By addressing these issues, textile firms can achieve significant improvements in energy efficiency, which leads to cost savings and more sustainable processes. The finishing sector functions as a model with its higher efficiency rates, determining the possible benefits of targeted energy-saving models.

4.8 Employs Awareness

Raising awareness in the employs about the energy efficiency and providing them education and training on it. It is an important factor of improving the energy productivity of the firms. Firms have knowledge about the energy efficient technologies, like energy efficient motors, lighting systems, air conditions to save the energy cost. The table below represents the awareness in the weaving and finishing firms of textile sector.

Table 4.4: Managers and Employs Awareness

Managers and Employs awareness				
Indicators		Total%	Weaving %	Finishing %
Awareness about EE	Yes	9.80	11.11	7.69
	No	90.20	88.89	92.31
Guidance reminder	Yes	5.39	6.35	3.85
	No	94.61	93.65	96.15
Equipment off when unused	Yes	97.06	100	92.31
	No	2.94	0.00	7.69
Note: This table highlights critical gaps and strengths in energy efficiency awareness and practices among managers and employees of weaving and finishing firms. Guidance reminder in weaving sector is higher than finishing sector. Unused equipment off is higher in weaving firms. The table suggests that employees may not always be are of energy efficient concepts, structured reminders and awareness trainings significantly influence energy saving behaviors.				

Source: Author's own Calculations.

Table 4.4 provides a comprehensive overview of energy efficiency awareness and practices among managers and employees in both weaving and finishing sectors of textile firms. By examining key indicators such as awareness about energy efficiency (EE), the presence of guidance reminders, and the practice of switching off equipment when unused, we can identify areas of improvement and highlight successful strategies that promote energy efficiency.

The data indicates varying levels of awareness about energy efficiency. Only 9.80% of respondents are aware of energy efficiency practices. Notably, awareness is a little higher in the Weaving sector 11.11 % compared to the Finishing sector 7.69 %. A significant majority, 90.20% overall, lack awareness about energy efficiency. This highlights a critical opportunity for both sectors to implement educational training programs and awareness campaigns to enhance understanding and adoption of energy-efficient practices among employees and managers.

The presence of guidance reminders plays a crucial role in reinforcing energy-efficient behaviors. Overall, only 5.39 % of firms provide guidance reminders. However, the weaving sector 6.35 % has a slightly higher implementation rate compared to the Finishing sector 3.85 %. The absence of guidance reminders is predominant, with 94.61% overall. This is more prevalent in the Finishing sector 96.15 % than in weaving 93.65 %.

The inequality suggests that effectiveness of guidance reminders, particularly in the Finishing sector, could significantly enhance energy efficiency practices across textile firms. Properly managing equipment usage when not in use is essential for energy conservation. A high percentage, 97.06 % overall, ensure equipment is switched off when not in use. This practice is strictly followed in the Weaving sector 100 % compared to the Finishing sector 92.31 %. However, a small percentage 2.94 % overall do not switch off equipment when unused.

This is more prevalent in the Finishing sector 7.69 % compared to the Weaving sector 0.00 %. This analysis highlights several key insights and recommendations for improving energy efficiency in textile firms. Develop comprehensive awareness programs to educate managers and employees about the importance and benefits of energy efficiency.

Implement regular and effective guidance reminders across both sectors, with particular emphasis on the Finishing sector to bridge the current gap. Encourage and reinforce the practice of switching off equipment when not in use across all sectors, learning from the exemplary performance of the weaving sector. Rise a culture of continuous improvement in energy efficiency practices through training, monitoring, and feedback mechanisms. By addressing these areas, textile firms can achieve significant improvements in energy efficiency, reduce operational costs, and contribute to sustainability goals effectively.

The data suggests the importance of proactive management and employee engagement in shaping energy-saving behaviors and practices within the workplace. In additions, collaboration with industry association and government agencies strengthen these efforts, providing firms with access to resources, financial incentives and expertise of the experts to support energy efficiency goals.

4.9 Challenges faced by firms to be energy efficiency

The weaving and finishing sector of textile in Faisalabad city faced various issues and challenges to survive in the economy. These challenges are affecting their energy productivity, energy efficiency and operational efficiency. There is a primary concern of the firms that the electricity prices are not bearable. Firms reported about the high tax rate, costly raw material, low investment, political instability, and inflation.

Table 4.5: Challenges faced by firms to be energy efficiency

Challenges faced by firms		
Challenges	**Weaving %**	**Finishing / Garments%**
High Electricity rate	100	100
High tax rate	12	5
Costly raw material	21	13
Declining demand	4	2
Low investment	0	6
Political instability	20	7
Inflation	9	12
Note: The table shows issues highlighted by the small and medium firms of textile sector.		

Source: Author's own calculation.

Table 4. presents challenges faced by the weaving and finishing sector of textile in Faisalabad. Every firms in both sector of textile weaving and finishing there is an issue of high electricity rate. This informed us that there is a universal issue of the high electricity.100 % of weaving and finishing firms struggling with this issue. The electricity cost significantly affect the operational cost of the firms.

A noticeable portion of the weaving firms 12 % reports that there is high tax rate from the government. Whereas a smaller portion 5 % suggest in the finishing and garment sector. This suggest that tax burden is upsetting the firms.

Costly raw material is another issue reported by both kind of firms. 21 % weaving and 13 % of finishing firms suggest that this is also a concerned issue in surviving in the textile sector. Both sector of textile relatively low percentages for the declining demand weaving has 4 % and 2 % by finishing sector. It is because of clothing is a basic need of humans. No weaving firm reported that there is issue of low investment whereas the 6 % finishing firms faced this issue. Political stability is major challenge for the weaving firms. 20 % of weaving firms reported that political stability affected the performance of the textile sector. Governance issue and ineffective policies indicates that inefficiency of the sector.

Weaving 9 % and 12 % finishing firms faced the issue of inflation. Although both sectors affected by this problem. Inflation is slightly significant challenge for the finishing sector. Finishing sector is more affected by inflation because of raw material specially yarn cones prices and sales tax on it is affecting the firms.

These challenges stresses about the complex environment of the textile sector in which textile firms are operating. This analysis highlights the different nature of challenges faced by the firms in textile sector of Faisalabad. This analysis suggests that there is need of interventions for small and medium textile firms that could help alleviate these issues from this sector of the economy. The policy support and collaborative efforts to address these issues and promote sustainable growth of the textile sector.

4.10 Regression analysis

In this section, we present the results of the regression analysis to estimate the determinants of energy productivity in the weaving and finishing sector of textile industry.

This analysis tries of to quantify the impact of key variables, containing capital, labor, firm age, motor condition, and firm category on energy productivity. The ordinary least square (OLS) technique is used to estimate the parameter of specified models.

Table 4.6: Impact of energy efficiency on firm's productivity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log K	0.251***	0.183**	0.188**	0.142				
	(0.0581)	(0.0793)	(0.0934)	(0.0909)				
Log L	0.333***	0.305***	0.316***	0.252***				
	(0.0587)	(0.0592)	(0.0728)	(0.0650)				
Log K/L					0.436***	0.443***	0.406***	0.454***
					(0.0544)	(0.0765)	(0.0907)	(0.0873)
Firm age (20-30 years)		0.372***	0.440***	0.585***		-0.444**	-0.167	-0.393**
		(0.117)	(0.125)	(0.132)		(0.185)	(0.157)	(0.188)
Firm age (30-50 years)		0.144	0.407***	0.496***		-0.114	0.536***	0.0326
		(0.159)	(0.121)	(0.132)		(0.117)	(0.150)	(0.0839)
Firm age (Above 50 years)		0.571*	0.608	0.950**		-0.704*	-0.444	-0.578
		(0.320)	(0.467)	(0.465)		(0.426)	(0.492)	(0.601)
Finishing sector		-0.352*	-0.0302	-0.153		-0.0993	0.412**	0.176
		(0.182)	(0.204)	(0.183)		(0.245)	(0.202)	(0.238)
Energy Efficiency variables								
Median Energy Efficiency		0.717***				0.763***		
		(0.104)				(0.160)		
Standard Motor efficiency			0.306*				0.970***	
			(0.181)				(0.202)	
Super Motor efficiency			0.0859				0.716***	
			(0.129)				(0.162)	
Rewind and original motor				0.978***				0.0182
				(0.255)				(0.230)
Original motor				0.340**				0.0372
				(0.147)				(0.140)
Constant	5.683***	6.440***	6.415***	7.069***	2.075***	1.832*	1.750	1.965
	(0.842)	(1.159)	(1.434)	(1.332)	(0.685)	(1.011)	(1.133)	(1.194)
Observations	**204**	**204**	**204**	**204**	**204**	**204**	**204**	**204**

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The table presents the result of the multiple regression analysis examining the relationship with different explanatory variables and dependent variable outcome of the firms and their energy productivity. The regression result split across different models (columns) with varying set of independent variables included. Dependent variable in this model is output energy productivity. The first model in the table is on level or baseline model of regression in which output energy productivity is dependent and independent variables are log of capital (log K) and log labor (log L). Where both are significant statistically and have a positive relationship with outcome energy productivity.

Across the model 1 to 4, the co-efficient for log K ranges from 0.142 to 0.251, all significant at 1% or 5% level. This suggests that an increase in the capital is associated with the output. The coefficient of log L varies between 0.252 to 0.333 significant at the 1% level in all models where it is included. This indicates that there is strong relationship between labor input and firms output level. In model (5) to (8), the capital labor ratio (Log K/L) included and has a positive and significant coefficients ranging 0.406 to 0.454. this suggest that higher the capital to labor ratio is positively associated with the output. To check the firm age effect, we included dummy variables in our analysis. 1-20 years' firm is our reference category for relating in the analysis.

In model (3) and (4), the coefficient is positive and highly significant (0.372) to (0.585), which indicates that firms aged 20-30 years tend to perform better compared to the reference category (likely younger firms). The coefficient is positive and significant in models (3) and (4) (0.407 and 0.496), suggesting better performance for the firms in the age of (30-50) years. The firm age above 50 years have positive coefficients and marginally significant in model (3) and highly significant in model (4) with values of (0.571 to 0.950). This indicates that very old firms tend to perform better than the younger ones in a certain context. The dummy variable for the finishing sector appears a negative and marginally significant effect in model (3) (-0.352). This suggests that firms in the finishing sector may underperform relative to weaving sector.

The dummy variable for medium energy efficiency (Dum Med EE) is positive and highly significant in models (3) and (7), suggesting that firms with medium energy efficiency levels have better outcomes. We define the motor efficiency in 3 categories least efficient, standard efficient, and super-efficient. Variables for standard and super motor efficiency also show positive and significant effects, particularly in model (7), indicating that higher motor efficiency contributes positively to firm performance. The other variable of energy included in the analysis named as motor history categorized in rewind motors and original and both kinds of motors. the dummy for firms using rewind and original motors shows a highly significant positive effect in model (5), suggesting that these firms perform better, potentially due to cost savings or efficiency improvements. The constant term is positive and significant in all models. Each model is based on the 204 observation and robust standard error are used for addressing the issue of heteroscedasticity. Stars next to the coefficients indicate the level of statistical significance with "" ***denoting p<0.01,*** *"" indicating p<0.05, and* "" signifying p<0.1.

Table 4.7: Determinants of Energy Productivity: Impact of Capital, Labor, Firm Age, and Energy Efficiency

Variables	**Model 1**	**Model 2**	**Model 3**	**Model 4**
Log K/E	0.354***	0.236***	0.361***	0.372***
	(0.0352)	(0.0316)	(0.0380)	(0.0383)
Log L/E	48.00***	32.02***	44.55***	43.75***
	(4.513)	(3.455)	(4.358)	(4.491)
Energy efficiency variables				
Median Energy efficiency		1.161***		
		(0.115)		
Standard			0.601***	
Motor efficiency			(0.144)	
Super			0.296***	
Motor efficiency			(0.108)	
Rewind and original motor				0.133
				(0.190)
Original motor				0.0287
				(0.128)
Firm Age (20-30 years)		-0.227**	-0.112	-0.234*
		(0.0984)	(0.108)	(0.121)
Firm Age (30-50 years)		0.0115	0.347**	0.0968
		(0.0714)	(0.171)	(0.139)
Firm Age (Above 50 years)		-0.698***	-0.565	-0.544
		(0.159)	(0.379)	(0.452)
Finishing sector		0.248**	0.713***	0.556***
		(0.105)	(0.117)	(0.131)
Constant	-0.651***	-0.223	-1.186***	-0.884***
	(0.208)	(0.204)	(0.246)	(0.280)
Observations	**204**	**204**	**204**	**204**

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The table presents a set of regression models aimed at examining the relationship between various explanatory variables and dependent variable energy productivity. Energy productivity is typically defined as the ratio of the output to energy input.

The key variables are capital to energy ratio (Log K/E) and labor to energy ratio (Log L/E). The coefficient for Log K/E are positive and statistically significant at 1% level across all the four models, ranging from 0.236 to 0.372. this indicates that an increase in the capital energy ratio is associated with a significant increase in energy productivity. Labor energy ratio (Log L/E) is highly significant at the 1% level across all the models with very large and positive coefficients ranging from (32.02 to 48.00). This result suggests very strong relationship between labor energy ratio and energy productivity. The results suggest the importance of the labor in the industry. In next segment of the table we included the energy efficiency variables.

Dum Med EE (Dummy for medium energy efficiency) Included in model (2), this dummy variable is positive and highly significant, with a coefficient of 1.161. This suggests that firms classified as having medium energy efficiency experience a substantial increase in energy productivity compared to the baseline group. The next variable we included for motors. Standard motor efficiency In model (3), the coefficient for standard motor efficiency is positive and highly significant (0.601***). This suggests that the adoption of standard efficient motors contributes significantly to increased energy productivity of the firms. Super motor efficiency also included in model (3), this variable has a positive and significant coefficient (0.296***), although the impact is smaller compared to standard motor efficiency.

This implies that motors with even higher efficiency ratings (super-efficient) further enhance energy productivity, though the marginal gain compared to standard efficient motors may be less pronounced. These variables are for motor history. According to rewind motors because that is our reference category, In model (4), the coefficient for the dummy variable indicating the use of rewind and original motors is positive but not statistically significant (0.133).

Similarly, the coefficient for the original motor dummy in model (4) is very small and not statistically significant (0.0287), indicating negligible impact on energy productivity. In the next part of the table we included the other characteristics of the firms. Dummy for the age group (20-30 years), This variable is included in models (2), (3), and (4). It has a negative and statistically significant coefficient in models (2) and (4) (-0.227** and -0.234*, respectively). This suggests that firms aged 20-30 years have lower energy productivity compared to the younger firms (1-20years). The negative impact diminishes in significance in model (3), indicating that other factors might be mediating this relationship.

Dummy for age (30-50 years), The coefficient for this variable is positive and significant in model (3) (0.347**), suggesting that firms aged 30-50 years have higher energy productivity. However, in model (4), the effect is positive but not statistically significant, indicating that the age of the firm plays a role in energy productivity. Dummy for firms aged above 50 years old, this variable has a strongly negative and highly significant coefficient in model (2) (-0.698***), implying that older firms (above 50 years) have significantly lower energy productivity. However, this effect is less pronounced and not statistically significant in models (3) and (4), suggesting that the impact of firm age may be less consistent or context-dependent. The next variable we added in the analysis is for sectoral findings.

The dummy variable for firms in the finishing sector is positive and statistically significant in models (2), (3), and (4), with coefficients ranging from 0.248** to 0.713***. This suggests that firms in the finishing sector tend to have higher energy productivity compared to firms in weaving sector, possibly due to more efficient energy usage practices or sector-specific characteristics that favor energy efficiency.

The constant term is negative and significant in models (1), (3), and (4), indicating that the baseline level of energy productivity is below zero when all other variables are at their minimum or baseline values. These findings highlight the importance of capital and labor efficiency, energy-efficient technologies, and sector-specific factors in enhancing energy productivity. The varying impact of firm age suggests that older firms may need targeted interventions to maintain or improve their energy efficiency.

Chapter 05

Conclusion and policy recommendation

5.1 Conclusion

In this thesis, we have explored the determinant of energy productivity in small and medium textile firms of Faisalabad. We focus on weaving and finishing/garment sector in this study. In this research we investigated the roles of capital, labor, firm age, and energy efficiency indicator like motor efficiency, lighting efficiency, and other barrier of not moving towards energy efficiency in the textile industry. The study utilized the primary data collected through the surveys and used the econometric technique to analyze the relationship between these variables and energy productivity. This study provides a comprehensive analysis of the factors influencing energy productivity in small and medium textile firms, with a focus on the critical role of capital, labor, firm age, energy efficiency, and sectoral characteristics.

The results consistently underscore the significance of both capital-to-energy and labor-to-energy ratios in driving energy productivity, with higher ratios strongly associated with better performance. This highlights the importance of efficient resource allocation in enhancing the overall productivity of firms. The analysis also reveals that energy-efficient technologies, such as standard and super motor efficiency, play a crucial role in boosting energy productivity. Most of the weaving firms are using standard efficient motors in the sector. The finishing sector have more energy efficient motors and tools.

Firms that adopt these technologies, particularly those with medium energy efficiency, experience substantial gains, emphasizing the need for widespread adoption of energy-saving practices across the sector.

Firm age presents a more complex picture, with middle-aged firms (30-50 years) generally performing better in terms of energy productivity, while very old firms (above 50 years) exhibit declining productivity. This suggests that older firms may face challenges related to outdated technologies or practices, necessitating targeted interventions to help them modernize and maintain their competitiveness.

Sector-specific analysis indicates that firms in the finishing sector tend to have higher energy productivity compared to those in the weaving sector, likely due to more efficient energy use practices inherent to the finishing process. This finding suggests that sectoral characteristics should be taken into account when designing policies aimed at improving energy efficiency.

Overall, the study underscores the critical importance of investing in energy-efficient technologies, optimizing the use of capital and labor, and providing targeted support to older firms and specific sectors. By addressing these factors, small and medium textile firms in Faisalabad can significantly enhance their energy productivity, leading to improved competitiveness, sustainability, and economic performance. These insights offer valuable guidance for policymakers and industry stakeholders seeking to foster a more efficient and resilient textile sector in Pakistan.

5.2 Limitation of study

Despite the valuable insights provided by this research study, several limitations should be acknowledged. including the reliance on primary data, which may be subject to biases and inaccuracies in respondents. The study utilized cross sectional data capturing a single point in time. This limits the ability to observe changes over the time. Some important variables of energy efficiency like motor efficiency, lighting efficiency, ac efficiency, employee's awareness used as binary variable. We used the preliminary energy audit questionnaire which is a basic level of measuring energy efficiency. More detailed energy audit could provide a more accurate assessment. There is need of specialized tools like LUX meter, loggers and other energy efficiency measuring devices to capture the accurate assessment. These are the expensive tools used by engineers to assess energy efficiency of firms. The study focuses on the internal determinant of the industry like energy productivity, capital, labor, firm specification. External factors, such as market conditions, regulatory changes, and technological improvements were not included in the analysis. This study is conducted in a specific geographical location Faisalabad, and focuses on the specific firms of the textile sector weaving and finishing/ garments. By acknowledging these limitations, future studies can be better designed to deal with these gaps and provide more comprehensive insights into contributing factors of energy productivity in the textile industry and beyond.

5.3 Policy Recommendation

- **Develop Sector-Specific Energy Efficiency Initiatives:** Create and implement targeted energy efficiency programs designed for high-energy consumption sectors, such as the weaving sector, to maximize energy productivity. This must include conducting more frequent energy audits and expanding energy efficiency awareness programs across the industry.

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Appendix

Energy Audit Questionnaire for

Textile industry

Firm information.

Company & organization

Name……………………………………………………………………………………….

Location……………………………………………Age of firm………………………….

Size of firm (No of employs) ………………………….

Annual/Monthly output………………………………

category of manufacturing unit?

1=small 2= medium 3= large

Type of firm

1=Spinning 2=weaving 3=wet processing/ finishing

Type of product manufactured?

1= yarn 2= Fabric 3=Finished Garment.

How many shifts are there?

1 2 3

Working time annual operating hours?

Personal information of the firm representative.

Name…………………………………………..

Designation……………………………………

Contact…………………………………………

Email…………………………………………..

Signature………………………………………

Preliminary Energy Audit questionnaire.

Sr #	**Electricity**		
1	Electricity bill monthly		
2	Total electricity cost in RS /-		
3	What does your Electricity source from grid=1 on site generation=2 Mix=3.		
4	No of transformer and their capacity		
5	Electricity shortage hour.		
	Motors		
1	What type of motors used in industry? AC/DC		
2	Motor history (original, rewound, replaced)		
3	No of electric motors & voltage		
4	Hours of usage.		
5	Motors are energy efficient or Conventional		
	Compressor		
1	Daily running hours		
2	Total related loads of motors		
3	Annual Kw/h consumption		
4	Is it energy efficient		
	Air conditioning		
1	Total no of A/C in plant		
2	No of Chillers with A/C Capacity.		
3	Type of AC (Convertor, conventional)		
4	Average used hours per day		
5	Connected power watt		
	Machine		
1	Total number of machines		

2	Rating per machine (electricity consumption)		
3	Daily running hours		
4	Annual power consumption		
5	Energy efficient		
	Lightening		
1	Type of light source (Tube light, Incandescent/filament bulb)		
2	No of lights		
3	Average power of lights		
4	Average running hours.		
5	Can halogen lamps be replaced by CFL or LED versions?		
6	Are there any unused areas being lit?		
	Employs awareness		
1	Is there prominent guidance in place that reminds employees of best practice?		
2	Do employees know to switch lights off in rooms that are not in use?		
3	Is all other equipment switched off when not in use?		
4	Is all other equipment as new and energy efficient as possible?		

Observations;

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[1] This preliminary energy audit made with the help of **National energy efficiency and conservation authority (NEECA) Islamabad**.