**Supplementary materials file**

**Appendix A**

**Table A1**. Recent studies on energy efficiency

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No** | **Author(s)** | **Research Focus & Objectives** | **Major Outcomes and Insights** | **Applied tools** |
| 1 | Zhao & Lin (2020) | Linking up a relationship between energy efficiency and foreign trade in China's textile industry. | Foreign trade potentials were revealed to adopt energy-efficient processes and reduce energy consumption. | Tobit model and empirical investigation |
| 2 | Marchi et al. (2018) | Coordinating between supply chain stages and energy maximization. | Optimal capital investment in energy-efficient technologies can improve the supply chain performance. | Numerical Analysis |
| 3 | Chen & Liu (2021) | Examining the impact mechanism of various technological advancements on factor endowment and energy efficiency. | Technological advancements influence were revealed to energy intensity. | Data envelopment analysis (DEA) |
| 4 | Sadiq et al. (2023) | Investigating the impact of economic factors on sustainable energy consumption. | The study identified a positive association of economic factors with sustainable energy consumption. . | Autoregressive distributed lag (ARDL) |
| 5 | Zhao & Lin (2019) | Evaluating the effect of agglomeration levels on energy efficiency in China's textile industry. | The study revealed that an industrial agglomeration degree of less than 1.3865 would promote energy efficiency. | Econometric model |
| 6 | Soepardi & Thollander (2018) | Analyzing and ranking the managerial and organizational impediments to energy efficiency improvements from an industrial standpoint | Management concentration on certain organizational barriers was analyzed, having significant driving force and dependability. | Interpretive structural modeling (ISM) |
| 7 | Ozturk et al. (2020) | Evaluating and prioritizing energy efficiency techniques to reduce energy consumption. | A total of thirteen energy efficiency techniques were emphasized, which would mitigate energy intake. | Criteria Weighting Method, Weighting Sum Method, Simple Ranking  Method |
| 8 | Özer & Güven, (2021) | Providing a basis for decision-making from obtained results of various energy-saving applications. | Potentially significant energy-saving applications were determined. | Regression analysis |
| 9 | Chang et al. (2022) | Exploiting big data analytics to create a framework for optimizing production facilities. | The framework could save more than 10% of energy consumption. | Regression model, Dynamic programming |
| 10 | Hasan et al. (2019) | Exploring the potential of energy efficiency and energy management strategies in Bangladesh's textile industry. | The study identified both important drivers and barriers to the implementation of energy efficiency practices. | Qualitative analysis |
| 11 | Lin & Bai (2020) | Measuring energy performance to reduce carbon emission and defective product rate. | By implementing low-carbon textile policies, energy performance increased significantly. | Global meta-frontier approach |
| 12 | Thollander et al. (2019) | Unveiling the energy efficiency potential as a wicked problem to mitigate climate change. | Technological advancements, as well as energy management and energy policy, will not give rise to such wicked problems. | Wicked problem framework |
| 13 | Costa et al. (2019) | Analyzed energy and resource consumption in dying, printing, and finishing processes along with the identification of mitigation measure options proposed for textile facility. | Improved technologies and cleaner production options were evaluated that will reduce water consumption and effluent volume for textile industries. | Ecological footprint methodology |
| 14 | Lawrence et al. (2019) | Assessing specific energy consumption to achieve higher industrial energy efficiency. | The study provided useful general guidelines on the use of specific energy consumption as an indicator of energy efficiency. | Exploratory analysis |
| 15 | Li & Solaymani (2021) | Evaluating the impacts of rationalizing energy subsidy and its energy efficiency improvements during 2010-2030 | The study suggested additional methods and policies needed for enhancing energy efficiency and phased-out energy subsidies. | Dynamic recursive computable general equilibrium model. |
| 16 | Zheng et al. (2023) | Investigating the nexus between the industrial structure and energy efficiency in China. | The improvement of industrial structure was revealed to increase energy efficiency, which is impacted by government involvement and technical innovation. | Spatial Econometric Model |
| 17 | Sheppard & Rahimifard (2019) | Leveraging peer benchmarking of machine and process design to evaluate energy consumption in food and drink manufacturing. | Through peer benchmarking, this study highlighted the considerable potential for energy efficiency enhancement accessible to machine and process design innovation. | Peer Benchmarking System |
| 18 | Wang et al. (2024) | Identifying and quantifying the influencing factors of total-factor energy efficiency of ten major energy-consuming countries. | The study exposed varied energy efficiency levels among countries, while energy consumption structure and GDP per capita were conclusive factors of energy efficiency. | Data envelopment analysis (DEA), Tobit regression model |
| 19 | Amjadi et al. (2022) | Analyzing the impact of rebound effect on energy efficiency in the Swedish manufacturing industry. | Energy efficiency improvement (EEI) was larger in the long run compared to the short run from the rebound effect, and three sectors were identified as having the most EEI potential. | Dynamic panel regression model, DEA |
| 20 | Binczarski et al. (2022) | Investigating the possibility of using acid hydrolysates from cotton waste as components in fermentation broths to produce bioethanol and biogas. | The presence of both natural and synthetic fibers in textiles, along with polymer additives and chemicals used in textile manufacturing, may serve as fermentation inhibitors and hinder the efficient production of biofuels through the fermentation process. | Scanning electron microscope with energy dispersive spectroscopy |

**Table A2:** Questionnaire for validating the driving factors promoting energy-efficient textile manufacturing

*Q.1: What position do you hold in Bangladesh's textile energy sector?*

*Q.2: How many years of expertise do you have in Bangladesh's textile energy sector?*

*Q.3: Please choose the critical driving factors promoting energy efficiency in the textile sector in emerging economies from the factors in the list provided below. Please respond 'Yes' if a factor is vital to promote energy efficiency in this sector of Bangladesh; else, write 'No'. You can also include other factors crucial for the promotion of energy efficiency in textile manufacturing in emerging economies associated for sustainable development.*

|  |  |
| --- | --- |
| **Driving Factors** | **Put "Yes" for relevant & "No" for irrelevant.** |
| Incorporating circular economy in the production process |  |
| Embracing biotechnological advancement |  |
| Procurement of energy-efficient materials, resources, and technologies |  |
| Adopting renewable energy |  |
| Raising consumer awareness about energy efficiency |  |
| Implementing effective in-house energy management measures |  |
| Strengthening government support |  |
| Developing an energy efficiency network (EEN) |  |
| Adopting advanced machineries & total productive maintenance |  |
| Installation of variable frequency drive (VFD) |  |
| Establishing energy audit system |  |
| Reduction and control of compressed air leaks |  |
| Installing IoT devices to manage gas combustion and minimize excess steam generation |  |
| Insulation of machineries, boilers & transmission system |  |
| Appropriate production planning |  |
| Employing nano-filtration ETP |  |
| Rising energy prices |  |
| Adopting alternative waterless dyeing technology |  |
| **Please suggest any influential factors** | |
| 1. | |
| 2. | |
| 3. | |

**Table A3**: Brief description of the finalized driving factors after validation.

|  |  |  |
| --- | --- | --- |
| ***Code*** | ***Driving factors*** | ***How this driving factor will promote energy efficiency in textile manufacturing*** |
| F1 | Incorporating circular economy in the production process | The recycling (both open and closed) of textile waste and reusing water are fundamental to promoting the circular economy concept. Incorporating the principles of the circular economy will enhance energy efficiency in optimized processes, recover heat energy, eliminate unnecessary steps, and reduce excessive processing. |
| F2 | Adopting renewable energy | Renewable energy has a significant and positive impact on sustainable development in the energy-intensive textile sector since it avoids depletion of natural resources and can replenish itself faster than its rate of usage. Solar energy possesses the ability to reduce reliance on natural gas and fuel in a variety of aspects of textile production, including lighting, cooling, office equipment, and temperature control systems. Furthermore, improving the utilization of large amounts of agricultural waste and algae biofuel in Bangladesh will replace the costly and environmentally disastrous use of fossil fuels in the textile sector's power generation. |
| F3 | Adopting alternative waterless dyeing technology | The waterless dyeing method for polyester, utilizing CO2 or air instead of water, is a sustainable alternative to traditional dyeing procedures that significantly reduces energy requirements, lowers prices, and meets stringent global responsibility standards. |
| F4 | Implementing effective in-house energy management measures | Department-wise, effective energy management is crucial for improving cost-effective internal operations and increasing energy efficiency in the textile industry. A dedicated full-time energy manager should be integrated into the management structure, given the authority to implement energy efficiency measures, set benchmark parameters, and be actively involved in strategy planning to maximize its effectiveness. Considering the financial benefits of energy costs, integrating energy objectives, allocating sufficient budget capital, and ensuring access to funding, the textile production sector can make significant progress in alleviating energy poverty by putting a strong emphasis on energy management systems. |
| F5 | Employing nano-filtration ETP | The nano-filtration ETP leverages a pressure-driven membrane separation technique that is distinguished by its low pressure, low energy consumption, high selectivity, and high rejection capacity. |
| F6 | Adopting advanced machineries & total productive maintenance | In the textile firm, the use of outmoded machines elevates power consumption, while older production processes include extra processing. Adopting modern and efficient technology-driven machineries can drastically minimize machine power consumption, waste, and rework in the manufacturing process, and remove excess motion. Also, Total Productive Maintenance maintains a well-organized work environment that focuses on developing shared responsibility for equipment care, error detection, and failure prevention, and overall enhancing collaboration across all departments. This, in turn, will improve machine productivity, safety, and reliability while making them energy efficient. |
| F7 | Establishing Energy audit system | Continuous sub-metering of energy end-use via energy performance evaluation and energy efficiency initiatives. Sub-metering allows for the effective allocation of power to specific equipment, product lines, and processes, as well as putting departments or operators liable for energy expenses. Textile companies can use this data to evaluate energy performance, devise effective solutions, and forecast expected investment costs for energy efficiency upgrades. |
| F8 | Reduction and control of compressed air leaks | With regular effective maintenance of the compressors used in textile plants and the installation of modern sensors, compressed air leakage can be reduced by 10%, lowering electricity usage and saving up to 10toe/air. |
| F9 | Installing IoT devices to manage gas combustion and minimize excess steam generation | Installing IoT-enabled smart meters and sensors can control and supervise gas combustion in generators and reduce steam generation in textile manufacturing facility boilers. This reduces natural gas usage by 6% and hence contributes to long-term energy efficiency. |
| F10 | Insulation of machineries, boilers & transmission system | Implementing thermal insulation on machinery, boilers, and transmission lines in the dyeing and finishing area, which are characterized by significant heat dissipation from their surfaces, will result in a reduction in energy consumption. |
| F11 | Appropriate production planning | Properly coordinated production processes wherein dyeing machines function at maximum capacity, yield significant energy savings when compared to situations with lower machine occupancy, resulting in good energy conservation outcomes. |
| F12 | Strengthening government support | Through different measures, such as offering financial support for integrating energy-efficient technology, providing attractive loans for energy-related initiatives, providing subsidies for energy audits, and forming long-term agreements with tax exemptions, can accelerate the motivation of textile owners to espouse energy-efficient textile production. |
| F13 | Rising energy prices | Escalating energy costs drive the textile industry, known for its substantial energy needs, to seek cost-effective alternatives. This entails implementing energy-efficient technologies, processes, and practices, ultimately promoting sustainable and resource-efficient production methods. |
| F14 | Raising consumer awareness about energy efficiency | Enhancing human behavioral factors such as employee motivation and awareness, as well as nurturing a positive organizational culture, is critical for energy security. This will allow a better understanding of the environmental and economic benefits associated with energy efficiency in textile production, as the industry currently faces challenges such as limited knowledge regarding the integration of new and existing technologies, insufficient expertise in implementing new technologies, and poor information quality. |
| F15 | Adoption of green emerging technologies | Designing building's architectural structure in an eco-friendly way that allows for the optimum use of natural daylight and the movement of fresh air, resulting in lower energy use. The use of artificial lighting and mechanical ventilation is reduced by providing enough daylight and open-air paths. Incorporating individual lighting circuits and temperature control systems also reduces energy consumption. |
| F16 | Employing motion and occupancy sensors and timer-based power control system | Installing motion and occupancy sensors, as well as timer-based lighting systems, in intermittently occupied areas such as lobbies, stairwells, and toilets, will drastically minimize wasteful power consumption during non-use periods. Excess energy usage can be minimized by deploying these technologies, which automatically turn off lights when no motion or occupancy is detected in these locations. |

**Appendix B: Calculations**

**Table B1**: Aggregated values

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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|  | **F1** | | | | **F2** | | | | **F3** | | | | **F4** | | | | **F5** | | | | **F6** | | | | **F7** | | | | **F8** | | | |
| **F1** | 0.000 | 0.000 | 0.000 | 0.000 | 0.347 | 0.570 | 0.322 | 0.481 | 0.397 | 0.623 | 0.273 | 0.361 | 0.560 | 0.761 | 0.166 | 0.233 | 0.447 | 0.661 | 0.208 | 0.324 | 0.000 | 0.000 | 0.000 | 0.000 | 0.156 | 0.388 | 0.503 | 0.633 | 0.248 | 0.479 | 0.381 | 0.541 |
| **F2** | 0.576 | 0.777 | 0.159 | 0.214 | 0.000 | 0.000 | 0.000 | 0.000 | 0.508 | 0.715 | 0.200 | 0.255 | 0.511 | 0.721 | 0.158 | 0.325 | 0.445 | 0.679 | 0.189 | 0.270 | 0.449 | 0.681 | 0.180 | 0.323 | 0.465 | 0.672 | 0.229 | 0.332 | 0.427 | 0.657 | 0.210 | 0.345 |
| **F3** | 0.386 | 0.597 | 0.262 | 0.504 | 0.196 | 0.435 | 0.444 | 0.547 | 0.000 | 0.000 | 0.000 | 0.000 | 0.396 | 0.600 | 0.341 | 0.454 | 0.145 | 0.396 | 0.375 | 0.560 | 0.628 | 0.830 | 0.103 | 0.233 | 0.246 | 0.488 | 0.391 | 0.473 | 0.196 | 0.449 | 0.384 | 0.546 |
| **F4** | 0.430 | 0.635 | 0.280 | 0.388 | 0.524 | 0.728 | 0.171 | 0.311 | 0.390 | 0.596 | 0.336 | 0.424 | 0.000 | 0.000 | 0.000 | 0.000 | 0.419 | 0.629 | 0.258 | 0.405 | 0.512 | 0.748 | 0.127 | 0.258 | 0.470 | 0.701 | 0.195 | 0.237 | 0.452 | 0.684 | 0.192 | 0.289 |
| **F5** | 0.470 | 0.701 | 0.195 | 0.237 | 0.127 | 0.361 | 0.534 | 0.700 | 0.161 | 0.408 | 0.416 | 0.577 | 0.346 | 0.554 | 0.373 | 0.482 | 0.000 | 0.000 | 0.000 | 0.000 | 0.446 | 0.651 | 0.284 | 0.318 | 0.148 | 0.376 | 0.487 | 0.721 | 0.127 | 0.361 | 0.534 | 0.700 |
| **F6** | 0.554 | 0.763 | 0.130 | 0.278 | 0.352 | 0.578 | 0.303 | 0.411 | 0.610 | 0.813 | 0.108 | 0.255 | 0.509 | 0.711 | 0.241 | 0.239 | 0.409 | 0.636 | 0.261 | 0.330 | 0.000 | 0.000 | 0.000 | 0.000 | 0.400 | 0.625 | 0.291 | 0.323 | 0.546 | 0.753 | 0.154 | 0.243 |
| **F7** | 0.466 | 0.669 | 0.276 | 0.312 | 0.427 | 0.629 | 0.317 | 0.407 | 0.403 | 0.604 | 0.347 | 0.486 | 0.423 | 0.631 | 0.275 | 0.363 | 0.371 | 0.596 | 0.313 | 0.361 | 0.415 | 0.616 | 0.331 | 0.444 | 0.000 | 0.000 | 0.000 | 0.000 | 0.466 | 0.669 | 0.276 | 0.312 |
| **F8** | 0.200 | 0.418 | 0.508 | 0.672 | 0.097 | 0.313 | 0.623 | 0.826 | 0.192 | 0.432 | 0.436 | 0.511 | 0.196 | 0.435 | 0.444 | 0.547 | 0.130 | 0.367 | 0.479 | 0.715 | 0.463 | 0.666 | 0.259 | 0.348 | 0.320 | 0.543 | 0.364 | 0.448 | 0.000 | 0.000 | 0.000 | 0.000 |
| **F9** | 0.130 | 0.356 | 0.554 | 0.717 | 0.144 | 0.378 | 0.531 | 0.737 | 0.228 | 0.465 | 0.422 | 0.527 | 0.402 | 0.608 | 0.321 | 0.388 | 0.072 | 0.284 | 0.636 | 0.794 | 0.524 | 0.728 | 0.171 | 0.311 | 0.424 | 0.651 | 0.265 | 0.271 | 0.487 | 0.692 | 0.248 | 0.244 |
| **F10** | 0.177 | 0.435 | 0.346 | 0.529 | 0.136 | 0.377 | 0.465 | 0.701 | 0.153 | 0.394 | 0.485 | 0.617 | 0.400 | 0.625 | 0.291 | 0.323 | 0.067 | 0.271 | 0.685 | 0.885 | 0.343 | 0.551 | 0.350 | 0.538 | 0.360 | 0.585 | 0.328 | 0.394 | 0.277 | 0.525 | 0.353 | 0.415 |
| **F11** | 0.546 | 0.753 | 0.154 | 0.243 | 0.166 | 0.393 | 0.507 | 0.635 | 0.000 | 0.000 | 0.000 | 0.000 | 0.498 | 0.702 | 0.200 | 0.333 | 0.294 | 0.516 | 0.368 | 0.559 | 0.435 | 0.644 | 0.263 | 0.332 | 0.391 | 0.618 | 0.241 | 0.450 | 0.435 | 0.644 | 0.263 | 0.332 |
| **F12** | 0.524 | 0.728 | 0.171 | 0.311 | 0.596 | 0.804 | 0.100 | 0.266 | 0.519 | 0.726 | 0.179 | 0.260 | 0.564 | 0.765 | 0.177 | 0.209 | 0.656 | 0.857 | 0.083 | 0.243 | 0.546 | 0.753 | 0.154 | 0.243 | 0.576 | 0.777 | 0.159 | 0.214 | 0.244 | 0.468 | 0.459 | 0.663 |
| **F13** | 0.399 | 0.629 | 0.241 | 0.345 | 0.623 | 0.826 | 0.097 | 0.260 | 0.495 | 0.696 | 0.252 | 0.261 | 0.535 | 0.741 | 0.171 | 0.238 | 0.153 | 0.396 | 0.402 | 0.658 | 0.487 | 0.691 | 0.222 | 0.326 | 0.406 | 0.633 | 0.245 | 0.369 | 0.446 | 0.651 | 0.284 | 0.318 |
| **F14** | 0.473 | 0.678 | 0.260 | 0.266 | 0.560 | 0.761 | 0.166 | 0.233 | 0.133 | 0.371 | 0.519 | 0.686 | 0.463 | 0.666 | 0.259 | 0.348 | 0.196 | 0.435 | 0.444 | 0.547 | 0.388 | 0.613 | 0.304 | 0.353 | 0.351 | 0.557 | 0.379 | 0.516 | 0.168 | 0.404 | 0.505 | 0.711 |
| **F15** | 0.602 | 0.803 | 0.128 | 0.223 | 0.524 | 0.725 | 0.230 | 0.219 | 0.352 | 0.578 | 0.303 | 0.411 | 0.446 | 0.676 | 0.228 | 0.253 | 0.361 | 0.572 | 0.300 | 0.504 | 0.450 | 0.653 | 0.272 | 0.380 | 0.395 | 0.604 | 0.316 | 0.362 | 0.487 | 0.692 | 0.248 | 0.244 |
| **F16** | 0.119 | 0.348 | 0.508 | 0.745 | 0.083 | 0.293 | 0.656 | 0.857 | 0.075 | 0.282 | 0.670 | 0.871 | 0.410 | 0.618 | 0.288 | 0.396 | 0.089 | 0.307 | 0.609 | 0.768 | 0.338 | 0.548 | 0.344 | 0.503 | 0.114 | 0.347 | 0.546 | 0.711 | 0.350 | 0.595 | 0.274 | 0.343 |

**Table B1**: Aggregated values (continues…)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **F9** | | | | **F10** | | | | **F11** | | | | **F12** | | | | **F13** | | | | **F14** | | | | **F15** | | | | **F16** | | | |
| **F1** | 0.414 | 0.621 | 0.307 | 0.355 | 0.159 | 0.395 | 0.451 | 0.647 | 0.432 | 0.641 | 0.247 | 0.371 | 0.120 | 0.360 | 0.468 | 0.665 | 0.393 | 0.625 | 0.237 | 0.322 | 0.519 | 0.726 | 0.179 | 0.260 | 0.373 | 0.602 | 0.277 | 0.344 | 0.086 | 0.308 | 0.542 | 0.782 |
| **F2** | 0.452 | 0.684 | 0.192 | 0.289 | 0.334 | 0.561 | 0.293 | 0.468 | 0.504 | 0.712 | 0.188 | 0.284 | 0.602 | 0.803 | 0.128 | 0.223 | 0.656 | 0.857 | 0.083 | 0.243 | 0.615 | 0.816 | 0.115 | 0.228 | 0.580 | 0.784 | 0.126 | 0.272 | 0.375 | 0.608 | 0.244 | 0.328 |
| **F3** | 0.190 | 0.426 | 0.464 | 0.598 | 0.193 | 0.446 | 0.377 | 0.509 | 0.288 | 0.527 | 0.328 | 0.435 | 0.176 | 0.407 | 0.500 | 0.666 | 0.247 | 0.493 | 0.345 | 0.451 | 0.309 | 0.547 | 0.345 | 0.409 | 0.340 | 0.583 | 0.287 | 0.375 | 0.169 | 0.408 | 0.446 | 0.678 |
| **F4** | 0.576 | 0.777 | 0.159 | 0.214 | 0.572 | 0.774 | 0.149 | 0.239 | 0.542 | 0.750 | 0.144 | 0.272 | 0.410 | 0.618 | 0.288 | 0.396 | 0.425 | 0.637 | 0.243 | 0.346 | 0.372 | 0.619 | 0.251 | 0.287 | 0.505 | 0.708 | 0.226 | 0.267 | 0.377 | 0.600 | 0.318 | 0.386 |
| **F5** | 0.075 | 0.282 | 0.670 | 0.871 | 0.122 | 0.351 | 0.550 | 0.714 | 0.128 | 0.364 | 0.471 | 0.668 | 0.000 | 0.000 | 0.000 | 0.000 | 0.288 | 0.507 | 0.410 | 0.546 | 0.239 | 0.478 | 0.409 | 0.517 | 0.193 | 0.448 | 0.313 | 0.543 | 0.113 | 0.335 | 0.593 | 0.797 |
| **F6** | 0.552 | 0.752 | 0.197 | 0.204 | 0.555 | 0.758 | 0.156 | 0.261 | 0.560 | 0.761 | 0.166 | 0.233 | 0.377 | 0.600 | 0.318 | 0.386 | 0.336 | 0.563 | 0.312 | 0.419 | 0.253 | 0.498 | 0.374 | 0.433 | 0.446 | 0.676 | 0.228 | 0.253 | 0.430 | 0.635 | 0.280 | 0.388 |
| **F7** | 0.382 | 0.609 | 0.299 | 0.330 | 0.509 | 0.711 | 0.241 | 0.239 | 0.362 | 0.569 | 0.362 | 0.472 | 0.433 | 0.638 | 0.298 | 0.348 | 0.349 | 0.555 | 0.356 | 0.577 | 0.373 | 0.580 | 0.346 | 0.432 | 0.396 | 0.600 | 0.341 | 0.454 | 0.420 | 0.625 | 0.312 | 0.380 |
| **F8** | 0.350 | 0.573 | 0.343 | 0.431 | 0.436 | 0.667 | 0.189 | 0.353 | 0.122 | 0.355 | 0.485 | 0.682 | 0.201 | 0.430 | 0.439 | 0.670 | 0.176 | 0.418 | 0.453 | 0.556 | 0.144 | 0.370 | 0.542 | 0.705 | 0.135 | 0.376 | 0.487 | 0.586 | 0.212 | 0.444 | 0.454 | 0.588 |
| **F9** | 0.000 | 0.000 | 0.000 | 0.000 | 0.300 | 0.536 | 0.361 | 0.447 | 0.229 | 0.480 | 0.365 | 0.526 | 0.094 | 0.316 | 0.591 | 0.753 | 0.247 | 0.493 | 0.345 | 0.451 | 0.222 | 0.444 | 0.487 | 0.691 | 0.129 | 0.366 | 0.502 | 0.598 | 0.109 | 0.337 | 0.562 | 0.726 |
| **F10** | 0.353 | 0.597 | 0.292 | 0.307 | 0.000 | 0.000 | 0.000 | 0.000 | 0.166 | 0.402 | 0.497 | 0.664 | 0.134 | 0.353 | 0.584 | 0.787 | 0.323 | 0.533 | 0.355 | 0.513 | 0.312 | 0.517 | 0.420 | 0.587 | 0.144 | 0.395 | 0.352 | 0.626 | 0.201 | 0.430 | 0.439 | 0.670 |
| **F11** | 0.415 | 0.616 | 0.331 | 0.444 | 0.432 | 0.641 | 0.247 | 0.371 | 0.000 | 0.000 | 0.000 | 0.000 | 0.357 | 0.561 | 0.385 | 0.553 | 0.195 | 0.438 | 0.368 | 0.583 | 0.367 | 0.598 | 0.272 | 0.321 | 0.166 | 0.417 | 0.397 | 0.528 | 0.101 | 0.322 | 0.605 | 0.810 |
| **F12** | 0.300 | 0.536 | 0.361 | 0.447 | 0.232 | 0.468 | 0.429 | 0.565 | 0.300 | 0.556 | 0.289 | 0.356 | 0.000 | 0.000 | 0.000 | 0.000 | 0.516 | 0.719 | 0.203 | 0.273 | 0.500 | 0.709 | 0.176 | 0.318 | 0.610 | 0.813 | 0.108 | 0.255 | 0.334 | 0.558 | 0.353 | 0.439 |
| **F13** | 0.377 | 0.600 | 0.318 | 0.386 | 0.347 | 0.570 | 0.322 | 0.481 | 0.262 | 0.494 | 0.394 | 0.475 | 0.528 | 0.731 | 0.182 | 0.279 | 0.000 | 0.000 | 0.000 | 0.000 | 0.495 | 0.696 | 0.252 | 0.261 | 0.466 | 0.698 | 0.183 | 0.265 | 0.283 | 0.514 | 0.396 | 0.533 |
| **F14** | 0.259 | 0.474 | 0.463 | 0.666 | 0.298 | 0.534 | 0.339 | 0.499 | 0.112 | 0.344 | 0.537 | 0.664 | 0.512 | 0.748 | 0.127 | 0.258 | 0.153 | 0.394 | 0.485 | 0.617 | 0.000 | 0.000 | 0.000 | 0.000 | 0.491 | 0.694 | 0.237 | 0.292 | 0.346 | 0.575 | 0.298 | 0.384 |
| **F15** | 0.426 | 0.658 | 0.234 | 0.258 | 0.417 | 0.622 | 0.293 | 0.424 | 0.381 | 0.612 | 0.248 | 0.352 | 0.452 | 0.684 | 0.192 | 0.289 | 0.288 | 0.527 | 0.328 | 0.435 | 0.491 | 0.694 | 0.237 | 0.292 | 0.000 | 0.000 | 0.000 | 0.000 | 0.281 | 0.502 | 0.379 | 0.570 |
| **F16** | 0.266 | 0.497 | 0.401 | 0.508 | 0.149 | 0.368 | 0.572 | 0.774 | 0.124 | 0.357 | 0.493 | 0.730 | 0.101 | 0.322 | 0.605 | 0.810 | 0.179 | 0.409 | 0.509 | 0.714 | 0.283 | 0.514 | 0.396 | 0.533 | 0.258 | 0.487 | 0.419 | 0.555 | 0.000 | 0.000 | 0.000 | 0.000 |

**Table B2**: Direct Relation Matrix

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **F1** | **F2** | **F3** | **F4** | **F5** | **F6** | **F7** | **F8** | **F9** | **F10** | **F11** | **F12** | **F13** | **F14** | **F15** | **F16** | **Sum** |
| **F1** | 0.000 | 0.507 | 0.554 | 0.682 | 0.591 | 0.250 | 0.356 | 0.433 | 0.559 | 0.362 | 0.575 | 0.335 | 0.555 | 0.649 | 0.538 | 0.290 | 7.235 |
| **F2** | 0.696 | 0.000 | 0.640 | 0.642 | 0.600 | 0.600 | 0.602 | 0.581 | 0.604 | 0.501 | 0.636 | 0.718 | 0.765 | 0.729 | 0.699 | 0.542 | 9.554 |
| **F3** | 0.532 | 0.396 | 0.000 | 0.538 | 0.370 | 0.741 | 0.439 | 0.404 | 0.386 | 0.405 | 0.472 | 0.366 | 0.444 | 0.488 | 0.516 | 0.366 | 6.861 |
| **F4** | 0.570 | 0.650 | 0.536 | 0.000 | 0.563 | 0.655 | 0.619 | 0.604 | 0.696 | 0.692 | 0.669 | 0.555 | 0.572 | 0.546 | 0.635 | 0.535 | 9.096 |
| **F5** | 0.619 | 0.329 | 0.375 | 0.498 | 0.000 | 0.585 | 0.342 | 0.329 | 0.252 | 0.322 | 0.339 | 0.250 | 0.454 | 0.429 | 0.406 | 0.300 | 5.828 |
| **F6** | 0.679 | 0.517 | 0.725 | 0.638 | 0.565 | 0.000 | 0.557 | 0.673 | 0.675 | 0.678 | 0.682 | 0.535 | 0.504 | 0.448 | 0.598 | 0.570 | 9.042 |
| **F7** | 0.601 | 0.564 | 0.539 | 0.567 | 0.533 | 0.552 | 0.000 | 0.601 | 0.543 | 0.638 | 0.511 | 0.573 | 0.494 | 0.522 | 0.538 | 0.561 | 8.336 |
| **F8** | 0.376 | 0.281 | 0.397 | 0.396 | 0.335 | 0.597 | 0.487 | 0.000 | 0.511 | 0.588 | 0.332 | 0.385 | 0.382 | 0.336 | 0.351 | 0.400 | 6.154 |
| **F9** | 0.325 | 0.336 | 0.420 | 0.547 | 0.268 | 0.650 | 0.579 | 0.621 | 0.000 | 0.478 | 0.428 | 0.294 | 0.444 | 0.392 | 0.344 | 0.311 | 6.435 |
| **F10** | 0.396 | 0.342 | 0.360 | 0.557 | 0.242 | 0.494 | 0.522 | 0.468 | 0.529 | 0.000 | 0.361 | 0.314 | 0.481 | 0.462 | 0.364 | 0.385 | 6.276 |
| **F11** | 0.673 | 0.361 | 0.250 | 0.628 | 0.461 | 0.578 | 0.546 | 0.578 | 0.552 | 0.575 | 0.000 | 0.499 | 0.398 | 0.535 | 0.384 | 0.289 | 7.306 |
| **F12** | 0.650 | 0.715 | 0.649 | 0.685 | 0.765 | 0.673 | 0.696 | 0.412 | 0.478 | 0.419 | 0.492 | 0.000 | 0.644 | 0.633 | 0.725 | 0.499 | 9.134 |
| **F13** | 0.558 | 0.736 | 0.625 | 0.663 | 0.362 | 0.619 | 0.561 | 0.585 | 0.535 | 0.507 | 0.446 | 0.654 | 0.000 | 0.625 | 0.616 | 0.456 | 8.550 |
| **F14** | 0.609 | 0.682 | 0.337 | 0.597 | 0.396 | 0.546 | 0.499 | 0.357 | 0.419 | 0.474 | 0.323 | 0.655 | 0.360 | 0.000 | 0.622 | 0.515 | 7.390 |
| **F15** | 0.718 | 0.651 | 0.517 | 0.598 | 0.512 | 0.585 | 0.545 | 0.621 | 0.583 | 0.558 | 0.545 | 0.604 | 0.472 | 0.622 | 0.000 | 0.450 | 8.581 |
| **F16** | 0.320 | 0.262 | 0.252 | 0.555 | 0.286 | 0.493 | 0.319 | 0.526 | 0.446 | 0.326 | 0.327 | 0.289 | 0.362 | 0.456 | 0.436 | 0.000 | 5.654 |

**Table B3**: Normalized Direct Relation Matrix

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **F1** | **F2** | **F3** | **F4** | **F5** | **F6** | **F7** | **F8** | **F9** | **F10** | **F11** | **F12** | **F13** | **F14** | **F15** | **F16** |
| **F1** | 0.000 | 0.053 | 0.058 | 0.071 | 0.062 | 0.026 | 0.037 | 0.045 | 0.058 | 0.038 | 0.060 | 0.035 | 0.058 | 0.068 | 0.056 | 0.030 |
| **F2** | 0.073 | 0.000 | 0.067 | 0.067 | 0.063 | 0.063 | 0.063 | 0.061 | 0.063 | 0.052 | 0.067 | 0.075 | 0.080 | 0.076 | 0.073 | 0.057 |
| **F3** | 0.056 | 0.041 | 0.000 | 0.056 | 0.039 | 0.078 | 0.046 | 0.042 | 0.040 | 0.042 | 0.049 | 0.038 | 0.047 | 0.051 | 0.054 | 0.038 |
| **F4** | 0.060 | 0.068 | 0.056 | 0.000 | 0.059 | 0.069 | 0.065 | 0.063 | 0.073 | 0.072 | 0.070 | 0.058 | 0.060 | 0.057 | 0.066 | 0.056 |
| **F5** | 0.065 | 0.034 | 0.039 | 0.052 | 0.000 | 0.061 | 0.036 | 0.034 | 0.026 | 0.034 | 0.035 | 0.026 | 0.048 | 0.045 | 0.042 | 0.031 |
| **F6** | 0.071 | 0.054 | 0.076 | 0.067 | 0.059 | 0.000 | 0.058 | 0.070 | 0.071 | 0.071 | 0.071 | 0.056 | 0.053 | 0.047 | 0.063 | 0.060 |
| **F7** | 0.063 | 0.059 | 0.056 | 0.059 | 0.056 | 0.058 | 0.000 | 0.063 | 0.057 | 0.067 | 0.053 | 0.060 | 0.052 | 0.055 | 0.056 | 0.059 |
| **F8** | 0.039 | 0.029 | 0.042 | 0.041 | 0.035 | 0.063 | 0.051 | 0.000 | 0.053 | 0.062 | 0.035 | 0.040 | 0.040 | 0.035 | 0.037 | 0.042 |
| **F9** | 0.034 | 0.035 | 0.044 | 0.057 | 0.028 | 0.068 | 0.061 | 0.065 | 0.000 | 0.050 | 0.045 | 0.031 | 0.047 | 0.041 | 0.036 | 0.033 |
| **F10** | 0.041 | 0.036 | 0.038 | 0.058 | 0.025 | 0.052 | 0.055 | 0.049 | 0.055 | 0.000 | 0.038 | 0.033 | 0.050 | 0.048 | 0.038 | 0.040 |
| **F11** | 0.070 | 0.038 | 0.026 | 0.066 | 0.048 | 0.061 | 0.057 | 0.061 | 0.058 | 0.060 | 0.000 | 0.052 | 0.042 | 0.056 | 0.040 | 0.030 |
| **F12** | 0.068 | 0.075 | 0.068 | 0.072 | 0.080 | 0.070 | 0.073 | 0.043 | 0.050 | 0.044 | 0.052 | 0.000 | 0.067 | 0.066 | 0.076 | 0.052 |
| **F13** | 0.058 | 0.077 | 0.065 | 0.069 | 0.038 | 0.065 | 0.059 | 0.061 | 0.056 | 0.053 | 0.047 | 0.068 | 0.000 | 0.065 | 0.064 | 0.048 |
| **F14** | 0.064 | 0.071 | 0.035 | 0.063 | 0.041 | 0.057 | 0.052 | 0.037 | 0.044 | 0.050 | 0.034 | 0.069 | 0.038 | 0.000 | 0.065 | 0.054 |
| **F15** | 0.075 | 0.068 | 0.054 | 0.063 | 0.054 | 0.061 | 0.057 | 0.065 | 0.061 | 0.058 | 0.057 | 0.063 | 0.049 | 0.065 | 0.000 | 0.047 |
| **F16** | 0.033 | 0.027 | 0.026 | 0.058 | 0.030 | 0.052 | 0.033 | 0.055 | 0.047 | 0.034 | 0.034 | 0.030 | 0.038 | 0.048 | 0.046 | 0.000 |

**Table B4**: Total Relation Matrix

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **F1** | **F2** | **F3** | **F4** | **F5** | **F6** | **F7** | **F8** | **F9** | **F10** | **F11** | **F12** | **F13** | **F14** | **F15** | **F16** | **D** |
| **F1** | 0.207 | 0.235 | 0.235 | 0.284 | 0.230 | 0.239 | 0.228 | 0.238 | 0.250 | 0.226 | 0.237 | 0.211 | 0.238 | 0.260 | 0.247 | 0.192 | 3.755 |
| **F2** | 0.339 | 0.242 | 0.300 | 0.348 | 0.285 | 0.338 | 0.310 | 0.312 | 0.314 | 0.297 | 0.298 | 0.302 | 0.315 | 0.328 | 0.323 | 0.267 | 4.916 |
| **F3** | 0.252 | 0.217 | 0.174 | 0.262 | 0.203 | 0.276 | 0.228 | 0.228 | 0.227 | 0.223 | 0.221 | 0.207 | 0.220 | 0.236 | 0.238 | 0.194 | 3.605 |
| **F4** | 0.313 | 0.292 | 0.277 | 0.270 | 0.269 | 0.328 | 0.299 | 0.302 | 0.310 | 0.303 | 0.289 | 0.274 | 0.284 | 0.297 | 0.303 | 0.255 | 4.665 |
| **F5** | 0.231 | 0.185 | 0.187 | 0.228 | 0.142 | 0.231 | 0.191 | 0.193 | 0.186 | 0.188 | 0.183 | 0.171 | 0.196 | 0.204 | 0.200 | 0.164 | 3.079 |
| **F6** | 0.319 | 0.276 | 0.291 | 0.329 | 0.266 | 0.260 | 0.289 | 0.304 | 0.305 | 0.298 | 0.287 | 0.268 | 0.274 | 0.284 | 0.295 | 0.255 | 4.601 |
| **F7** | 0.294 | 0.265 | 0.259 | 0.304 | 0.249 | 0.297 | 0.218 | 0.281 | 0.276 | 0.278 | 0.256 | 0.258 | 0.258 | 0.275 | 0.274 | 0.241 | 4.284 |
| **F8** | 0.213 | 0.185 | 0.194 | 0.225 | 0.180 | 0.240 | 0.212 | 0.166 | 0.217 | 0.220 | 0.187 | 0.189 | 0.194 | 0.200 | 0.200 | 0.179 | 3.202 |
| **F9** | 0.218 | 0.199 | 0.204 | 0.249 | 0.181 | 0.255 | 0.229 | 0.237 | 0.176 | 0.219 | 0.205 | 0.189 | 0.208 | 0.214 | 0.208 | 0.178 | 3.370 |
| **F10** | 0.220 | 0.196 | 0.195 | 0.245 | 0.175 | 0.235 | 0.220 | 0.218 | 0.224 | 0.166 | 0.194 | 0.187 | 0.208 | 0.217 | 0.207 | 0.182 | 3.290 |
| **F11** | 0.274 | 0.223 | 0.208 | 0.281 | 0.220 | 0.271 | 0.248 | 0.254 | 0.252 | 0.248 | 0.182 | 0.228 | 0.225 | 0.250 | 0.234 | 0.194 | 3.793 |
| **F12** | 0.326 | 0.303 | 0.293 | 0.342 | 0.293 | 0.334 | 0.310 | 0.287 | 0.293 | 0.280 | 0.277 | 0.224 | 0.295 | 0.310 | 0.316 | 0.256 | 4.738 |
| **F13** | 0.301 | 0.292 | 0.277 | 0.323 | 0.242 | 0.314 | 0.284 | 0.289 | 0.285 | 0.275 | 0.259 | 0.275 | 0.219 | 0.295 | 0.292 | 0.240 | 4.462 |
| **F14** | 0.275 | 0.259 | 0.223 | 0.285 | 0.220 | 0.274 | 0.249 | 0.238 | 0.245 | 0.243 | 0.221 | 0.248 | 0.228 | 0.204 | 0.264 | 0.221 | 3.897 |
| **F15** | 0.314 | 0.281 | 0.264 | 0.315 | 0.254 | 0.308 | 0.280 | 0.290 | 0.288 | 0.278 | 0.266 | 0.268 | 0.264 | 0.292 | 0.229 | 0.237 | 4.429 |
| **F16** | 0.195 | 0.172 | 0.168 | 0.226 | 0.165 | 0.217 | 0.184 | 0.207 | 0.199 | 0.183 | 0.175 | 0.169 | 0.181 | 0.199 | 0.196 | 0.129 | 2.967 |
| **R** | 4.293 | 3.822 | 3.749 | 4.515 | 3.574 | 4.419 | 3.978 | 4.043 | 4.046 | 3.927 | 3.736 | 3.667 | 3.808 | 4.066 | 4.026 | 3.385 |  |

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