Exploration of the Factors Affecting Efficient Production Planning: A case study of the Ready-Made Garments Industries of Bangladesh

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Abstract

The Ready-Made Garments (RMG) Industries are the major contributors to the export-oriented economy of Bangladesh. In the current competitive market, efficient production planning has become a key strategy to meet buyers' timeline and ensure timely shipment of the finished goods. Several issues or factors cause major deviation of the actual production from the planned production. This research has explored the major factors that affect the efficient production planning, by causing major deviation of the actual production from the planned schedule, in the RMG industries of Bangladesh, by using a Multi Criteria Decision Making (MCDM) tool. In this paper, first, the factors affecting the efficient production planning has been identified through expert feedbacks and literature review. Then, a Decision-Making Trial and Evaluation Laboratory (DEMATEL) method has been utilized to find out the priority ranking of the identified factors and to explore the interrelationships among the factors through a casual diagram. From the results obtained from this study, 'low productivity' has been identified as the most critical of all factors, while 'fabric delay' has been identified as the least critical one. The research findings are expected to help the managers of the RMG and other similar industries to enhance the efficiency of their production plan in order to improve their overall profitability.

Keywords
Production Planning, Priority ranking, RMG Industries, DEMATEL

1 Introduction
Production planning is one of the most vital activities in any manufacturing industry. It is comprised of various components, from scheduling of every task in the manufacturing process, to the finishing and delivery of the product. The management of the RMG industries need to focus on enhancing the efficiency of the production planning process, to improve the overall productivity and profitability.

In an RMG industry, production planning is usually done in such a way that it is in the same cadence with the overall operational strategy, which usually aligns with the corporate strategic objectives. During the planning process, the planner has to consider the external and internal environment, company's profitability, policies, vision, and objectives. Most of the time, there is a contrast between the planned production, and the actual production. If the planning is done in a more efficient manner, it is possible to reduce the gap between them (Cheraghalikhani, et al. 2019, Tareque and Islam 2020). There are lots of factors that influences this gap between the planned production and actual production. If these influencing factors can be identified and managed properly, they can contribute to reduce this gap. Currently, there is no significant research that has focused on identifying these factors and exploration of the relationships among the identified factors. Thereby, this research aims to identify the factors that influence this gap between the planned production, and actual production, in order improve the efficiency of the overall production planning.

In this research, at first, the influencing factors have been identified, both from expert opinion and through the review of previous literatures. Then, a DEMATEL approach has been utilized to rank the identified factors from the most important to the least important. After that, the interrelationships among the identified factors have also been explored by using DEMATEL method, via a causal relationship diagram. The insights obtained from this research is expected to help not only the managers of the RMG industries, but also all the production-oriented industries, which operates the same way as the RMG industries, to take necessary corrective actions to reduce the gap between the planned and actual production. This research work intends to achieve the following objectives

- Identification of the factors that influences the gap between the planned production and the actual production in the RMG industries of Bangladesh.
- Prioritization or ranking of the identified factors using an appropriate decision analysis tool. This study has utilized the DEMATEL method for this purpose.
- Exploration of the interrelationship among the identified factors through a causal relationship diagram, which is obtained using the DEMATEL method.

This research work intends to answer the following research questions

1. What are the factors that causes and influences the gap between the planned production and the actual production in the RMG industries of Bangladesh?
2. Do these factors have interrelationships among themselves as well?

The rest of the paper is organized into the following sections: Section 2 presents a literature review and identifies the influencing factors. Section 3 discusses the relevant research methodologies, and calculations. Section 4 presents the obtained results and discussions. Section 5 discusses the managerial implications of the research. Finally, Section 6 concludes the paper and discusses some future research directions.

2 Literature Review

Several recent literatures have been studied to understand the process, implication, and application of efficient production planning in the modern manufacturing industries. Decision-making for production planning in RMG industries is very challenging due the heavy fluctuation in demand and other related variables. Current pandemic situation has made these fluctuations even worse. In recent years, several researchers have tried to analyse and explore the issues related to production planning, for instance, Gholmy (2010) tried to find the best way to manage the production planning and control system in a knit garments industry to achieve higher efficiency, to reduce the waste of time and improve control on raw material supply and other related processes. The study found that due to the fluctuation in demand, execution of the received orders become very difficult as available resources often do not match the demand, which leads to the either increased inventory cost or an insufficient stock or inventory. Gozali et al. (2020) tried to forecast demand, calculate production aggregate, control the inventory cost, and design production planning inventory control system in a knit fabric industry by using an Artificial Neural Network (ANN) method. Through time study, Jadhav et al. (2017) showed that proper time management with improved quality control of products leads to the improvement in the overall productivity. Cadavid et al. (2020) used a machine learning approach for production planning and control to facilitate the implementation of industry 4.0 in the manufacturing industries. Gyulai et al. (2017) developed a robust production planning and control system for a multi-stage production process with flexible final assembly lines. Altaf et al. (2018) developed an integrated production planning and control system for a home prefabrication facility using simulation and RFID.

Different MCDM tools has been used in recent days to explore productivity in the RMG industries. Halder et al. (2018) used a fuzzy AHP method to evaluate the factors affecting the productivity in the RMG industries of Bangladesh, where the results demonstrated that “line balancing” has the highest weight among all the factors under investigation. Gürbüz et al. (2012) used a hybrid MCDM method, including Analytic Network Process (ANP), and Measuring Attractiveness by a Categorical Based Evaluation Technique (MACBETH) method, to solve an ERP selection problem, while Ghaleb et al. (2020) compared the performance of different MCDM methods for evaluation and selection of appropriate manufacturing process.

As an effective MCDM tool, DEMATEL and its different variants have been utilized for decision-making in various areas including production process improvement (Tsai et al. 2017), supply chain management (Lopez et al. 2021), safety management (Yazdi et al. 2020), service management (Feng and Ma 2020), waste management (Garg 2018), risk assessment (Wu and Zhou 2019) etc. Based on the DEMATEL method, the cause-effect assortment of the factors can be achieved as well, which can assess the relationships among different factors and discover their influences (Ding et al. 2018, Si et al. 2018).

Until now, there is no research that has used MCDM tools such as DEMATEL to explore the factors affecting efficient production planning in the RMG industries of Bangladesh, which presents a clear research gap that is worth exploration. This proposed research, thereby, intends to address this gap. In this research, 14 such factors have been identified from the previous relevant literatures and feedbacks of twenty experts working in the production department of different RMG industries in Bangladesh. The identified factors have been shown in Table 1.

Table 1: Factors influencing efficient Production Planning

ID	Factor name	Source
C1	Fabric delay	Expert Feedback
C2	Sewing items delay	Expert Feedback
C3	Frequent Changes of Delivery Date	Ye and Lau (2018); Expert Feedback
C4	Sample Approval delay	Expert Feedback
C5	Buyer Postpone Order	Expert Feedback
C6	Frequent Layout change	Expert Feedback
C7	Pre-production Delay	Expert Feedback
C8	Line not balanced	Karmaker et al. (2018); Rehman et al. (2019); Expert Feedback
C9	Low Productivity	Hamja et al. (2019); Saha (2019); Expert Feedback
C10	Unskilled Worker	Mia and Akter (2019); Expert Feedback
C11	Defective Product	Expert Feedback
C12	Machine Breakdown	Janasekaran and Lim (2020); Expert Feedback
C13	Delay From Subcontract	Expert Feedback
C14	Workers Absenteeism and Migration	Hasan, (2019); Expert Feedback

3. Research Methodology and Calculations

This section consists of two subsections. First subsection (3.1) describes the steps of the DEMATEL method. The second subsection (3.2) follows those steps to performs necessary calculations to evaluate the factors effecting the efficient production planning in the RMG industries of Bangladesh

3.1 Decision-Making Trial and Evaluation Laboratory (DEMATEL) Method

DEMATEL is a comprehensive method for building and analysing structural models involving relations among factors (Thakkar 2021). Steps of the DEMATEL method (Si et al. 2018) are as following:
Step 1: From the review of previous relevant literatures and expert opinions, the influencing factors have been identified and listed with their source (this has been done in the section 2 of this study).

Step 2: To establish a Direct-Relation Matrix (DRM), the experts were requested to provide feedbacks on the relative influence of one factor over another, using a scale ranging from 0 to 4. Here, 0 indicated 'no influence', 1 indicates 'very low influence', 2 indicates 'low influence', 3 indicates 'high influence', and 4 indicates 'very high influence'.

Let, the notation x_{ij} indicates the degree to which the respondent believes factor i affects factor j. For $i = j$, the diagonal elements are set to zero. For each respondent, a $(n \times n)$ non-negative matrix can be established as $x^k = [x_{ij}^k]$, where k is the number of respondents with $1 \leq k \leq H$, H is the total number of respondents and n is the number of factors. Thus, X^1, X^2, X^3, ….., X^H are the matrices from H respondents. To incorporate the opinions collected from all H respondents, the average matrix A = $[a_{ij}]$ can then be constructed by using equation (1) and (2).

$$A = [a_{ij}] = \frac{1}{H}\sum_{k=1}^{H} x_{ij}^k \qquad (1)$$

$$A = \begin{bmatrix} 0 & a_{12} & \cdots & a_{1n} \\ a_{21} & 0 & \ldots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & 0 \end{bmatrix} \tag{2}$$

Step 3: To determine the normalized immediate relation matrix, the normalization factor S is calculated using equation (3).

$$S = Min\left[\frac{1}{Max_i\left(\sum_{j=1}^{n} aij\right)}, \frac{1}{Max_j\left(\sum_{i=1}^{n} aij\right)}\right] \tag{3}$$

The normalized direct relation matrix is denoted as M and is determined by the multiplication of the matrices A and S as shown in equation (4).

$$\mathrm{M} = \mathrm{S} \times \mathrm{A} \tag{4}$$

Step 4: To calculate total relation matrix (T), equation (5) is then used.

$$\mathrm{T} = \lim_{k \to \propto}\left(\mathrm{M} + \mathrm{M}^2 + \mathrm{M}^3 + \cdots + \mathrm{M}^k\right) = \mathrm{M}(\mathrm{I} - \mathrm{M})^{-1} \tag{5}$$

Here, matrix I is an identity matrix. An essential feature of the DEMATEL method is the visualization of the most influenced and the most influential factor. After calculating the total relation matrix T, the sum of the values in a row is denoted as D, as shown in equation (6) and the sum of the values in a column is denoted as R, as shown in equation (7).

$$D = \left(\sum_{j=1}^{n} t_{ij}\right)_{nx1}, (i = 1,2,3 \ldots \ldots n) \tag{6}$$

$$R = \left(\sum_{i=1}^{n} t_{ij}\right)_{nx1}, (i = 1,2,3 \ldots \ldots n) \tag{7}$$

Step 5: After calculation of D and R, (D + R) and (D – R) values are calculated. (D + R) value indicates the importance or prominence of a factor and (D – R) value indicates the relation of that factor with the other factors. If the (D – R) value for a particular factor is positive, then it is classified into the cause group, and if the value is negative, then the factor is classified into the effect group. For an enhanced visual understanding, a causal relationship diagram can also be created with the (D+R) values on x-axis and the (D-R) values on the y-axis, which can demonstrate the overall influence any particular factor over other factors.

3.2 Calculation and Evaluation using DEMATEL Method

First step of DEMATEL method is the identification of the factors. The identified influencing factors has been presented in the Table 1 of section 2. Since this research focuses on exploring the factors affecting the efficient production planning in the RMG industries of Bangladesh, all the related information and feedbacks were collected from the relevant domain experts. Twenty experienced production managers working in different RMG industries of Bangladesh were contacted to collect their expert opinions and quantitative feedbacks on the factors identified in Table 1. Expert opinions and feedbacks were collected through an extensive online survey (questionnaire type) using Google forms. The profile of the experts who participated in the study, is provided in the Table 2 bellow.

Table 2. Profile of the experts

Experts participated in the study to provide feedback on the evaluation criteria			
Total number of experts (N=20)	Experience	N	Percentage
	< 10 years	11	55%
	From 10 to 15 years	5	25%
	> 15 years	4	20%

A direct relation matrix has been formed following the equation (1) and (2) of step 2, as described in section 3.1, which is shown in Table 3. In Table 3, All the diagonal elements are zero, as the influence of a particular factor over itself is zero.

Table 3: Direct Relation Matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	Sum
C1	0	1	3	2	1	1	3	1	1	1	2	1	1	1	19
C2	1	0	1	2	1	1	4	1	1	1	2	1	2	1	19
C3	2	3	0	2	1	2	2	2	1	1	1	1	2	1	21
C4	2	2	2	0	2	1	4	2	2	1	1	1	3	1	24

C5	3	3	2	1	0	3	3	1	2	1	1	1	1	1	23
C6	1	1	1	1	1	0	1	4	3	1	3	2	1	2	22
C7	2	2	1	1	1	1	0	1	1	1	2	1	2	1	17
C8	1	1	1	1	1	3	1	0	4	1	3	1	3	2	23
C9	1	1	3	2	1	3	2	4	0	3	3	1	2	3	**29**
C10	1	1	1	2	1	2	3	4	1	0	3	3	2	2	26
C11	1	1	1	2	3	3	2	2	3	4	0	2	2	1	27
C12	1	1	1	2	1	1	2	2	3	1	4	0	1	2	22
C13	1	1	3	1	2	3	1	1	4	1	1	1	0	1	21
C14	1	1	1	1	1	3	2	4	3	3	2	1	1	0	24
Sum	18	19	21	20	17	27	**30**	29	29	20	28	17	23	19	

To normalise the direct relation matrix, sum of each row and column has been calculated as shown in the right side and the bottom of Table 3. Following equation (3), the normalization factor S has been found to be 1/30. Thereby, the direct relation matrix has been multiplied by S = 1/30, according to equation (4), to obtain the normalized direct relation matrix, which is shown in Table 4.

Table 4: Normalized Direct Relation Matrix

	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**C12**	**C13**	**C14**
C1	0.000	0.033	0.100	0.067	0.033	0.033	0.100	0.033	0.033	0.033	0.067	0.033	0.033	0.033
C2	0.033	0.000	0.033	0.067	0.033	0.033	0.133	0.033	0.033	0.033	0.067	0.033	0.067	0.033
C3	0.067	0.100	0.000	0.067	0.033	0.067	0.067	0.067	0.033	0.033	0.033	0.033	0.067	0.033
C4	0.067	0.067	0.067	0.000	0.067	0.033	0.133	0.067	0.067	0.033	0.033	0.033	0.100	0.033
C5	0.100	0.100	0.067	0.033	0.000	0.100	0.100	0.033	0.067	0.033	0.033	0.033	0.033	0.033
C6	0.033	0.033	0.033	0.033	0.033	0.000	0.033	0.133	0.100	0.033	0.100	0.067	0.033	0.067
C7	0.067	0.067	0.033	0.033	0.033	0.033	0.000	0.033	0.033	0.033	0.067	0.033	0.067	0.033
C8	0.033	0.033	0.033	0.033	0.033	0.100	0.033	0.000	0.133	0.033	0.100	0.033	0.100	0.067
C9	0.033	0.033	0.100	0.067	0.033	0.100	0.067	0.133	0.000	0.100	0.100	0.033	0.067	0.100
C10	0.033	0.033	0.033	0.067	0.033	0.067	0.100	0.133	0.033	0.000	0.100	0.100	0.067	0.067
C11	0.033	0.033	0.033	0.067	0.100	0.100	0.067	0.067	0.100	0.133	0.000	0.067	0.067	0.033
C12	0.033	0.033	0.033	0.067	0.033	0.033	0.067	0.067	0.100	0.033	0.133	0.000	0.033	0.067
C13	0.033	0.033	0.100	0.033	0.067	0.100	0.033	0.033	0.133	0.033	0.033	0.033	0.000	0.033
C14	0.033	0.033	0.033	0.033	0.033	0.100	0.067	0.133	0.100	0.100	0.067	0.033	0.033	0.000

Next step is to calculate the total relation matrix (T), following equation (5), which is shown in Table 5.

Table 5: Total-Relation Matrix

	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**C12**	**C13**	**C14**
C1	0.1151	0.1546	0.2241	0.1884	0.1431	0.2019	0.2720	0.2120	0.2120	0.1623	0.2351	0.1406	0.1825	0.1528
C2	0.1459	0.1189	0.1632	0.1860	0.1437	0.2015	0.3003	0.2097	0.2142	0.1621	0.2354	0.1402	0.2120	0.1525
C3	0.1852	0.2221	0.1443	0.1988	0.1519	0.2473	0.2590	0.2581	0.2326	0.1710	0.2237	0.1499	0.2259	0.1654
C4	0.2042	0.2116	0.2290	0.1531	0.1979	0.2444	0.3420	0.2813	0.2875	0.1901	0.2468	0.1640	0.2770	0.1828
C5	0.2270	0.2341	0.2194	0.1812	0.1274	0.2912	0.3056	0.2471	0.2738	0.1840	0.2418	0.1606	0.2062	0.1777
C6	0.1653	0.1715	0.1915	0.1850	0.1677	0.2179	0.2437	0.3532	0.3267	0.2001	0.3147	0.1968	0.2159	0.2190
C7	0.1641	0.1690	0.1535	0.1467	0.1336	0.1884	0.1629	0.1953	0.1994	0.1518	0.2212	0.1313	0.1967	0.1426
C8	0.1710	0.1776	0.2034	0.1911	0.1748	0.3206	0.2519	0.2436	0.3653	0.2080	0.3202	0.1730	0.2807	0.2252
C9	0.2041	0.2135	0.2930	0.2554	0.2041	0.3666	0.3326	0.4162	0.2933	0.3002	0.3692	0.2056	0.2962	0.2875
C10	0.1853	0.1920	0.2103	0.2338	0.1865	0.3033	0.3326	0.3768	0.2970	0.1833	0.3418	0.2453	0.2701	0.2354
C11	0.1963	0.2035	0.2246	0.2445	0.2528	0.3468	0.3211	0.3377	0.3626	0.3141	0.2622	0.2267	0.2788	0.2174
C12	0.1671	0.1733	0.1918	0.2156	0.1698	0.2467	0.2774	0.2899	0.3202	0.2014	0.3389	0.1337	0.2152	0.2151
C13	0.1616	0.1695	0.2474	0.1763	0.1869	0.2941	0.2333	0.2505	0.3332	0.1842	0.2360	0.1573	0.1689	0.1784
C14	0.1758	0.1824	0.2025	0.1956	0.1756	0.3248	0.2897	0.3743	0.3403	0.2690	0.3028	0.1799	0.2303	0.1690

After that, the values of D and R are calculated from Table 5, following equation (6) and (7). The calculated values of D and R are shown in the Table 6.

Table 6: Calculating D and R

	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**C12**	**C13**	**C14**	**D**
C1	0.1151	0.1546	0.2241	0.1884	0.1431	0.2019	0.2720	0.2120	0.2120	0.1623	0.2351	0.1406	0.1825	0.1528	2.5964
C2	0.1459	0.1189	0.1632	0.1860	0.1437	0.2015	0.3003	0.2097	0.2142	0.1621	0.2354	0.1402	0.2120	0.1525	2.5855
C3	0.1852	0.2221	0.1443	0.1988	0.1519	0.2473	0.2590	0.2581	0.2326	0.1710	0.2237	0.1499	0.2259	0.1654	2.8352

C4	0.2042	0.2116	0.2290	0.1531	0.1979	0.2444	0.3420	0.2813	0.2875	0.1901	0.2468	0.1640	0.2770	0.1828	3.2118
C5	0.2270	0.2341	0.2194	0.1812	0.1274	0.2912	0.3056	0.2471	0.2738	0.1840	0.2418	0.1606	0.2062	0.1777	3.0772
C6	0.1653	0.1715	0.1915	0.1850	0.1677	0.2179	0.2437	0.3532	0.3267	0.2001	0.3147	0.1968	0.2159	0.2190	3.1692
C7	0.1641	0.1690	0.1535	0.1467	0.1336	0.1884	0.1629	0.1953	0.1994	0.1518	0.2212	0.1313	0.1967	0.1426	2.3565
C8	0.1710	0.1776	0.2034	0.1911	0.1748	0.3206	0.2519	0.2436	0.3653	0.2080	0.3202	0.1730	0.2807	0.2252	3.3064
C9	0.2041	0.2135	0.2930	0.2554	0.2041	0.3666	0.3326	0.4162	0.2933	0.3002	0.3692	0.2056	0.2962	0.2875	4.0376
C10	0.1853	0.1920	0.2103	0.2338	0.1865	0.3033	0.3326	0.3768	0.2970	0.1833	0.3418	0.2453	0.2701	0.2354	3.5934
C11	0.1963	0.2035	0.2246	0.2445	0.2528	0.3468	0.3211	0.3377	0.3626	0.3141	0.2622	0.2267	0.2788	0.2174	3.7890
C12	0.1671	0.1733	0.1918	0.2156	0.1698	0.2467	0.2774	0.2899	0.3202	0.2014	0.3389	0.1337	0.2152	0.2151	3.1559
C13	0.1616	0.1695	0.2474	0.1763	0.1869	0.2941	0.2333	0.2505	0.3332	0.1842	0.2360	0.1573	0.1689	0.1784	2.9775
C14	0.1758	0.1824	0.2025	0.1956	0.1756	0.3248	0.2897	0.3743	0.3403	0.2690	0.3028	0.1799	0.2303	0.1690	3.4119
R	2.468	2.594	2.898	2.752	2.416	3.795	3.924	4.046	4.058	2.882	3.890	2.405	3.256	2.721	

As the values of D and R of each criterion are found, next step is to find the value of (D-R) and (D+R), which has been shown in Table 7.

Table 7: (D+R) and (D-R) Value Calculation

ID	Factor name	D	R	D+R	D-R
C1	Fabric delay	2.5964	2.4680	5.0644	0.1284
C2	Sewing items delay	2.5855	2.5938	5.1793	-0.0082
C3	Frequent Changes of Delivery Date	2.8352	2.8979	5.7332	-0.0627
C4	Sample Approval delay	3.2118	2.7515	5.9634	0.4603
C5	Buyer Postpone Order	3.0772	2.4158	5.4930	0.6613
C6	Frequent Layout change	3.1692	3.7954	6.9645	-0.6262
C7	Pre-production Delay	2.3565	3.9239	6.2805	-1.5674
C8	Line not balanced	3.3064	4.0457	7.3521	-0.7392
C9	Low Productivity	4.0376	4.0580	8.0957	-0.0204
C10	Unskilled Worker	3.5934	2.8816	6.4751	0.7118
C11	Defective Product	3.7890	3.8899	7.6789	-0.1009
C12	Machine Breakdown	3.1559	2.4049	5.5608	0.7510
C13	Delay From Subcontract	2.9775	3.2562	6.2337	-0.2787
C14	Workers Absenteeism and Migration	3.4119	2.7209	6.1328	0.6910

4 Results and Discussions

In DEMATEL method, the value of (D+R) represents how important the factor is and (D - R) indicates the type and degree of relation the factor has with other factors. The factors having higher value of (D+R) has more importance over other criteria and those having smaller value of (D+R) has less importance compared to other criteria. Hence, the importance order of the identified factors based upon the D + R value, can be given as: C9 - C11 – C8 – C6 - C10 – C7 – C13 - C14 - C4 – C3 – C12 – C5 – C2 – C1, which has been shown in Table 8.

Table 8: Degree of Importance based (D + R) value

Prominence Group			
Rank	**Factor ID**	**Factor name**	**D + R**
1	C9	Low Productivity	8.0957
2	C11	Defective Product	7.6789
3	C8	Line not balanced	7.3521
4	C6	Frequent Layout change	6.9645
5	C10	Unskilled Worker	6.4751

6	C7	Pre-production Delay	6.2805
7	C13	Delay From Subcontract	6.2337
8	C14	Workers Absenteeism and Migration	6.1328
9	C4	Sample Approval delay	5.9634
10	C3	Frequent Changes of Delivery Date	5.7332
11	C12	Machine Breakdown	5.5608
12	C5	Buyer Postpone Order	5.4930
13	C2	Sewing items delay	5.1793
14	C1	Fabric delay	5.0644

In addition, based upon (D – R) values, C12, C10, C14, C5, C4, and C1 have been categorized as the cause group factors and C7, C8, C6, C13, C11, C3, C9, and C2 have been categorized as the effect group factors, as shown in Table 9.

Table 9: Interrelationships among the factor based on (D − R) values

Relation					
Cause Group			**Effect Group**		
Rank	**Factors**	**D – R**	**Rank**	**Factors**	**D – R**
1	C12	0.7510	1	C7	-1.5674
2	C10	0.7118	2	C8	-0.7392
3	C14	0.6910	3	C6	-0.6262
4	C5	0.6613	4	C13	-0.2787
5	C4	0.4603	5	C11	-0.1009
6	C1	0.1284	6	C3	-0.0627
			7	C9	-0.0204
			8	C2	-0.0082

A causal relationship diagram, based on the findings in Table 9, has been shown in Figure 1, for an improved visual understanding of the implication of the (D – R) values. This causal diagram is in fact a (D+R) vs (D-R) scatter plot diagram, where (D+R) is represented in the horizontal axis and (D-R) is represented in the vertical axis. The diagram explains whether a factor has influence over other factors or is it influenced by other factors.

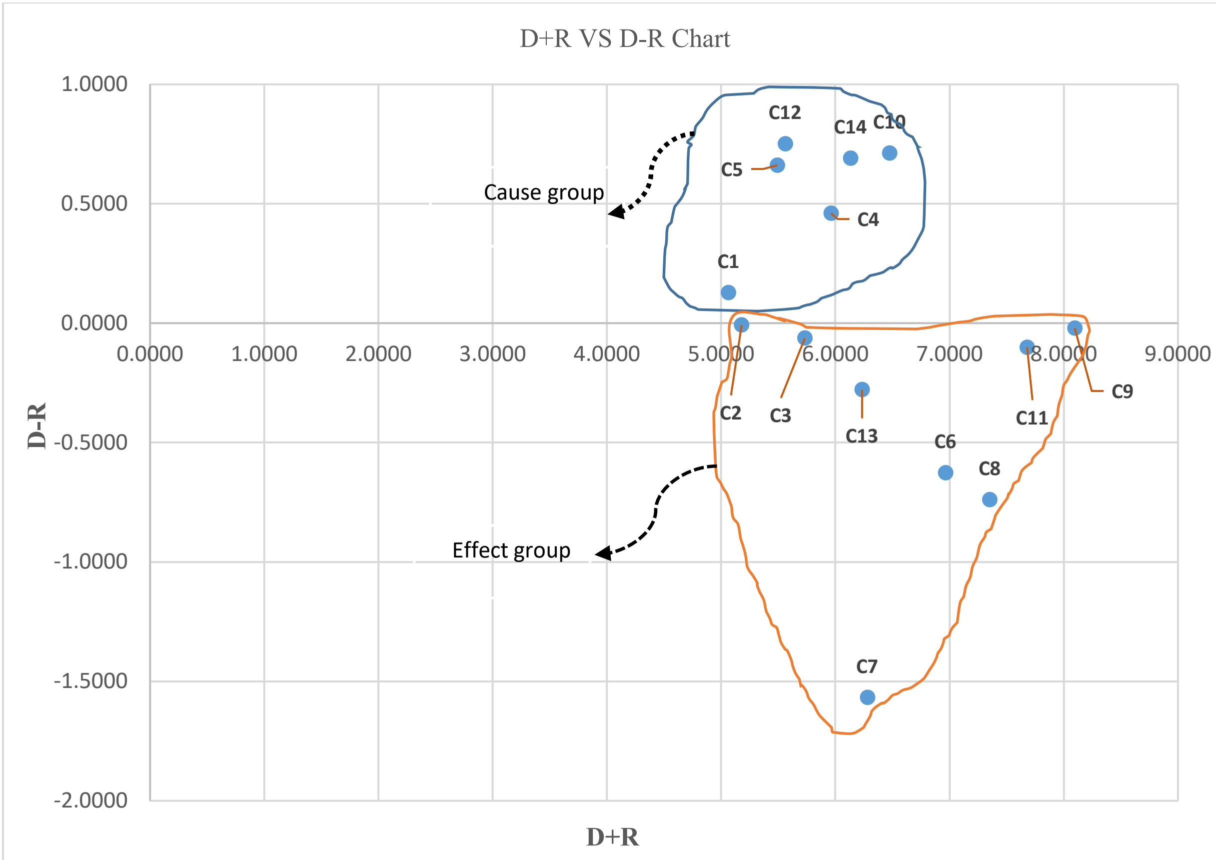

Figure 1: D+R VS D-R Diagram

Obtained results show that "low Productivity (C9)" has the highest (D+R) value, which indicates that it is the most important factor that influences efficient production planning. This is because, in the current competitive market productivity is the centre of all operations in an industry and it ultimately determines the organization's fate. "Defective product (C11)" has the second highest (D+R) value, which indicates that it is a very important factor that influences production planning. Producing defective product leads to remaking the same product again to make up the deficit in the order, which requires further planning and production spaces. Defects can also damage the reputation of the company, as every time an undiscovered flaw makes it out of the production line, the company reputation takes a hit. Similarly, "line not balanced (C8)" has the third highest (D+R) value, which indicates that it is a very important factor as well. Line balancing involves the practice of allocating processes to employees in order to create a smooth production flow and smooth production flow leads to smooth execution of the production plan. Thereby, if line balancing is not done properly, it impacts the production plan negatively. On the other hand, "Fabric delay (C1)" has the lowest (D+R) value, which indicates that it is the least important factor that influences efficient production planning. This is mainly because, alternate fabric sometimes can be allotted to a specific product in case of fabric delay and sometimes buyer even accepts the delayed shipment of that specific product, considering it is mostly supplier's liability and not usually the manufacturers.

The (D-R) value indicates the kind of relationship a factor has with other factors. When (D-R) value is positive, the factor belongs to the cause group, which is also known as the Dispatcher, as these factors can influence other factors. Machine Breakdown (C12) has the highest positive (D-R) value. It is because the machine is a valuable resource of the company thar is used for value addition to the product under processing. Machine breakdown, hence, negatively affects the factory's productivity, quality, line balancing and the overall production planning. Unskilled Worker (C10) has the second highest positive (D-R) value. It is because the link between skill and productivity is very conspicuous. Unskilled workforce can negatively influence the overall efficiency of the production planning and company's profitability. Similarly, Workers Absenteeism and Migration (C14) has the third highest positive (D-R) value. In labour-intensive sectors, worker absenteeism and migration results in production delay for businesses and a reduction in the possibility meet the buyer's deadline. When employees migrate, segmental delays become bottlenecks, which affects the factory's productivity, line balancing and the overall production planning. Other factors in the cause group includes Buyer Postpone Order (C5), Sample Approval Delay (C4), and Fabric Delay (C1), as they all have positive (D-R) value.

On the other hand, if (D-R) value is negative, the factor belongs to the effect group, which is also known as the Receivers, as these factors are influenced by other factors. Pre-production Delay (C7) has the highest negative (D-R) value. It is because, pre-production phase involves the planning process that occurs prior to the mass production and this process is influenced by other issues like the time required to develop and approve the samples, sourcing and testing of raw materials, pattern creation, process planning etc. Line not balanced (C8) has the second highest negative (D-R) value, as it is influenced by factors like unskilled worker, worker absenteeism and so on. Similarly, Frequent Layout change (C6) has the third highest negative (D-R) value, as it is influenced by factors like the fabric delay, sewing items arrival delay, line imbalance, low productivity etc. Other factors in the effect group includes Delay from Subcontract (C13), Defective Product (C11), Frequent Changes of Delivery Date (C3), Low Productivity (C9), and Sewing items delay (C2), as they all have negative D-R value.

5 Managerial Implications

Obtained results were discussed with the industrial experts to derive better understanding of the implications of the study. Managers working in different RMG industries can obtain significant insights from this study. For instance, in the developing or underdeveloped countries resources are usually constrained, which makes it difficult for the managers to focus on multiple factors and issues at the same time. Since this research identifies and ranks the factors that contribute to efficient production planning in the RMG industries, managers will get a clear idea from it about which factor they should focus on first to improve production planning efficiency, if the resource is inadequate.

This research also discusses the relationship among different factors. The causal relationship diagram in Figure 1 clearly distinguishes whether a factor has influence over other factors (the cause group) or is it influenced by the other factors (the effect group). Managers should try their best to minimize the influence of the factors like 'Machine Breakdown', 'Unskilled Worker', 'Unskilled Worker' etc. in the cause group, to improve the factors like 'Pre-production Delay', 'Line not balanced', 'Frequent Layout change' etc., which are in the effect group.

The research is expected to make mangers more aware of the importance of the different influencing factors, so that they can become more proactive and efficient in production planning to improve the overall profitability of their respective industries. Managers of other similar industrial sectors in the developing counties can utilize this research as well, for the evaluation of the factors influencing their production planning.

6 Conclusion

This study has explored different factors that influence efficient production planning using DEMATEL method, in perspective of the RMG industries of Bangladesh. Obtained results suggest that 'low Productivity', 'defective product', and 'line not balanced' are the three most important factors, while 'Fabric delay' is the least important factor that influences efficient production planning. Obtained results also suggest that 'Machine Breakdown', 'Unskilled Worker', and 'Unskilled Worker' are the most influencing factors in the cause group, i.e., they have significant influence on the other factors. Again, the results suggest that 'Pre-production Delay', 'Line not balanced', and 'Frequent Layout change' are the topmost factors in the effect group, which means they are highly influenced by the factors in the cause group.

Based on this research, proper and regular training should be arranged for the managers and the employees, to make them more conscious about the influencing factors to improve the overall productivity of their industry. Although, this research has been carried out in the RMG industries, this technique can be applied to any production-related organization, such as beverage industries, steel appliance manufacturing industries, furniture manufacturing industries, etc. to perform similar study.

The research has some limitations as well, on which future researchers can focus to overcome them. For example, the number of experts took part in this research were limited. The future research can be done with a larger number of experts to reduce opinion bias. Moreover, only DEMATEL method has been used in this research. Hence, more robust results can be obtained by using two or more methods together as integrated hybrid method. Other MCDM tools can also be used for this study and the obtained results can be compared together, to evaluate the performance of the DEMATEL method and explore the best method to be used in similar studies. This research has been conducted for the RMG industries of Bangladesh. The results can be different, if the same study is conducted for other type of industries situated in a different country, which is an interesting idea that is worth exploring in future.

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