Optimization of Product Mix in Cold Rolling Steel Industry Using Product Portfolio Matrix and Multi Objective Goal Programming Model

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Abstract

This paper aims to develop an optimum product mix for monthly saleable steel in cold rolling steel industry (JSW) which is one of the leading cold rolling, galvanizing and colour coating house in India. The company is going for the production of 45000mt per month and aiming for maximum EBIDTA and maximum utilization of all main line. Out of 13 products selected for optimization company aim is to decide monthly production tonnage of each selected product. This is done by making product portfolio matrix which shows which products are more convenient for production considering market attractiveness and competitive position factors by taking opinion of marketing and operation expert’s. Further Multi objective linear programming approach is applied for getting solution of optimal product mix. After getting results by both approach it is compared with actual figures of company and final production figures of all 13 products are freeze for maximum EBIDTA and maximum utilization of plant.

Keywords: Product portfolio matrix, cold rolling, galvanizing, market attractiveness factors, competitive position factors.

1. Conceptual Framework

Company has various production facility for cold rolling, galvanizing and colour coating, which has different production capability with respect to product, thickness and quality. There are total 13 identified products which can be produced in plant, but due to various operational and market constraints company is not able to fix the production volume of each product to get the maximum profit, maximum plant utilization and long term market stability. Comparative evaluation and results of both methods will be done to finally decide acceptable product volume.

1.1 Product mix for the company.

The details of Products are as follows:

1) GC-Retail (≤0.25mm)
2) GC-Retail (≤0.27mm)
3) GP-Retail
4) HR SP/PO- OEM
5) CRCA- CD
6) CRCA- OEM
7) GP SP- CD
8) GP/ GP SP- OEM
9) BGL- OEM
10) BGL- Retail
11) PPGI- CD
12) PPGI- OEM
13) PPGLR P&C / Retail

2. Data & Methodology

The optimization of product mix can be done by using two different methods

1) Product portfolio matrix

2) Multi objective goal programming model

2.1 Product portfolio matrix: The matrix is being prepared by taking the opinion of marketing and operational experts on market attractiveness and competitive position factors. The workshop was conducted of marketing and operation experts with five groups having five persons in each group and rating of various products is done based on given factors, the results of PPM is illustrated below:

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>GROUP1</th>
<th>GROUP2</th>
<th>GROUP3</th>
<th>GROUP4</th>
<th>GROUP5</th>
<th>AVG RATING</th>
</tr>
</thead>
<tbody>
<tr>
<td>1). GC-Retail (≤0.25mm)</td>
<td>49</td>
<td>45</td>
<td>48</td>
<td>53</td>
<td>53</td>
<td>50</td>
</tr>
<tr>
<td>2) GC-Retail (≥0.27mm)</td>
<td>49</td>
<td>47</td>
<td>49</td>
<td>53</td>
<td>52</td>
<td>50</td>
</tr>
<tr>
<td>3) GP-Retail</td>
<td>48</td>
<td>48</td>
<td>45</td>
<td>50</td>
<td>48</td>
<td>48</td>
</tr>
<tr>
<td>4) HR SP/PO-OEM</td>
<td>61</td>
<td>62</td>
<td>64</td>
<td>68</td>
<td>65</td>
<td>64</td>
</tr>
<tr>
<td>5) CRCA-CD</td>
<td>47</td>
<td>51</td>
<td>51</td>
<td>54</td>
<td>54</td>
<td>51</td>
</tr>
<tr>
<td>6) CRCA-OEM</td>
<td>57</td>
<td>58</td>
<td>58</td>
<td>60</td>
<td>59</td>
<td>58</td>
</tr>
<tr>
<td>7) GP SP-CD</td>
<td>53</td>
<td>52</td>
<td>52</td>
<td>53</td>
<td>53</td>
<td>53</td>
</tr>
<tr>
<td>8) GP/ GP SP-OEM</td>
<td>67</td>
<td>61</td>
<td>63</td>
<td>68</td>
<td>69</td>
<td>66</td>
</tr>
<tr>
<td>9) BGL- OEM</td>
<td>63</td>
<td>63</td>
<td>63</td>
<td>66</td>
<td>65</td>
<td>64</td>
</tr>
<tr>
<td>10). BGL- Retail</td>
<td>55</td>
<td>58</td>
<td>56</td>
<td>62</td>
<td>58</td>
<td>58</td>
</tr>
<tr>
<td>11) PPGL-CD</td>
<td>66</td>
<td>63</td>
<td>66</td>
<td>70</td>
<td>69</td>
<td>67</td>
</tr>
<tr>
<td>12) PPGL-OEM</td>
<td>61</td>
<td>59</td>
<td>62</td>
<td>51</td>
<td>61</td>
<td>59</td>
</tr>
<tr>
<td>13) PPGL- P&amp;C/ Retail</td>
<td>62</td>
<td>63</td>
<td>62</td>
<td>64</td>
<td>65</td>
<td>63</td>
</tr>
<tr>
<td>PRODUCT</td>
<td>GROUP1</td>
<td>GROUP2</td>
<td>GROUP3</td>
<td>GROUP4</td>
<td>GROUP5</td>
<td>AVG RATING</td>
</tr>
<tr>
<td>---------</td>
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<td>--------</td>
<td>------------</td>
</tr>
<tr>
<td>1) GC-Retail (≤0.25mm)</td>
<td>83</td>
<td>88</td>
<td>76</td>
<td>82</td>
<td>83</td>
<td>82</td>
</tr>
<tr>
<td>2) GC-Retail (≥0.27mm)</td>
<td>89</td>
<td>83</td>
<td>89</td>
<td>93</td>
<td>92</td>
<td>89</td>
</tr>
<tr>
<td>3) GP-Retail</td>
<td>86</td>
<td>86</td>
<td>80</td>
<td>73</td>
<td>81</td>
<td>81</td>
</tr>
<tr>
<td>4) HR SP/PO- OEM</td>
<td>70</td>
<td>70</td>
<td>74</td>
<td>68</td>
<td>71</td>
<td>71</td>
</tr>
<tr>
<td>5) CRCA- CD</td>
<td>52</td>
<td>56</td>
<td>53</td>
<td>52</td>
<td>56</td>
<td>54</td>
</tr>
<tr>
<td>6) CRCA- OEM</td>
<td>59</td>
<td>60</td>
<td>63</td>
<td>55</td>
<td>60</td>
<td>59</td>
</tr>
<tr>
<td>7) GP SP- CD</td>
<td>65</td>
<td>64</td>
<td>67</td>
<td>68</td>
<td>66</td>
<td>66</td>
</tr>
<tr>
<td>8) GP/ GP SP- OEM</td>
<td>83</td>
<td>89</td>
<td>86</td>
<td>86</td>
<td>91</td>
<td>87</td>
</tr>
<tr>
<td>9) BGL- OEM</td>
<td>74</td>
<td>76</td>
<td>76</td>
<td>75</td>
<td>65</td>
<td>73</td>
</tr>
<tr>
<td>10) BGL- Retail</td>
<td>73</td>
<td>72</td>
<td>75</td>
<td>76</td>
<td>77</td>
<td>75</td>
</tr>
<tr>
<td>11) PPGL- CD</td>
<td>71</td>
<td>75</td>
<td>75</td>
<td>78</td>
<td>74</td>
<td>75</td>
</tr>
<tr>
<td>12) PPGL- OEM</td>
<td>79</td>
<td>77</td>
<td>76</td>
<td>79</td>
<td>79</td>
<td>78</td>
</tr>
<tr>
<td>13) PPGL- P&amp;C/ Retail</td>
<td>79</td>
<td>81</td>
<td>82</td>
<td>84</td>
<td>82</td>
<td>82</td>
</tr>
</tbody>
</table>

Based on the results, Product portfolio matrix is prepared as follows:
2.2 Result of product portfolio matrix:

The results are concluded as the products which are having highest rating of both factors that are Product no 4, 9,11,10,12,8,13 are most suitable for production and sell, whereas products which are having very low rating that are product no 5, 6 are to be eliminated from list of product Hence as per the PPM matrix CRCA CD and CRCA OEM are not considered for production. With this results it is concluded that all other products are feasible for production excluding CRCA Products , now decision is with company management whether to continue with production Of CRCA or not. PPM resulted selection of products but volume of products are yet to be Finalize which can’t be done by PPM hence operation research techniques to be applied for Fixing volume of each product so as to achieve company objective of making more profit.

2.3 Multi objective goal programming model:

In real world decision making situation, it may not be feasible or desirable to achieve goals of An organization into a single objective, for example, instead of focusing only on profits, the Organization may simultaneously be interested in utilization of plant, minimum rejection and long Term market stability.

Programming is an extension of linear or non linear involving an objective or multiple objectives. While developing a model, the decision variables are to be defined first, and then the managerial Goals related to the problem are to be listed along with various constraints.

The objectives of the organization are as follows:

1) Maximization of EBIDTA
2) Maximum plant utilization
3) Long term market stability
4) Introduction of new product in the market
5) Expansion of plant for 6000mt per month saleable steel

2.4 Formulation of Linear Programming model:

Variable for linear programming:

<table>
<thead>
<tr>
<th>S.No.</th>
<th>NAME OF THE PRODUCT</th>
<th>VARIABLE</th>
<th>EBIDTA (Rs.)</th>
<th>GROWTH RATE (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>GC-Retail (0.14mm)</td>
<td>X51</td>
<td>4000</td>
<td>7-9</td>
</tr>
<tr>
<td>2</td>
<td>GC-Retail (0.16mm)</td>
<td>X52</td>
<td>3500</td>
<td>7-9</td>
</tr>
<tr>
<td>3</td>
<td>GC-Retail (0.18mm)</td>
<td>X53</td>
<td>3200</td>
<td>7-9</td>
</tr>
<tr>
<td>4</td>
<td>GC-Retail (0.20mm)</td>
<td>X54</td>
<td>3000</td>
<td>7-9</td>
</tr>
<tr>
<td>5</td>
<td>GC-Retail (0.23mm)</td>
<td>X55</td>
<td>2700</td>
<td>7-9</td>
</tr>
<tr>
<td>6</td>
<td>GC-Retail (0.25mm)</td>
<td>X55</td>
<td>2455</td>
<td>7-9</td>
</tr>
<tr>
<td>7</td>
<td>GC-Retail (≥0.27mm)</td>
<td>X2</td>
<td>2278</td>
<td>7-9</td>
</tr>
</tbody>
</table>
2.5 OBJECTIVE FUNCTION:

1) MAXIMIZE EBITDA:
\[
2455X56+2700X55+3000X54+3200X53+3500X52+4000X51+2278X2+1000X3+100X4+500X5
+3313X6+2983X7+1342X8+1962X9+4087X10+4126X11+5162X12
\]

2) MAXIMIZE : X10+X11+X12 = 6000MT (CCL UTILIZATION)

3) MAXIMIZE : X51+X52+X53+X54+X55+X56+X2+X3+X6+X10 = 10000MT (CGL1 UTILIZATION)

4) MAXIMIZE : X8+X9+X12 = 13000MT (GALVALUME UTILIZATION)

5) MAXIMIZE : X4+X7+X11 = 15000MT (CGL4 UTILIZATION)

6) MINIMIZE REJECTION:
\[
10%X51+10%X52+9%X53+7%X54+6%X55+6%X56
+3%X2+2%X3+2%X4+5%X5+10%X6+5%X7+7%X8+6%X9+10%X10+5%X11+3%X12
\]

7) LONG TERM MARKET STABILITY:
MAXIMIZE: X5+X7+X8+X9+X10+X11+X12 (GROWTH RATE)

2.6 CONSTRAINT ANALYSIS:

1) PICKLING CONSTRAINT <= 6000MT
X51X52+X53+X54+X55+X56+X2+X3+X4+X5+X6+X7+X8+X9+X10+X11+X12 <= 6000MT

2) ROLLING MILL CONSTRAINT 6 HI <= 15000MT
X51+X52+X53+X54+X55+X56+X2+X3+X6+X9 <= 15000MT

3) ROLLING MILL CONSTRAINT 4 HI <= 20000MT
X4+X7+X8+X10+X11+X12 <= 20000MT

4) CCL CONSTRAINT <= 6000MT
\[
\begin{align*}
X_{10}+X_{11}+X_{12} & \leq 6000\text{MT} \\
5) \text{CGL1 PRODUCTION CONSTRAINT} & \leq 10000\text{MT} \\
X_{51}+X_{52}+X_{53}+X_{54}+X_{55}+X_{56}+X_{2}+X_{3}+X_{6}+X_{10} & \leq 10000\text{MT} \\
6) \text{CGL4 PRODUCTION CONSTRAINT} & \leq 20000\text{MT} \\
X_{8}+X_{9}+X_{12} & \leq 13000\text{MT} \\
7) \text{GALVALUME PRODUCTION CONSTRAINT} & \leq 15000\text{MT} \\
X_{8}+X_{9}+X_{12} & \leq 15000\text{MT} \\
8) \text{GC THINNER PRODUCTION CONSTRAINT} & \leq 5000\text{MT} \\
X_{51}+X_{52}+X_{53}+X_{54}+X_{55}+X_{56} & \leq 5000\text{MT} \\
9) \text{GC THICKER PRODUCTION CONSTRAINT} & \leq 3000\text{MT} \\
X_{2} & \leq 5000\text{MT} \\
10) \text{CTL2 CONSTRAINT} & \leq 2000\text{MT} \\
X_{6}+X_{10} & \leq 2000\text{MT} \\
11) \text{CTL1/CTL4 CONSTRAINT} & \leq 3500\text{MT} \\
X_{3}+X_{9} & \leq 3500\text{MT} \\
12) X_{51} & \leq 500\text{MT} \\
13) X_{52} & \leq 500\text{MT} \\
14) X_{53} & \leq 500\text{MT} \\
15) X_{54} & \leq 1000\text{MT} \\
16) X_{55} & \leq 1000\text{MT} \\
17) X_{56} & \leq 1500\text{MT}
\end{align*}
\]

As this is the multi objective LPP we can solve by using goal programming technique
Hence above LPP we have to convert into goal program to get results

### 2.7 Goal Programming Formulation:

<table>
<thead>
<tr>
<th>Priority</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>Maximize EBIDTA</td>
</tr>
<tr>
<td>P2</td>
<td>Maximize Plant utilization</td>
</tr>
</tbody>
</table>
Minimize Rejection

Maximize Long term market stability

\[ P_3 \] Dup = Amount by which the profit goal is underachieved

\[ P_4 \] Dop = Amount by which the profit goal is overachieved

\[ P_2 \] Dua = Amount by which the CCL plant utilization goal is underachieved

\[ P_2 \] Doa = Amount by which CCL plant utilization goal is overachieved

\[ P_2 \] Dub = Amount by which the CGL1 plant utilization goal is underachieved

\[ P_2 \] Dob = Amount by which CGL1 plant utilization goal is overachieved

\[ P_2 \] Duc = Amount by which the GALVALUME plant utilization goal is underachieved

\[ P_2 \] Doc = Amount by which GALVALUME plant utilization goal is overachieved

\[ P_2 \] Dud = Amount by which the CGL4 plant utilization goal is underachieved

\[ P_2 \] Dod = Amount by which CGL4 plant utilization goal is overachieved

\[ P_3 \] Due = Amount by which the rejection goal is underachieved

\[ P_3 \] Doe = Amount by which the rejection goal is overachieved

\[ P_4 \] Duf = Amount by which the market stability goal is underachieved

\[ P_4 \] Dof = Amount by which the market stability goal is overachieved

**2.8 OBJECTIVE FUNCTION:**

Minimize \( Z = P_1 \text{Dup} + P_2 \text{Dua} + P_2 \text{Dub} + P_2 \text{Duc} + P_2 \text{Dud} + P_3 \text{Doe} + P_4 \text{Duf} \)

Subject to:

1) \[ 2455X_{56} + 2700X_{55} + 3000X_{54} + 3200X_{53} + 3500X_{52} + 4000X_{51} + 2278X_{2} + 1000X_{3} + 100X_{4} + 500X_{5} + 3313X_{6} + 2983X_{7} + 1342X_{8} + 1962X_{9} + 4087X_{10} + 4126X_{11} + 5162X_{12} \]

\[ \text{Dup-Dop} = 70000000 \text{ (7crore)} \]

2) \[ X_{10} + X_{11} + X_{12} + \text{Dua-Doa} = 6000MT \]

3) \[ X_{51} + X_{52} + X_{53} + X_{54} + X_{55} + X_{56} + X_{2} + X_{3} + X_{6} + X_{10} + \text{Dub-Dob} = 10000MT \]

4) \[ X_{8} + X_{9} + X_{12} + \text{Duc-Doc} = 8000MT \]

5) \[ X_{4} + X_{7} + X_{11} + \text{Dud-Dod} = 18000MT \]

6) \[ 0.1X_{51} + 0.09X_{52} + 0.08X_{53} + 0.07X_{54} + 0.06X_{55} + 0.06X_{56} + 0.03X_{2} + 0.02X_{3} + 0.02X_{4} + 0.05X_{5} + 0.1X_{6} + 0.05X_{7} + 0.07X_{8} + 0.06X_{9} + 0.1X_{10} + 0.05X_{11} \]
\[ +0.03X_{12} + \text{Due-Doe} = 1500 \text{mt} \]

7) \[ X_5 + X_7 + X_8 + X_9 + X_{10} + X_{11} + X_{12} + \text{Duf-Dof} = 1500 \text{mt} \]

8) \[ X_{51} + X_{52} + X_{53} + X_{54} + X_{55} + X_{56} + X_2 + X_3 + X_4 + X_5 + X_6 + X_7 + X_8 + X_9 + X_{10} + X_{11} + X_{12} + S_1 = 40000 \text{MT} \]

9) \[ X_{51} + X_{52} + X_{53} + X_{54} + X_{55} + X_{56} + X_2 + X_3 + X_9 + S_2 = 15000 \text{MT} \]

10) \[ X_4 + X_7 + X_8 + X_{10} + X_{11} + X_{12} + X_6 + S_3 = 20000 \text{MT} \]

11) \[ X_{10} + X_{11} + X_{12} + S_4 = 6000 \text{MT} \]

12) \[ X_{51} + X_{52} + X_{53} + X_{54} + X_{55} + X_{56} + X_2 + X_3 + X_6 + X_{10} + S_5 = 10000 \text{MT} \]

13) \[ X_8 + X_9 + X_{12} + S_6 = 8000 \text{MT} \]

14) \[ X_4 + X_7 + X_{11} + S_7 = 18000 \text{MT} \]

15) \[ X_{51} + X_{52} + X_{53} + X_{54} + X_{55} + X_{56} + S_8 = 3000 \text{MT} \]

16) \[ X_2 + S_9 = 3000 \text{MT} \]

17) \[ X_6 + X_{10} + S_{10} = 2000 \text{MT} \]

18) \[ X_3 + X_9 + S_{11} = 3500 \text{MT} \]

19) \[ X_{51} + S_{12} = 400 \text{MT} \]

20) \[ X_{52} + S_{13} = 400 \text{MT} \]

21) \[ X_{53} + S_{14} = 500 \text{MT} \]

22) \[ X_{54} + S_{15} = 500 \text{MT} \]

23) \[ X_{55} + S_{16} = 700 \text{MT} \]

24) \[ X_{56} + S_{17} = 700 \text{MT} \]

25) \[ X_5 + S_{18} = 2000 \text{MT} \]

26) \[ X_{10} + X_{11} + S_{19} = 2000 \text{MT} \]

\[ X_{51}, X_{52}, X_{53}, X_{54}, X_{55}, X_{56}, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10}, X_{11}, X_{12}, \]
\[ \text{Dup, Dop, DuA, Dua, Dub, Dob, Duc, Doc, Dud, Dod, Doe, Doc, Duf, DoF,} \]
\[ S_1, S_2, S_3, S_4, S_5, S_6, S_7, S_8, S_9, S_{10}, S_{11}, S_{12}, S_{13}, S_{14}, S_{15}, S_{16}, S_{18}, S_{19} >= 0 \]

3 . Results of Goal Programming:

The input of objective and constraint is used in software TORA
And results will be taken out as follows:

\[ X_{56} = 700 \text{mt}, \ X_{55} = 700 \text{mt}, \ X_{54} = 500 \text{mt}, \ X_{53} = 500 \text{mt}, \ X_{52} = 400 \text{mt}, \ X_{51} = 200 \text{mt}, \ X_2 = 3000 \text{mt}, \ X_3 = 0 \text{mt} \]
\[ X_4 = 6389 \text{mt}, \ X_5 = 2889 \text{mt}, \ X_6 = 0 \text{mt}, \ X_7 = 6110 \text{mt}, X_8 = 1500 \text{mt}, X_9 = 3500 \text{mt}, X_{10} = 1755 \text{mt}, X_{12} = 3000 \text{mt} \]
Dub=2755mt, Dud=3744mt, S1=7610mt, S2=5500mt, S5=2755mt, S7=2500mt, S10=755mt, S12=200mt, S18=110mt

4. Comments:

1) In this model first priority is given for profit goal, second and equal priority is given for Main lines utilization, third priority is given for rejection goal and fourth priority is Given for market stability goal

2) Profit goal of 7 crore is achieved

3) CGL1 utilization goal is under achieved by 2755mt

4) CGL4 utilization goal is under achieved by 3744mt

5) CCL and Galvalume line goal is archived.

6) As a Goal programming technique we change priority of goals and based on priority Results will be differentiated.

5. Conclusion:

Here we have proposed two methods of optimization of product mix in which we need to take workshop of experts to generate PPM which will help in selection of products from basket of the product where multi objective linear programming model will give the exact volume of each selected products in PPM, here we have to compare results of linear programming model. With actual production volume of each product of company and if our results are giving more accuracy and profitability then we can suggest company to use this model for making monthly and Annual production plan. In addition to this we can implement sensitivity approach by this model.

References:


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