**ANOVA Analysis**

To gain insights into the success factors used to establish the DoE setting, an ANOVA analysis is conducted for the proposed reliability level () using the average fitness function (FF) values achieved by the proposed GACRFNI algorithm across all disruption degrees. This analysis allows for a detailed examination of the influence of factors and their interactions on the overall cost. Table 1 presents the three-way ANOVA results, while Figure 1 illustrates the main and interaction effect plots for the controlled factors.

According to the ANOVA results in Table 1, all success factors -namely, the number of collection centers , the number of warehouses , and the number of demand points - are found to be statistically significant. These factors have a significant impact on the overall cost at the preferred risk aversion level. Additionally, the interactions between and , as well as between and , are also statistically significant.

It is also noteworthy that the R-squared (R-sq) and adjusted R-squared (R-sq(adj)) values are 0.91 and 0.89, respectively. This indicates that the controlled factors are well-determined, accounting for a significant percentage of the variation in overall cost.

**Table 1** ANOVA results for FF values

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Three-way ANOVA: FF versus |C|. |W|. and |P| | | | | | | |
| **Source** | **DF** | **Adj SS** | **Adj MS** | **F-Value** | **P-Value** | **Partial eta squared** |
| |C| | 2 | 1.94E+11 | 9.72E+10 | 57.98 | **0** | 0.653 |
| |W| | 2 | 4.0853E+10 | 2.04E+10 | 12.18 | **0** | 0.283 |
| |P| | 2 | 5.45E+11 | 2.73E+11 | 162.62 | **0** | 0.84 |
| |C|\*|W| | 4 | 3.80E+11 | 9.51E+10 | 56.68 | **0** | 0.786 |
| |C|\*|P| | 4 | 226418453 | 56604613 | 0.03 | **0.03** | 0.02 |
| |W|\*|P| | 4 | 783226846 | 1.96E+08 | 0.12 | 0.12 | 0.008 |
| Error | 8 | 1.04E+11 | 1.68E+09 |  |  |  |
| Total | 26 | 1.27E+12 |  |  |  |  |
| R-sq | R-sq(adj) | |  |  |  |  |
| 0.9179 | 0.8940 |  |  |  |  |  |

P-value less than 0.05 means statistically significant effect

The main effect plots in Figure 1 illustrate the individual effects of the factors on the FF values. As indicated by the ANOVA results, all controllable factors have a significant impact on the FF values. For all factors, the lowest levels correspond to the lowest FF values. However, given the limited capacity of both warehouses and collection centers to meet demand during humanitarian crises, it is recommended to select the highest number of warehouses to design a resilient HSC with a focus on viability. If the assumption of unlimited capacity for each warehouse holds, the lowest number of warehouses may be preferred for HSC design.

When examining the interaction plots in Figure 1, the interaction between and is particularly important. The lowest objective function values are consistently achieved when both factors are at their lowest levels. This observation is further supported by the data in Table 1, which shows that partial eta squared is highest for this interaction. Therefore, analyzing the interactions between controllable factors provides valuable insights into their impact on the results.

metin, diyagram, ekran görüntüsü, çizgi içeren bir resim

Açıklama otomatik olarak oluşturuldu

**Figure 1** Main effects plot and interaction plot for FF

This study addresses the resilience of HSCs with a focus on viability. Therefore, analyzing the significance of the controllable factors and their interactions on ETSC values is crucial. By doing so, the appropriate levels can be identified to reduce shortages and meet customer demand at an acceptable level.

To complement the sensitivity analysis, an ANOVA analysis is conducted at the proposed risk aversion level () using the ETSC values achieved by the GACRFNI algorithm across all disruption degrees. This analysis offers a detailed examination of the influence of factors and their interactions on shortage levels. Table 2 presents the three-way ANOVA results, while Figure 2 illustrates the main and interaction effect plots for the controlled factors.

According to the ANOVA results in Table 2, all controllable factors and their interactions are statistically significant. These factors and their interactions have a considerable impact on shortage levels at the preferred risk aversion level.

It is also noteworthy that the R-squared (R-sq) and adjusted R-squared (R-sq(adj)) values are 0.98 and 0.97, respectively. This indicates that the controlled factors are well-determined and account for nearly all changes in ETSC, confirming that there are no redundant or missing factors in the DoE setting.

**Table 2** ANOVA results for ETSC values

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Three-way ANOVA: ETSC versus |C|. |W|. and |P| | | | | | | |
| **Source** | **DF** | **Adj SS** | **Adj MS** | **F-Value** | **P-Value** | **Partial eta squared** |
| |C| | 2 | 1.25E+00 | 0.625916 | 254.41 | **0** | 1 |
| |W| | 2 | 1.06279 | 0.531394 | 215.99 | **0** | 1 |
| |P| | 2 | 1.03E+00 | 5.14E-01 | 208.76 | **0** | 1 |
| |C|\*|W| | 4 | 2.47E+00 | 0.618109 | 251.24 | **0** | 1 |
| |C|\*|P| | 4 | 0.02693 | 0.006733 | 2.74 | **0.037** | 0.86 |
| |W|\*|P| | 4 | 0.05291 | 0.013227 | 5.38 | **0.001** | 0.993 |
| Error | 8 | 1.53E-01 | 0.00246 |  |  |  |
| Total | 26 | 6.05E+00 |  |  |  |  |
| R-sq | R-sq(adj) | |  |  |  |  |
| 0.9748 | 0.9674 |  |  |  |  |  |

The main effect plots in Figure 2 illustrate the individual effects of the factors on the ETSC values. As indicated by the ANOVA results, all controllable factors significantly impact the ETSC values. The lowest number of demand points results in the minimum ETSC values, while a moderate level of warehouses and collection centers yields the lowest ETSC values. Therefore, to design a resilient HSC with viability consideration, it is preferable to have a moderate or high number of collection centers and warehouses. The interaction plots in Figure 2 further demonstrate that when the highest levels are used for the number of collection centers and warehouses, the lowest ETSC values are consistently achieved, regardless of demand levels.

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Açıklama otomatik olarak oluşturuldu

**Figure 2** Main effects plot and interaction plot for ETSC