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Cost and Benefit Analysis of Newly Installed Digital Printing Department by Using System Dynamics Modeling Technique

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Abstract

After the establishment of any facility, it is quite necessary to determine the profitability of the unit. The present research provides a detailed analysis of the case unit along with the necessary costs and returns on investment. This research paper also includes the cost and benefits analysis of a newly installed digital printing department at Sapphire Diamond Company. Since the relationship between fabric printing and most of the costs is non-linear, this is the reason the system dynamics modelling technique was used in the present research; it was used to model the requirement of material, electricity, and human resources. The model was developed by using the stocks, flows, variables, and parameters in the Anylogic PLE version and the simulated results were validated from the real-time scenario. The data regarding the labour cost, electricity cost, and material cost were collected from the case department. Furthermore, the scenario analysis was conducted and simulated results were downloaded in Microsoft Excel. Several line charts were plotted in Microsoft Excel and Origin software. It was indicated from the scenario analysis that the cost per meter decreased by increasing the production rate. It was also indicated that if the digital printing machine was operated at its maximum capacity, the ROI would be maximum. Incurred overheads were also the subject of concern in the present scenario. After the overall analysis, it was concluded that the digital printing facility was still in profit even if its production rate per day was 150+50. Since the present research encompasses the detailed cost and benefit analysis of a newly installed digital printing facility, therefore, it can be beneficial for investors as analytical support to decide on installing digital textile printing machines.

Keywords: Textile printing; fabric; labor cost; material cost; electricity cost; cost and benefit analysis, system dynamics; cost estimation.

1. Introduction

In Pakistan, the digital textile printing market is expanding as it has generated good opportunities for producing good designs cost-effectively [1]. The printing technique, based upon the technique of transferring coloured ink decreases on the material with special electric signals, and also where unrestricted pattern length, as well as limitless colour combinations, can be obtained, and thus called the digital printing technique [2]. All printing methods are described by the generic term i.e. digital printing; by which the digitized image is transferred onto the underlying substance layer [3]. Continuous flow, electrostatic, and drop-on-demand (DOD) are the types of digital printing [3]. In Pakistan, Mimaki, Reggiani, and Durst are the leaders in providing digital printing technology [4]. In the textile printing system, this technology is considered quite efficient; this technology consists of ink, printer, software, and printing fabrics with a particular treatment [5]. The need for new product improvements has driven the interest in Inkjet digital textile printing (IJDTP) to respond to consumer demand quickly [6].

This interest in digital printing continues today with remarkable enhancements in computer system capacities, software and also digital design advancements, new digital printing dyes, and textile pretreatments [7]. From a technical perspective, the digital printing sector is counted among the fastest-growing sectors in the market of printing[8].Digital printing likewise creates marginal tainted wastewater from the general printing process [7]. In the detailed instance of digital printing, CAD systems in addition to certain software applications were displayed

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which generated designs with wonderful information as well as image resolution [7]. Designers are no longer limited to numerous colours or pattern repeats. It has become possible to publish material without big setup expenses. This fairly sustainable technology minimizes water usage and is also dye-wastage [9]. Adoption rates of this technology in the textile sector continue to be very low ranging from 6-7%. The current technical conversion speed from rotary display printing to digital printing is questionably slow-moving when compared to the technical conversion from engraved roller printing to rotary display printing technology in the 1960s to1970s [10]. The Digital printing market can be categorized into 2 segments; the standard textile printing and digital textile printing markets. Carpetings, ceramic tiles, floor coverings, apparel, home textiles, flags, banners, and so on belong to the typical printing market; whereas sportswear, t-shirts, and industrial textiles fall in the classification of brand-new digital textile markets [11]. In the case company, a digital printing machine was used for textile fabric printing, and in the present research, the profitability analysis of the present situation was carried out: moreover, the scenario analysis was conducted to see the impact of this technology on the costs and profit. Moreover, the cost and benefit analysis of the department was also conducted to see the costs and profit when the production rate is low.

2. Literature Review

In many countries, foreign exchange earnings and employment generation are mainly dependent on textile and clothing along with their economic growth. The share of textiles and clothing is about 6% of today's textiles and clothing business and accounts for total world exports [4]. Textile digital printing was introduced in the 1990s as a prototyping tool and a vehicle for printing fabric in small lots for small markets [12].

With the advent of new technology, companies are required to innovate their processes and technology [13], [14]. Essentially, the printing industry is based on a make-to-order production system that makes customized products [15]. Digital printing in the textile sector is a quickly expanding segment of the textile printing market. Unlike various other types of textile printing, digital printing deals with the prospective to entirely change the way the textiles are printed and marketed. Approaches associated with the operations and organization will be required to improve as more companies adopt the digital printing process in the textile sector [16]. Producers and merchants are searching for shorter runs as well as even more personalized products to fulfil changing consumer demands [16] (p. 1). The increasing demand and supply of textile products have been observed across the globe and the textile export is given in Figure 1.

This printing system is a superb selection for the printing of fashion as well as interior design textiles with unsurpassed performance, dependability, and cost per meter, supplying an excellent service for lower-cost digital textile printing, for short runs, yet much longer runs as well [18]. These market fads will need much greater reliability as well as the exact organization and production details circulation along the textile supply chain to enable incredibly quick action to the marketplace and global deals, in addition to sustaining personalized and unconventional shopping [19]. Figure 2 indicates the usage of numerous inks in the printing of textile substrates. Digital printing of textiles initially appeared in the early 90s, and its share in the complete printing market dramatically increased because of advancements in the last 5 years due to the advantages of the digital printing technique, but there is still much to attain to acquire a commendable area [20].

Needham, Meredith O, 2008 interviewed to learn: 1) what is the current market for electronically printed textiles? 2) what are the operations for a typical personalized digital textile? 3) what are the future forecasts for the marketplace of customized digital textiles? Business A is an industry leader that provides tailored workflow as well as production processes relying on the consumers' final requirements.

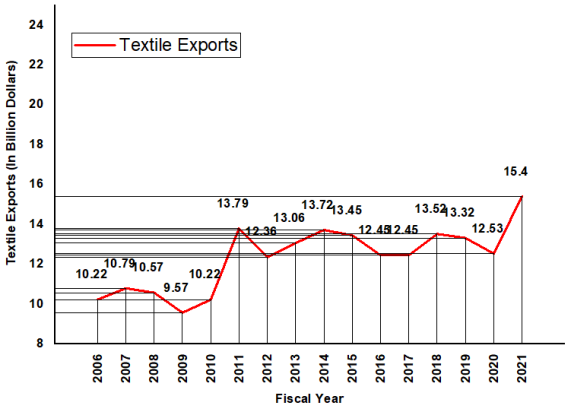

Figure 1. Export products of textiles from Pakistan (Source:[17])

Figure 2. The ink was used for various fibres; data were obtained from the source and were converted into this list by the authors of the present research (Source: [11]).

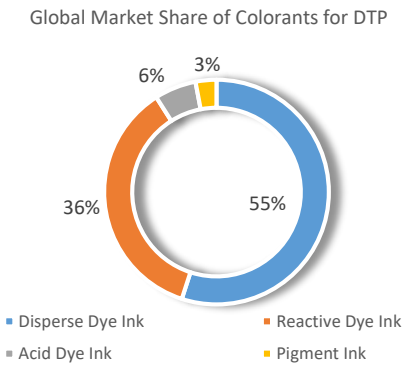

Figure 3. Textile printings by colourant across the Globe (Source: [10])

The Share of reactive colorants in textile printing is up to 27% as shown in Figure 3 [21]. Whereas, reactive ink is being used with a proportion of 36% these days. The effectiveness of a digital inkjet printer for a wider variety of colourants is much higher as compared to a conventional printer. The incremental cost of adding additional colors and screens is added in conventional printing whereas, for inkjet printing, additional action is not required. On the other hand, an extra effort is required to prepare a dye for extra colour in the case of traditional printing. Most importantly, the repetition of design is quite easy in digital printing scenarios because designs are computer-generated as compared to traditional printing [22].

As far as the novelty of the present research paper is concerned, the model discussed in the present research paper presents the dynamics of various variables involved.

Several techniques are used for decision making i.e. multi-criteriadecision-making[23] and optimization like multi-objective optimization [24].These techniques are not used to understand the dynamics of the system behaviour like the system dynamics modelling technique which is used in the scenario when the variables to be modelled have non-linear association with one another [25]. The system dynamics model was developed for the evaluation of manufacturing systems` complexity to improve process performance by the Six Sigma methodology in the knitted textile production company of Southern Guanajuato. Results indicated an improvement in the performance of the process by enhancing the Six Sigma level allowing the validation of the suggested approach [26]. The System dynamics model was developed for the mass production in the context of the apparel supply chain by Issa et al, M. et al (2019). They indicated a variety of products, return policy, lead time, and levels of quality as dramatic influencers of supply chain profit [27]. During the literature review, no system dynamics model was found associated with the modelling of production activities or cost-benefit analysis of textile printing facilities. In this regard, the contribution of the present research cannot be ignored.

3. Research Objective

The present research aimed to conduct the profitability analysis of a newly installed digital printing unit at Sapphire Diamond Company. The above-mentioned aim was achieved by the following objectives.

To conduct the cost analysis of the digital printing unit in the present scenario by using the system dynamics model

To conduct the scenario analysis by considering the increasing rate of production so that the cost variation pattern can be revealed.

To suggest the necessary improvements to the case company for its betterment.

4. Research Methodology

Methods used in the research are described under the heading of research methodology with a brief justification. After the literature review and visit to the case unit, the system dynamics model was developed and the required data was collected. Model validation and scenario analysis were conducted thereafter to complete this research. All the steps are presented below given Figure 4.

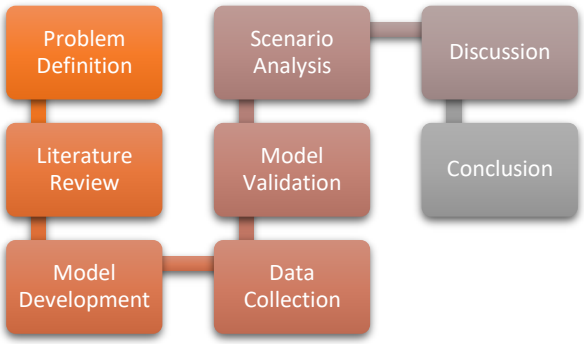

Figure 4. Diagram for the present research

4.1. Data Collection

The present research was conducted at the newly established digital printing unit of Sapphire Diamond Private Limited. At the very first, the production rate of the digital printing facilitywas collected from the relevant department and then the actual production rate was calculated with its standard deviation. The data collection included the consumption of ink, adhesives, and power consumption (amperes) of various devices being used at the facility. The average consumption of ink from the various available designs was calculated and they were inputted into the model. The amperes of various devices (digital printing machines, computers, air conditioners, dryers, plotters, and printers) were collected with the help of an ampere meter. Moreover, the monthly salaries of all employees working in the department were also collected from the payroll office of the company so that the incurred labour cost could be considered in the model.

4.2. Used Software

Initially, the data was put into Microsoft Excel for the calculation of the average and standard deviation of the collected data. From the collected data, the model was developed in Anylogic by using the system dynamics

modelling technique. Moreover, model simulation was conducted in Anylogic and the simulated data was downloaded in Microsoft Excel. At last, Origin, 2019b was used for plotting graphs.

4.3. Notations

Notations used in the equations of the present model are given below.

Notation	Description of Notation
Φ_p	Average production rate
P_r	Production rate
P_{ir}	Production increment rate
d_p	Digital printing flow
M_c	Material cost
E_c	Electricity cost
L_c	Labour Cost
P_c	Printing Cost
P_{cm}	Printing Cost per Meter
M_{cm}	Material Cost per Meter
E_{cm}	Electricity Cost per Meter
L_{cm}	Labour Cost per Meter
R	Revenue
P	Profit
P_m	Profit Per Meter
$CkWh$	Cost of KwH
F_a	Area of Fabric Printed in meters
INK	Quantity of ink used in litres
C_{ink}	Cost of ink per litre
AD	Quantity of adhesives used in Kgs
C_{ad}	Cost of adhesive per Kg
ADR	Quantity of adhesives remover used in Kgs
C_{adr}	Cost of adhesive remover per kg
ROI	Return on investment
N_{am}	Number of assistant managers
N_o	Number of Operators
N_{ao}	Number of assistant operators
N_h	Number of helpers
N_d	Number of designers
S_d	Salary of designer
S_h	Salary of helper
S_o	Salary of operator
S_{ao}	Salary of assistant operator
S_{am}	Salary of assistant manager

5. Model Development

The system dynamics model was developed in the Anylogic PLE version by the inclusion of several parameters, dynamic variables, and flow and stock as can be seen in Figures 1 to 5.

5.1. Production Rate

After the data was collected from the production department, it was organized in Microsoft Excel and then the production rate was calculated to be 150±30 linear meters per day. The demand increment rate was calculated to be 27.65%. The digital printing rate and the stock of printed fabric P(t) are represented with the below-given equations (1) and (2).

$$\varphi_p = P_r(1 + P_{ir}) \quad (1)$$

$$P(t) = \int_{t_0}^{T} \varphi_{dp}\, dt + P(t_0) \quad (2)$$

t refers to the working day *(t = 0, 1, 2, 3, ..., T)*. The average production rate was then defined as as given in eq. (1).

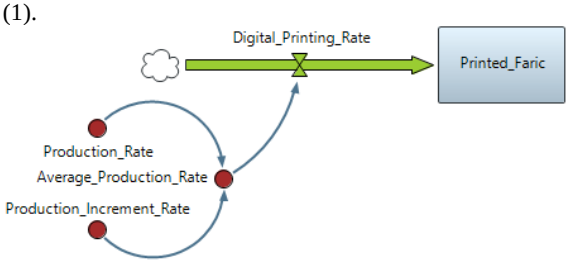

Figure 5. Stock and flow diagram of production rate and digital printing of fabric

Flow i.e. digital printing rate was inputted equal to the average production rate as can be seen in Figure 5. After defining the production rate in the model, the next stage was to include the material being used in the production was worked on as discussed in the heading 5.2.

5.2 Material Cost

After the input of production flow and its stock, the material cost was the second step to be modelled. In the material cost, the consumption of ink, adhesive, and adhesive remover was incorporated into the model by the use of parameters and dynamic variables as can be seen in Figure 6. Variable consumption per linear meter of various ink colours was put into the model i.e. black (2.914 ml), cyan (0.2968 ml), magenta (0.38608 ml), yellow (1.208 ml), green (0.1761 ml), red (0.2237 ml), and blue (0.6050 ml). The average consumption of various colours was calculated by considering the varying print designs.

$$M_c = INK\ C_{ink} + AD\ C_{ad} + ADR\ C_{adr} \quad (3)$$

Various considered adhesives and adhesive removers were used as per schedule (after the total sum of 30000 meters of printed fabric). Material cost was calculated by equation (3).

5.2. Labor Cost

After the establishment of the new digital printing unit, one assistant manager, two operators, two assistant operators, two helpers, and one designer were hired. The cost of the mentioned human resources was obtained from the payroll department of the case company and was put into the model as given in Figure 7. Labour cost was calculated by using eq (4).

$$L_c = N_{am}S_{am} + N_oS_o + N_{ao}S_{ao} + N_hS_h + N_dS_d \quad (4)$$

Moreover, the cost of human resources incurred per meter was also part of the calculation in the developed model.

5.3. Electricity Cost

Where they are electrical devices, the consumption of electricity is certain. In this regard, the electricity consumption of various devices was collected by the use of an ampere meter. There were two types of air conditioners (ACs) i.e. 4 ACs (10 amperes per unit) of 4 tons for digital printing rooms and 3 ACs (6 amperes per unit) of 1.5 tons for offices.

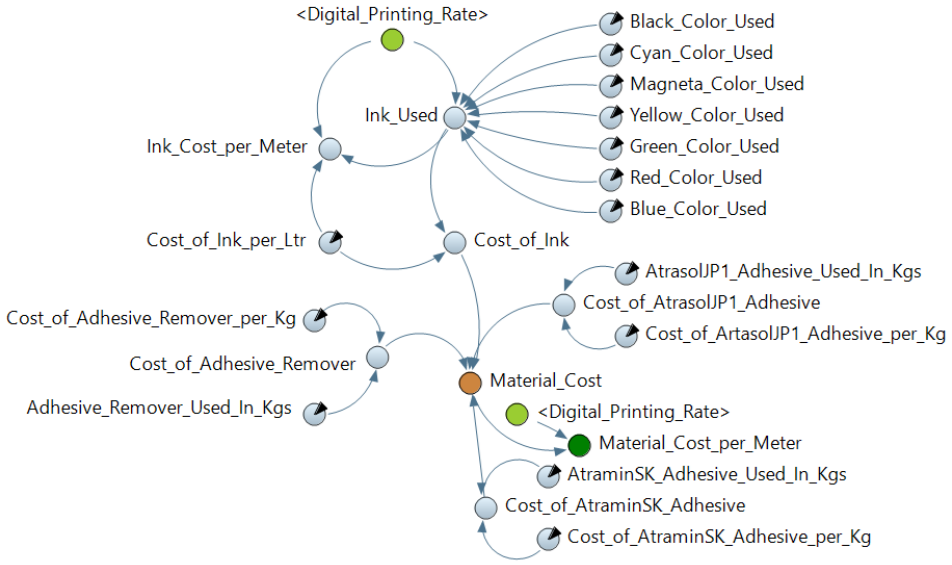

Figure 6. Calculation of material cost

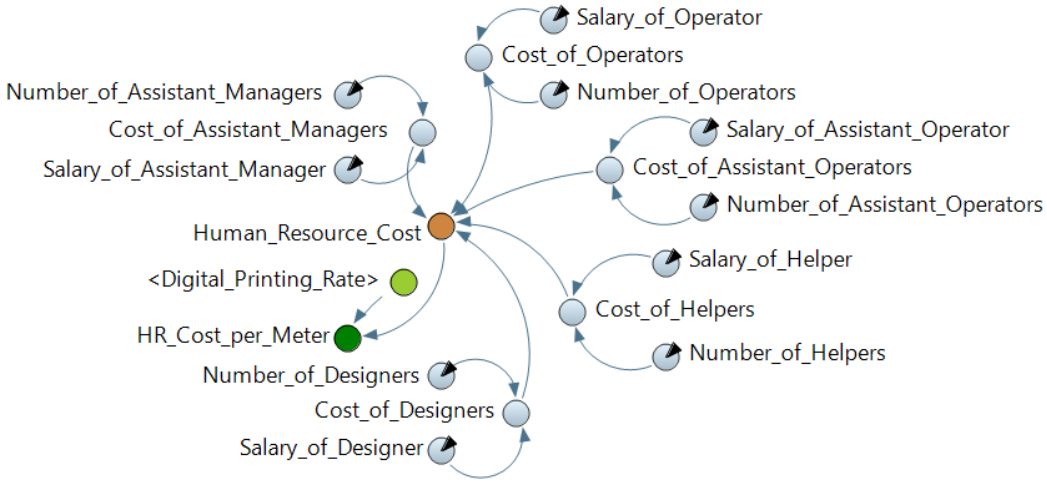

Figure 7. Calculation of labour cost

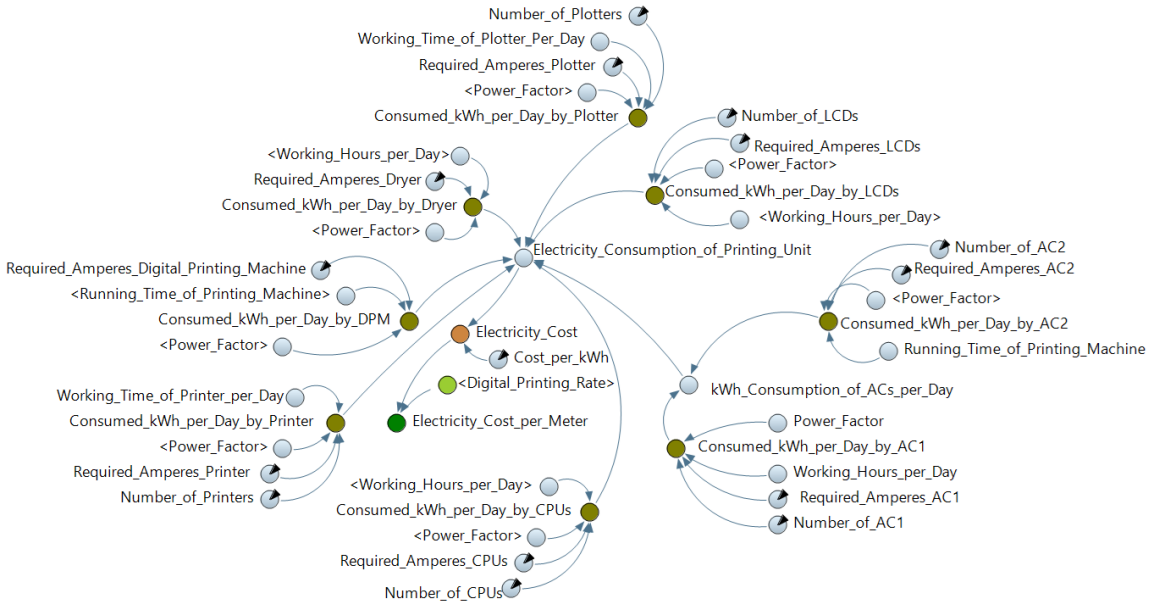

Figure 8. Calculation of electricity cost

Other devices included one digital printing machine (48 amperes), one dryer (40 amperes), 3 central processing units (CPUs) (0.5 amperes per unit), 3 LCDs (0.8 amperes per unit), one printer (0.3 amperes), and one plotter (3 amperes).

$$E_c = \left(\frac{VICos\emptyset}{1000}\right) C_{kWh} \quad (5)$$

The number of various devices was inputted with the help of parameters and their electricity costs were calculated with the help of dynamic variables (using equation (5)) as given in Figure 8.

5.4. Calculations

After the calculation of material cost, labour cost, and electricity cost, the total printing cost and printing cost per meter were calculated with the help of dynamic variables as given in Figure 9.

$$P_c = M_c + E_c + L_c \quad (6)$$

$$P_{cm} = \frac{P_{cd}}{\Phi_p} \quad (7)$$

$$M_{cm} = \frac{M_c}{\Phi_p} \quad (8)$$

$$E_{cm} = \frac{E_c}{\Phi_p} \quad (9)$$

$$L_{cm} = \frac{L_c}{\Phi_p} \quad (10)$$

$$R = F_a(P_{cm} + P_m) \quad (11)$$

$$ROI = \frac{P}{P_c} \quad (12)$$

Various variables used in Figure 9 were calculated by using equations from (6) to (12).

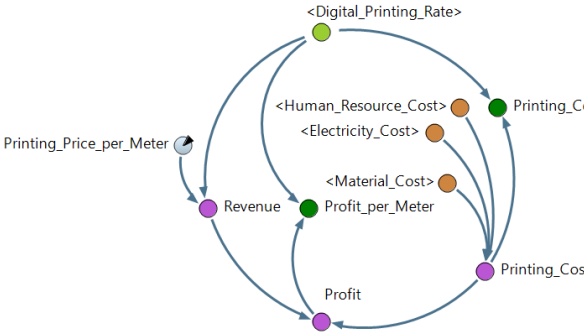

Figure 9. Calculation of revenues, cost, and profit

5.5. Model Validation

The developed model was then validated by matching the results with the real-time data. The current production rate of the unit was put into the model and the model was simulated for 12 months (see Figure 10).

A look at Figure 10 indicates that with the increase in the production rate per day, return on investment (ROI) increases across 12 months.

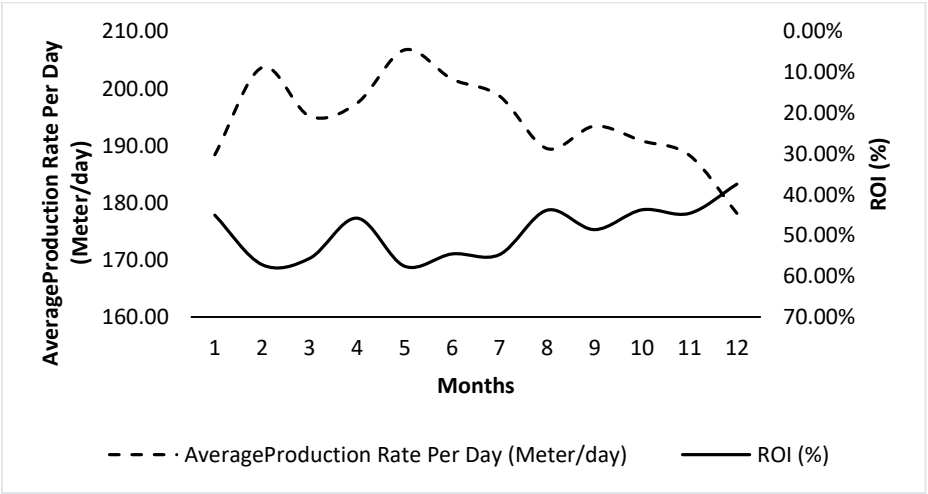

Figure 10. Graphical representation of production rate and profit/printing cost

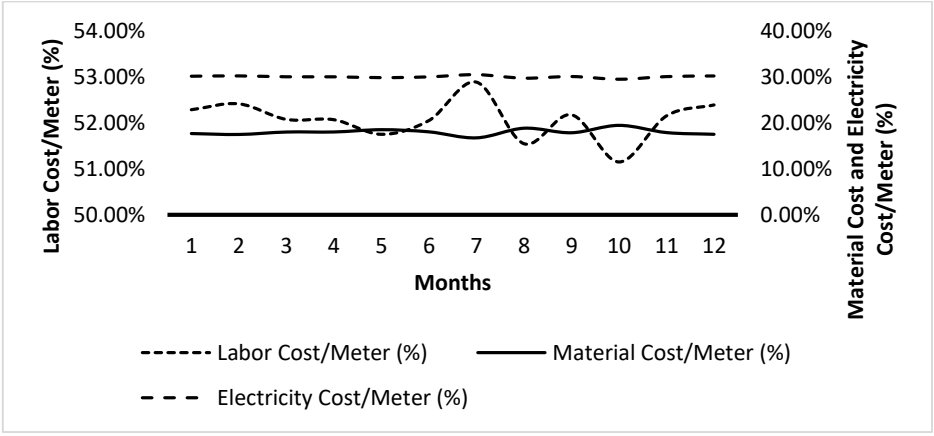

Figure 11. Percentage of labour cost, material cost, and electricity cost per meter

In Figure 11, the costs i.e. electricity cost (it was calculated by the formula P=(VICosø)n/1000), material cost, and labour cost per meter are visualized. Working time was initialized to be 8 hours per day. Thus the electricity cost was varied accordingly. Variations in printing cost per meter and the earned profit per meter can be seen in Figure 12. With the fluctuation in the production rate, the printing cost and the profit vary accordingly.

6. Results

6.1. Scenario Analysis

Scenario analysis was based on three scenarios; in each scenario, the production rate and working times were variably initialized. The printing speed of the digital printing machine was set to be 350 meters per hour; considering the speed of the printing machine, the working times were set accordingly as shown in Figure 13.

In Figure 14 it can be seen that the digital printing rate per day touches 1000 meters per day in the third scenario, this was the reason, the working time was set to 24 hours. Production rates were increased in each scenario so that the varying patterns of cost could be observed.

6.1.1. Graphical Representation of Results

In the scenario analysis, the production of machines was increased in each scenario as can be seen in Figure

14.With the increase in the production rate (see Figure 14), material cost (see Figure 15) per day increases across the various scenarios. With the increase in the production rate per day throughout various scenarios, electricity cost in the third scenario; whereas, human resource cost is the same across all the scenarios (see figure 16). Human resource cost varies from Rs. 2 to Rs. 12 per meter as given in Figure 17. In the second scenario, the human resource cost fluctuates between Rs 1.5 and Rs 5. and it fluctuates between Rs 1 and Rs 2.5 in the third scenario (see Figure 17).

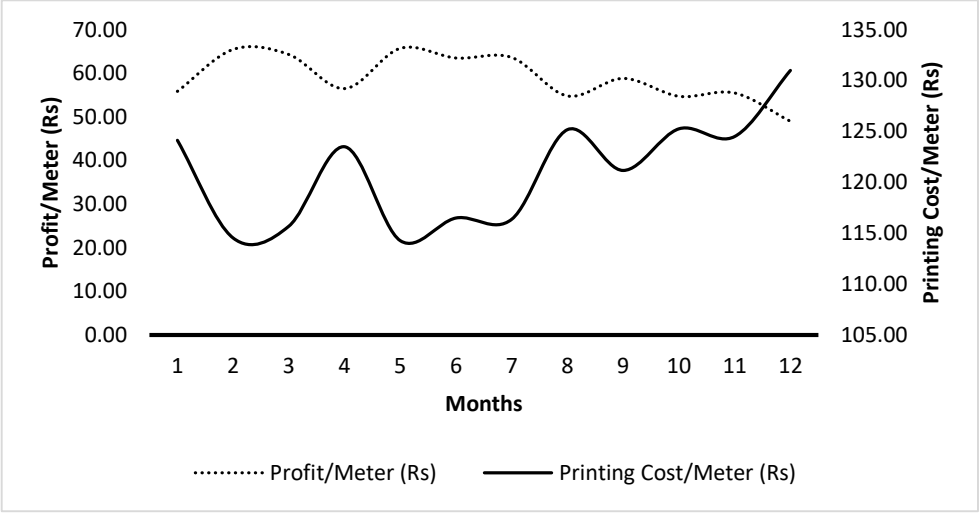

Figure 12. Graphical presentation of printing cost per meter and profit per meter across 12 months

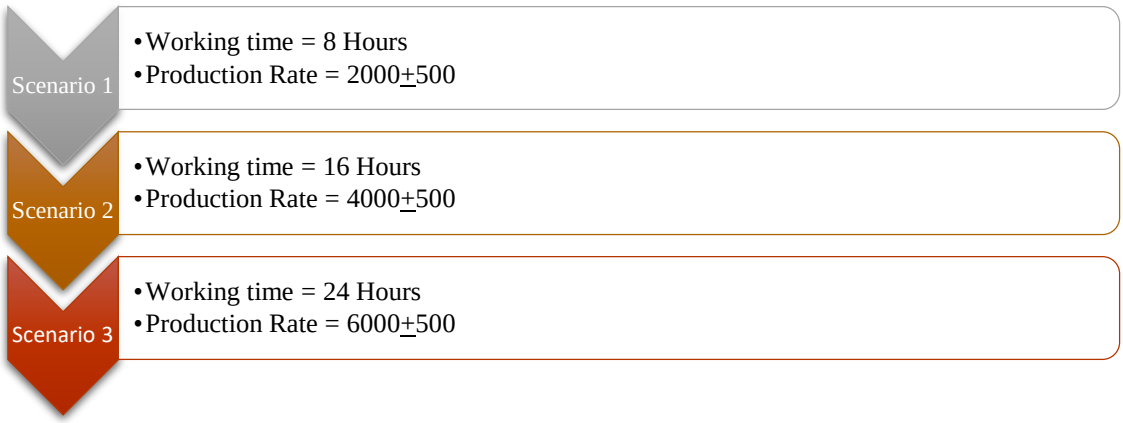

Figure 13. Initialization of the various scenarios

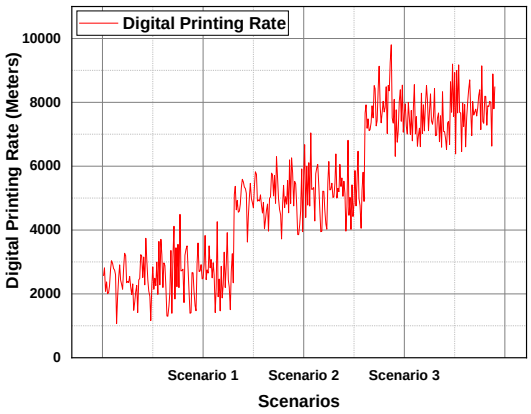

Figure 14. The production rate in various scenarios

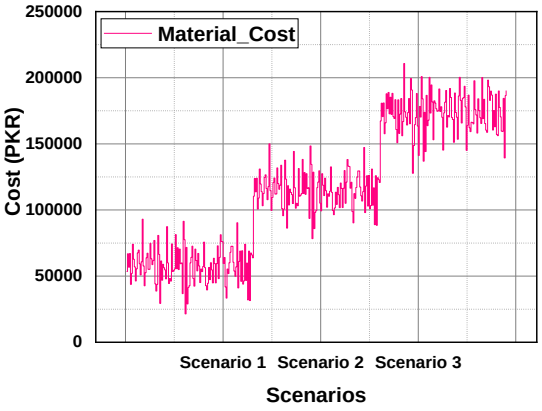

Figure 15. Material cost in various scenarios

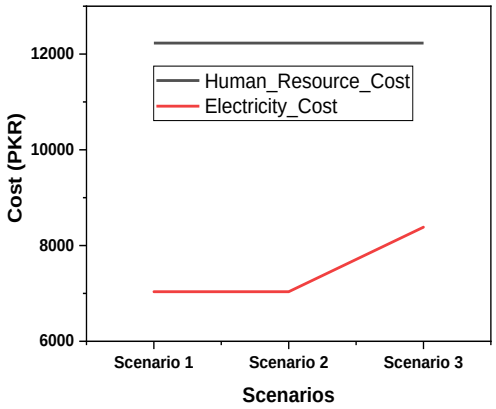

Figure 16. Electricity cost and human resource cost in various scenarios

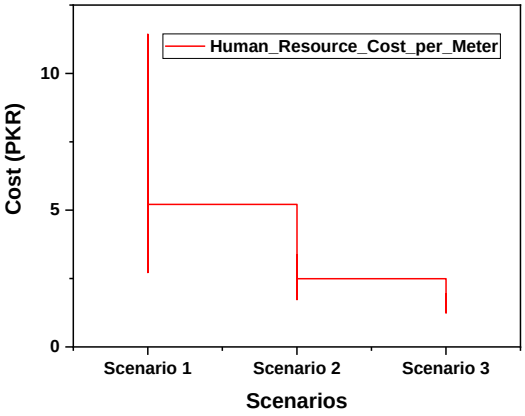

Figure 17. Human resource cost per meter in various scenarios

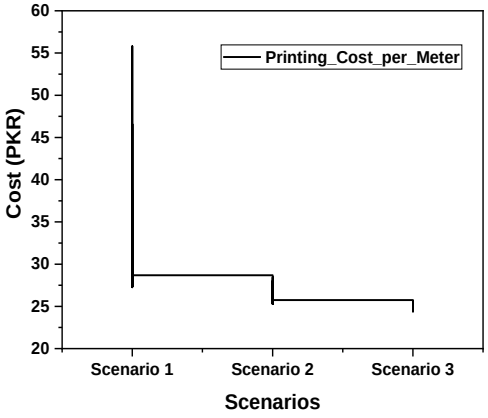

Figure 18. Printing cost per meter in various scenarios

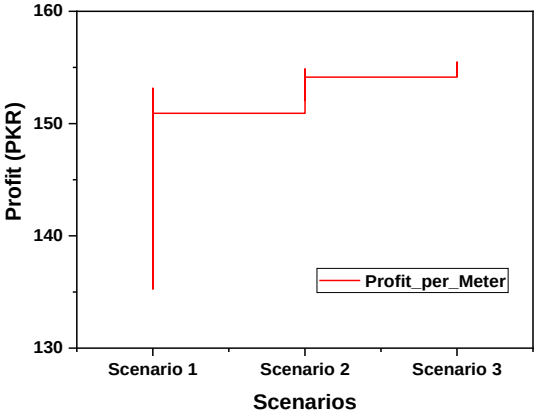

Figure 19. Profit per meter in various scenarios

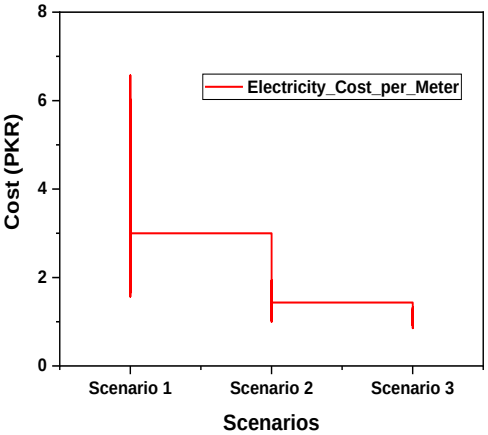

Figure 20. Electricity cost per meter in various scenarios

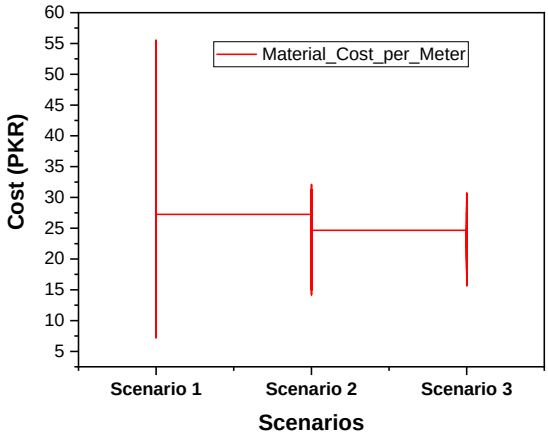

Figure 21. Material cost per meter in various scenarios

Printing cost per meter (see Figure 18) fluctuates between Rs 27.5 and Rs 56 per in the first scenario; it decreases further in the second and third scenarios. In the third scenario, the profit per meter was calculated to be Rs 155 per meter; whereas, the revenue per meter was collected to be Rs 180 per meter. According to the above-presented analysis in scenario 3 in Figure 19, the profit of Rs 154 per meter yields 620% ROI. Comparing small run and sampling costs of IJDTP with regular screen printing is quite low [6]. Figures 20 and 21 represent the values of electricity cost per meter and material cost per meter across various scenarios. The costs decrease with the increase in production as per the representation of figures.

The results of the current model are as per the economy of scale which means, the cost decreases with the increase in production. If the optimal production run is determined, the maintenance cost and breakdowns can be avoided; moreover, to ensure the optimal life of the machine, it is essential to operate it as per its properly scheduled capacity. The present model can also be like the feasibility for those who are interested in the installation of digital textile printing machines in their textile printing facilities.

7. Discussion

Mechanical printing techniques, occasionally also called analogue approaches, stand for the traditional way of printing, based upon a set master printing plate, cylinder, pattern, and so on [8]. The master has picture areas, which accept and transfer ink, as well as non-image locations, which stay devoid of ink. Ink is applied onto the image area of the master and also moved onto the substrate paper, board, plastic, etc with contact as well as nip stress. The transfer can be made straight from master to paper, or indirectly utilizing a rubber-coated blanket cylindrical tube [8]. There are some limitations to conventional screen printing such as stains, pinholes, dye transformation, improper heading or curing, etc. [28]. The above limitations affect the overall print quality [28]. The quantity of digital inkjet printers is increasing day by day in the textile sector due to the easy availability of industrial print heads since 2011 [3]. Presently, The annual growth rate of digital textile printing is about 25% [4]. Rapid changes are occurring in textile printing asserts Tippett (2001). Eventually, variation in design and colour is demanded by the customer and to meet the demand is a necessity in today's marketplace. Digital printing can meet such demand and can save sampling costs, time, and other wastages along with providing variation in colours, and designs [29]. The digital printing method can be applied to fabric, paper, or ceramic, and works for many industries like, fashion, marketing, and interior design [2].

Memon and Noor Ahmed (2015) reported that the current industry record recommended that our nation has ended up being fashion-obsessed, most consumers look online for patterns and fashion highlights. Digital printing machine manufacturers have developed systems that will be an option to offset as well as various other printing techniques and also use high quality, brighter, and more colour possibilities at the preferred rate, on the preferred material and also are much more cost-efficient [2]. Reduced ink wastefulness and water usage make DTP an extra eco-friendly printing technique [9]. In the scenario of digital printing the ink is not supposed to be blended manually by labour as it is carried out in traditional textile printing; in the case of manual blending of ink and manual making of recipe, the possibility of ink wastage is greater. Whereas. In the case of digital printing, the ink boxes are attached to the machines and ink is used as per the requirement of the design to be printed; therefore, in the case of digital printing, the ink is not wasted in this method just like traditional textile printing.

Needham and Meredith 2008 found that sample printing is still a significant market for digital, while firms are gradually raising their one-to-one customized fabric sales. Nonetheless, none of the companies have truly brought mass modification to digital textile printing. The product costs are still too expensive (ink, textile), and there are a lot of variables involved in lending digital textile printing to the standardization of mass modification [16]. Kašiković, Nemanja, et al. 2016 stated that in high-volume runs, the display printing technique is far more affordable as the rate goes down with each duplicate, while when it comes to digital printing, the cost for every print coincides, regardless of the circulation [18]. In the present research, the author experienced the opposite of what was argued by Kašiković, Nemanja, et al. 2016; the material cost, electricity cost, and overall printing cost per meter decreased significantly on increasing the production volume as can be observed in Figure 20, 21 and 18 respectively. Prabha et al. 2021 argued that in order to determine the complete cost, it is required to take into consideration the cost of each stage of the technological sequence, as well as the cost of electrical energy, and the cost of preparing the print. To establish the cost of one print [30]. As far as the operational cost of digital textile printing its electricity cost per meter was calculated to be PKR 6.8 per meter (see Figure 20) in the first scenario when the production was quite low but on increasing the production rate, it decreased significantly as can be seen in Figure 20. The material cost (ink, adhesive, adhesive remover) of digitally printed fabric per meter was calculated to be PKR 55 but it dropped significantly when the production was increased in scenarios 2 and 3 (see Figure 21). According to Chiu et al. (2019), the overall cost of production can be reduced when there is more than one product with some common components [31]. In contradiction with this statement, the ink used by the digital printing machine can be saved by optimizing the design to be printed in a way that ink consumption is minimized.

In the present research, the cost i.e. electricity cost per meter, and human resource cost per meter were observed to be reduced with the increase in production. Moreover, with the decrease in printing cost (see Figure 18), the line of profit in graph inclined (see Figure 19). The developed model in the present research can be used in general for established digital printing units for evaluation of cost and benefit analysis of departments. In the present research, material cost per meter was calculated to be PKR 22.287. Moreover, in DTP the printing cost per meter remains whereas, it decreases with the increasing length of fabric to be printed as can be seen in Figure 22.

8. Conclusion

Recently, work simplification techniques are being applied for waste reduction i.e. lean manufacturing so that costs can be saved in the textile sector [32]. In the textile printing market, DTP is a small part these days but it will be a more cost-effective printing method (see Figure 18) as compared to other methods available in the market [3]. In the DTP method, the whole control is in the hands of the designer and it provides a user-friendly program to run process therefore the customer himself can be a designer [33].

It was indicated from the scenario analysis of the developed model that the cost per meter decreases if the production rate increases. If the digital printing machine is operated at its maximum capacity the ROI would be maximum. Incurred overheads are also the subject of concern in the present scenario. After the overall analysis, it was indicated that still, the unit is still in profit even if its production rate per day is 150±50. Maximum profit can be gained with the increase in production.

The colourants being used in the DTP are too costly [9]. In the present research, the cost of ink used per meter was calculated to be PKR 22.287. In conventional printing methods i.e. screen printing, the cost of ink used per square meter decreases with the increase in printing length; whereas, in the case of DTP, it remains the same [34] (p. 26) (see Figure 22). This benefit leads companies towards reduced ink wastages and efforts of labor which were supposed to be incurred on the preparation of dye manually. This method is simply cost-saving and less time-consuming as compared to traditional methods.

After the erection of the DTP machine, companies don`t need the labour for preparing ink recipes, and no proper storage space for inventory (dry ink and required accessories) and a library for keeping records of recipes needed for traditional textile printing. benefits of digital. Moreover, The present research would be beneficial for investors as analytical support to decide on installing a digital textile printing machine.

9. Suggestions

In textile digital printing, when the machine is operated at its maximum capacity then the printing cost would be minimal (see Figure 18). It can be seen in Figure 20 that electricity cost also decreases with an increase in production. To maximize the profit, it is highly needed to operate the machine maximally as indicated in Figure 19. The machine operation must be not abusive to the capacity of the DTP machine.

The ink used in digital textile printing is very costly i.e. $8 per liter. The consumption of the ink cannot be minimized because it is used as per requirement; the cost can be minimized in the existing scenario by employing helpers, assistant operators, and operators on daily wages. The linear programming approach can also be used for the minimization of cost and maximization of profit.

Future Work

The productivity of a machine is measured by Overall Equipment Effectiveness (OEE); in which the performance of the machine is multiplied by its quality and availability [35]. The final result in percentage is the representation of its properly scheduled run. Future managerial implication is suggested to be OEE calculation of the DTP facility to carry out the optimal production run to avoid greater maintenance costs and to optimize the life of the DTP machine.

The digital printing unit uses the energy supplied by the government and it is produced from fossil fuels. It has been reported that global warming is increasing which is dangerous for the planet and at the same time prices of electricity are increasing [36]. It has been reported that energy generation from non-renewable sources causes CO_2 emissions and this is the reason, millions of tons of $CO_2$are generated every year [37]. This is the reason, the world is switching towards sustainable energy sources [38]. In this regard, this research can be extended in the future by incorporating the aspect of the carbon footprint generated by the digital printing facility.

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Conflict of Interest

No conflict of the research was found among the authors of the present research paper.

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