APPENDIX - B

SAMPLE CALCULATIONS RELATED TO MCDM METHODS

Two alternative policies from Table 6.6 are chosen as samples to illustrate the calculations involved in the MCDM methods. Alternatives versus criteria array (payoff matrix) related to these two alternative policies are presented in Table B-1 below.

Table B-1  Array of alternative policies versus Criteria (for G1W100 and G2W100)

<table>
<thead>
<tr>
<th>Chosen Alternative policies</th>
<th>Criteria 1 LABOUR (in Crore Man days)</th>
<th>Criteria 2 PRODUCTION (Lakh tons)</th>
<th>Criteria 3 BENEFITS (Crore Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1W100</td>
<td>0.2602</td>
<td>2.2052</td>
<td>12.3659</td>
</tr>
<tr>
<td>G2W100</td>
<td>0.2752</td>
<td>2.7897</td>
<td>10.6106</td>
</tr>
<tr>
<td>Weight of criteria</td>
<td>0.1290</td>
<td>0.3248</td>
<td>0.5462</td>
</tr>
<tr>
<td>Difference between G1W100 and G2W100</td>
<td>-0.0150</td>
<td>-0.5845</td>
<td>1.7553</td>
</tr>
</tbody>
</table>

ELECTRE-2

The calculations for concordance and discordance indexes for two alternatives G1W100 and G2W100 (represented as a and b in section 3.4.1) are done as follows (Ref. Table B-1):

Concordance Index

$$ C(a, b) = \frac{\{ W^+(a, b) + W^-(a, b) \}}{[ W^+(a, b) + W^-(a, b) + W(a, b) ]} $$
From Table B-1, \( W^* (a, b) = 0.5462; W^w (a, b) = 0; W^- (a, b) = 0.4538 \)

Concordance Index = \( C (G_1W_{100}, G_2W_{100}) = 0.5462 \)

Discordance Index:

\[
d(a, b) = \left[ \frac{f(b) - f(a)}{f(a)} \right] \text{ for criterion } j (1, j)
\]

\[
D(a, b) = \text{Max} \left[ d(a, b) \right] \text{ over all the criteria}
\]

Discordance Index \( d(G_1W_{100}, G_2W_{100}) \) for each criteria are as follows:

- Labour = \( \frac{(0.2752 - 0.2602)}{0.2602} = 0.0576 \)
- Production = \( \frac{(2.7897 - 2.2052)}{2.2052} = 0.2651 \)
- Benefits = \( \frac{(10.6106 - 12.3659)}{12.3659} = -0.1419 \)

\[
D(G_1W_{100}, G_2W_{100}) = \text{Maximum of } (0.0576, 0.2651, -0.1419) = 0.2651
\]

Discordance Index = 0.2651

Steps followed for both forward & reverse ranking (Goicochea et al., 1982) for the example of 100% dependable inflow and weighted scenario are as follows:

**Forward ranking**

If \( Y^{(k)} \) is a subset of \( G_s \) where \( Y^{(0)} = G_s \), the set of the best alternatives \( A^{(k)} \) which will receive ranking \( k+1 \) is chosen as follows:

1) \( k \) is set to zero
2) All nodes of \( Y^{(k)} \) not having a precedent are selected (the alternatives not being outranked by other elements) that represent the set \( D \).
3) All nodes in \( D \) that are related through \( R_w \) as depicted in \( G_w \) are identified and \( U \) represents this set.
4) All nodes in U not having a precedent in Gw are selected and B represents this set.

5) \( A^{(k)} \) is defined as \( (D - U) \cup B \).

6) A ranking for every \( x \in A^{(k)} \) is obtained by setting \( v(x) = k + 1 \).

7) \( Y^{k+1} \) is set as \( Y^{(k)} \setminus A^{(k)} \).

8) If \( Y^{k+1} \) and returned to step 2.

**Reverse Ranking**

1) The directions of the arrows in \( G_s \) and \( G_w \) are reversed.

2) A ranking, \( a(x) \), for each alternative \( x \) as was done in the strong ranking procedure (substituting \( a(x) \) for \( v(x) \) in step 6) is obtained.

3) The rank is obtained as

\[
a(x) = a_{\text{max}} - k \quad x \in X
\]

where

\[x = \text{Set of all nondominated alternatives} \]

\[a_{\text{max}} = \max a(x) \text{ such that } x \in X\]

The final rank = \[v(x) + a(x) \]/2.

**EXAMPLE**

[Ref. Figs. 6.1 (a) and (b) : Tables 6.9 (a) and (b)].

**Forwarding Ranking**

1. \( k = 0, \ Y^0=G_s \)

2. \( D = (G1W100) \) (Only node \( G1W100 \) having no precedents)

3. \( U = (G1W100) \)

**Reverse Ranking**

1. \( k = 0, \ Y^0=G_s \)

2. \( D = (G2W100) \)

3. \( U = (G2W100) \)
4. \( B = (G1W100) \)
5. \( A^{(0)} = (D - U) \cup B = (G1W100) \)
6. \( v(G1W100) = k + 1 = 1 \)
7. \( Y^{(1)} = Y^{(0)} - A^{(0)} = (G2W100, G3W100, G4W100, G5W100) \)
8. \( k = k + 1 = 1 \)

**Iteration two**

1. \( D = (G4W100) \)
2. \( U = (G4W100) \)
3. \( B = (G4W100) \)
4. \( A^{(1)} = (D - U) \cup B = (G4W100) \)
5. \( v(G4W100) = k + 1 = 1 + 1 = 2 \)
6. \( Y^{(2)} = Y^{(1)} - A^{(1)} = (G2W100, G3W100, G5W100) \)
7. \( k = k + 1 = 1 + 1 = 2 \)

**Iteration three**

1. \( D = (G5W100) \)
2. \( U = (G5W100) \)
3. \( B = (G5W100) \)
4. \( A^{(2)} = (D - U) \cup B = (G5W100) \)
5. \( v(G5W100) = k + 1 = 2 + 1 = 3 \)
6. \( Y^{(3)} = Y^{(2)} - A^{(2)} = (G2W100, G3W100) \)
7. \( k = k + 1 = 2 + 1 = 3 \)
Iteration four
1. D = (G3W100)  
2. U = (G3W100)  
3. B = (G3W100)  
4. A^3 = (D - U) ∪ B = (G3W100)  
5. v(G4W100) = k + 1 = 3 + 1 = 4  
6. Y^{(4)} = Y^{(3)} - A^{(3)} = (G2W100)  
7. k = k + 1 = 3 + 1 = 4

Iteration five
1. v(G2W100) = k + 1 = 4 + 1 = 5
2. a(G1W100) = 1

\[ a_{\text{max}} = \max_{x \in X} a(x) = 5 \]

Average ranking = \[ \frac{v(x) + v(x)}{2} \]

PROMETHEE-2

The calculations of Multicriterion Preference Index for two alternatives G1W100 and G2W100 (represented as a and b in section 3.4.2) are done as follows (Ref. Table B-1):

# All the criteria are towards maximization direction
# Type of criterion function chosen is usual criterion
The difference between two alternative policies G1W100 and G2W100 for each criteria are presented in Table B-1. If the difference between two alternatives for any criteria is greater than zero then preference function value is one else zero. Based on the differences the preference function values are computed as 0, 1 and 0. Weighted sum of preference function values for all the criteria gives the Multicriterion Preference Index for pair of alternatives G1W100 and G2W100.

\[ \Pi (a, b) = \sum w_j P_j (a, b) / \sum w_j ; j = 1, j. \]

where

- \( w_j \) = Weight assigned to the criteria \( j \)
- \( \Pi (a, b) \) = Multicriterion Preference Index
- \( P_j (a, b) \) = Preference function

\[ \Pi (G1W100, G2W100) = 0 \times 0.1290 + 0 \times 0.3248 + 1 \times 0.5462 = 0.5462 \]

**Analytic Hierarchy Process (AHP)**

Calculations of elements of pairwise comparison matrix are done as follows (Ref. Table B-1). The values of two alternative policies G1W100, G2W100 for labour criteria are 0.2602 and 0.2752. the element (G1W100 versus G2W100) of pairwise comparison matrix for labour will be 0.2602 / 0.2752 i.e., 0.9455. In the present analysis all the three criteria are quantitative and there is no subjective parameter. It the element in the pairwise comparison matrix is less than 1/9 or greater than 9 in the above analysis then the minimum and maximum values can be fixed as 1/9 and 9, in which case inconsistency may occur. If the values are within 1/9 and 9, then the normalization of alternative policies for each criteria yields the same local priority values as were done in eigen vector approach (Wu, 1987).
Compromise Programming (CP)

The calculation $L_p$-metric values for alternative $a$ are done as follows (section 3.4.4):

$$L_p(a) = \left[ \sum w_j \{ f_j^* - f(a) \} / (M_j - m_j) \right]^{1/p}$$

where $j = 1, j$ and

- $L_p(a)$ = $L_p$-metric for alternative $a$
- $f(a)$ = Value of alternative $a$ for criterion $j$
- $M_j$ = Maximum value of criterion $j$ in set $A$
- $m_j$ = Minimum value of criterion $j$ in set $A$
- $f_j^*$ = Ideal value of criterion $j$
- $p$ = Parameter reflecting the attitude of the decision maker.

The parameters required for $L_p$-metric calculations are presented in Table B-2.

<table>
<thead>
<tr>
<th>From proposed alternative policies</th>
<th>Criteria 1 LABOUR (in Crore Man days)</th>
<th>Criteria 2 PRODUCTION (Lakh tons)</th>
<th>Criteria 3 BENEFITS (Crore Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$m_j$ Minimum</td>
<td>0.2492</td>
<td>2.1312</td>
<td>10.2925</td>
</tr>
<tr>
<td>$M_j$ Maximum</td>
<td>0.2785</td>
<td>3.0855</td>
<td>12.4940</td>
</tr>
<tr>
<td>$f_j^*$ Ideal</td>
<td>0.2785</td>
<td>2.8407</td>
<td>12.4940</td>
</tr>
<tr>
<td>diff.</td>
<td>0.0294</td>
<td>0.9543</td>
<td>2.2015</td>
</tr>
</tbody>
</table>
\[ L_p - \text{metric for alternative G1W100 for } p = 2 \text{ is} \]
\[ = \left[ 0.1290 \times \frac{(0.2785 - 0.2602)}{0.0294} \right]^2 + \left[ 0.3248 \times \frac{(3.0855 - 2.2052)}{0.9543} \right]^2 \]
\[ + \left[ 0.5462 \times \frac{(12.4940 - 12.3658)}{2.2015} \right]^2 \]
\[ = 0.5610 \]

**Multicriterion Q-Analysis-2 (MCQA-2)**

Calculation of converting payoff matrix into preference matrix are done as follows (Ref. Table 6.6). The payoff matrix is presented in Table B-3.

The payoff matrix is transformed to preference matrix on a scale of 1 to 7 (section 3.4.5). Minimum value of labour criteria is 0.2492 and maximum value is 0.2785 (Ref. Table B-2). The corresponding scale values are fixed as 1 and 7. To get the intermediate elements in the preference matrix corresponding to payoff matrix values, the linearity procedure is employed. For example

<table>
<thead>
<tr>
<th>Chosen alternative policies</th>
<th>Labour (In crore of Man Days)</th>
<th>Production (Lakhs of Tons)</th>
<th>Benefits (Crores Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1W100</td>
<td>0.2602</td>
<td>2.2052</td>
<td>12.3659</td>
</tr>
<tr>
<td>G2W100</td>
<td>0.2752</td>
<td>2.7897</td>
<td>10.6106</td>
</tr>
<tr>
<td>G3W100</td>
<td>0.2632</td>
<td>2.7000</td>
<td>11.0788</td>
</tr>
<tr>
<td>G4W100</td>
<td>0.2752</td>
<td>2.3112</td>
<td>11.5979</td>
</tr>
<tr>
<td>G5W100</td>
<td>0.2612</td>
<td>3.0322</td>
<td>11.2195</td>
</tr>
</tbody>
</table>
Elements in the preference matrix =

\[
\text{Minimum value of scale} + (\text{Maximum} - \text{Minimum value of scale}) \times 
\left(\frac{\text{Difference between maximum and minimum values}}{\text{Required payoff matrix value for which scale value is required} - \text{Minimum value}}\right)
\]

The value of 0.2602 in preference matrix is

\[
1 + \left(\frac{7 - 1}{0.2785 - 0.2492}\right) \times (0.2602 - 0.2492) = 3.3
\]

Similarly the other elements of preference matrix are also computed and presented in Table B-4.

Table B-4 Preference matrix (U)

<table>
<thead>
<tr>
<th>Chosen alternative policies</th>
<th>Labour</th>
<th>Production</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1W100</td>
<td>3.3</td>
<td>1.5</td>
<td>6.67</td>
</tr>
<tr>
<td>W2W100</td>
<td>6.3</td>
<td>5.1</td>
<td>1.9</td>
</tr>
<tr>
<td>G3W100</td>
<td>3.9</td>
<td>4.6</td>
<td>3.1</td>
</tr>
<tr>
<td>G4W100</td>
<td>6.3</td>
<td>2.1</td>
<td>4.6</td>
</tr>
<tr>
<td>G5W100</td>
<td>3.5</td>
<td>6.7</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Calculations for PSI, PCI and PDI are done as follows (section 3.4.5)

i) First the value of the slicing parameter \( \alpha \) is fixed.

ii) If the value of an element in the preference matrix (U) is greater than or equal to \( \alpha \), then the particular value for the incidence matrix \( T \) is taken as one otherwise it is taken as zero. The incidence matrix is presented below in Table B-5, taking \( \alpha = 6.0 \).
PROJECT SATISFACTION INDEX (PSI)

iii) Sum of weights corresponding to criteria satisfied at level \( \alpha \) is defined as \( V \) and are presented in Table B-6.

iv) PSI can be defined for each alternative as the product of value \( V \) and \( \alpha \). If multiple of \( \alpha \) values are existing then PSI for each alternative is summation of product of value \( V \) and corresponding \( \alpha \) values.

Table B-5 Incidence matrix (T)

<table>
<thead>
<tr>
<th>Chosen alternative policies</th>
<th>Labour</th>
<th>Production</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1W100</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>G2W100</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>G3W100</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>G4W100</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>G5W100</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Table B-6 Values of V

<table>
<thead>
<tr>
<th>Chosen alternative policies</th>
<th>Labour</th>
<th>Production</th>
<th>Benefits</th>
<th>PSI value</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1W100</td>
<td>0.0000</td>
<td>+</td>
<td>0.0000</td>
<td>+ 0.5462</td>
</tr>
<tr>
<td>G2W100</td>
<td>0.1290</td>
<td>+</td>
<td>0.0000</td>
<td>+ 0.0000</td>
</tr>
<tr>
<td>G3W100</td>
<td>0.0000</td>
<td>+</td>
<td>0.0000</td>
<td>+ 0.0000</td>
</tr>
<tr>
<td>G4W100</td>
<td>0.1290</td>
<td>+</td>
<td>0.0000</td>
<td>+ 0.0000</td>
</tr>
<tr>
<td>G5W100</td>
<td>0.0000</td>
<td>+ 0.3248</td>
<td>+ 0.0000</td>
<td>0.3248</td>
</tr>
</tbody>
</table>

EVALUATION OF SHARED FACE MATRIX

v) The product of incidence matrix \( T \) and transpose of incidence matrix \( T^{Tr} \) minus matrix I (matrix of unity) yields shared face matrix. Table B-7 presents the shared face matrix using the above given
values. The information contained either in the upper or lower triangular portion can be used for further analysis. In this methodology upper triangular portion is used.

Table B-7 Shared face matrix

<table>
<thead>
<tr>
<th></th>
<th>G1W100</th>
<th>G2W100</th>
<th>G3W100</th>
<th>G4W100</th>
<th>G5W100</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1W100</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G2W100</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G3W100</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>G4W100</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>G5W100</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**PROJECT CONCORDANCE INDEX ( PCI )**

vi) The main diagonal of shared face matrix is also the highest q-level ($q_{\text{max}}$) of each alternative.

vii) Reading across a row or down a column associated with an element provides a measurement of the connectivity of that element with the other elements. Two elements at a given connectivity level $q$ are in the same equivalence class if they share a number in the incidence matrix at least equal to $q_{\text{min}}$ which means that it is the level at which each alternative joins for the first time in the same equivalence class as another alternative. Negative sign indicates that the particular alternative is not connected to any other alternative directly. For this example

Connectivity at 0-level = None
Connectivity at 1-level = G1W100, G2W100, G3W100, G4W100, G5W100
Connectivity at 2-level = None

In this example all alternatives are joining others at 1-level. Table B-8 shows the $q_{\text{max}}$ and $q_{\text{min}}$ for each alternative. $\Delta q$ is defined as the difference between $q_{\text{max}}$ and $q_{\text{min}}$. PCI can be defined for each
alternative as product of $\Delta q$ and $\alpha$. If multiple $\alpha$ values are available then PCI for each alternative is summation of the product of $\Delta q$ and the corresponding $\alpha$ values.

Table B-8 Calculation of parameters for PCI for $\alpha = 1.9$

<table>
<thead>
<tr>
<th>Chosen alternative policies</th>
<th>$q_{\text{max}}$</th>
<th>$q_{\text{min}}$</th>
<th>$\Delta q$</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1W100</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>G2W100</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>G3W100</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>G4W100</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>G5W100</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

PROJECT DISCORDANCE INDEX (PDI)

viii) The Project Discordance Index (PDI) is defined analogously to the PCI by using complimentary incidence matrix $\overline{T}$ instead of the original incidence matrix $T$.

\[
\overline{T}(i,j) = 1 \text{ if } T(i,j) = 0 \\
\overline{T}(i,j) = 0 \text{ if } T(i,j) = 1
\]

Similar type of calculations yield Table B-9.

Table B-9 Calculation of parameters for PDI, $\alpha = 1.9$

<table>
<thead>
<tr>
<th>Chosen alternative policies</th>
<th>$q_{\text{max}}$</th>
<th>$q_{\text{min}}$</th>
<th>$\Delta q$</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1W100</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>G2W100</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>G3W100</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>G4W100</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>G5W100</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

ix) The final values of PSI, PCI and PDI for each alternative corresponding to $\alpha = 1.9$ are shown in Table B-10.
Table B-10 Values of PSI, PCI and PDI

<table>
<thead>
<tr>
<th>Chosen alternative policies</th>
<th>PSI $\alpha \times V$</th>
<th>PCI $\alpha \times Aq$</th>
<th>PDI $\alpha \times Aq$</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1W100</td>
<td>1.0378</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>G2W100</td>
<td>0.2451</td>
<td>1.9</td>
<td>0</td>
</tr>
<tr>
<td>G3W100</td>
<td>0.0000</td>
<td>1.9</td>
<td>0</td>
</tr>
<tr>
<td>G4W100</td>
<td>0.2451</td>
<td>1.9</td>
<td>0</td>
</tr>
<tr>
<td>G5W100</td>
<td>0.6171</td>
<td>1.9</td>
<td>0</td>
</tr>
</tbody>
</table>

Spearman Rank Correlation Coefficient

Suppose two MCDM methods ELECTRE-2 and MCQA-2 ranked the given six alternatives as given under column U and V of Table B-11 where $D_n$ is the difference in ranks and N is the number of alternatives (six in this case). Then the Spearman rank Correlation Coefficient $r$ is calculated as

$$r = 1 - \frac{6 \sum D_n^2}{N(N^2 - 1)}$$

Table B-11 Spearman rank correlation coefficient (Ref. Table 6.24)

<table>
<thead>
<tr>
<th>Chosen alternative policies</th>
<th>Ranks</th>
<th>Ranks</th>
<th>Diff. ranks</th>
<th>$D_n^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>U</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>G1W100</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>G2W100</td>
<td>4</td>
<td>5</td>
<td>-1</td>
<td>1</td>
</tr>
<tr>
<td>G3W100</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>G4W100</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>G5W100</td>
<td>1</td>
<td>3</td>
<td>-2</td>
<td>4</td>
</tr>
</tbody>
</table>

The rank correlation coefficient between ELECTRE-2 and PROMETHEE-2 is 0.5 for 100% weighted scenario.
EXPECTED RANK

Here, the expected rank is calculated for PROMETHEE-II under 100% weighted scenario (Ref. Table 6.25(b)).

$X_i$ denotes the rank of policy $Gi$ with $100\%$ weight. So, $X_i = 1, 2, 3, 4, 5$ for each $i$.

$P(X_1=1) = 0; P(X_1=2) = 0; P(X_1=3) = 194/216; P(X_1=4) = 22/216; P(X_1=5) = 0$

$P(X_2=1) = 0; P(X_2=2) = 0; P(X_2=3) = 22/216; P(X_2=4) = 186/216; P(X_2=5) = 8/216$

$P(X_3=1) = 0; P(X_3=2) = 8/216; P(X_3=3) = 0; P(X_3=4) = 0; P(X_3=5) = 208/216$

$P(X_4=1) = 16/216; P(X_4=2) = 192/216; P(X_4=3) = 0; P(X_4=4) = 8/216; P(X_4=5) = 0$

$P(X_5=1) = 200/216; P(X_5=2) = 16/216; P(X_5=3) = 0; P(X_5=4) = 0; P(X_5=5) = 0$

$E(X_1) = 3 \times (194/216) + 4 \times (22/216)$
$= (582 + 88)/216$
$= 670/216 = 3.10$

$E(X_2) = 3 \times (22/216) + 4 \times (186/216) + 5 \times (8/216)$
$= (66 + 744 + 40)/216$
$= 850/216 = 3.94$

$E(X_3) = 2 \times (8/216) + 5 \times (208/216)$
$= (16 + 1040)/216$
$= 1056/216 = 4.89$

$E(X_4) = 1 \times (16/216) + 2 \times (192/216) + 4 \times (8/216)$
$= (16 + 38 + 32)/216$
$= 432/216 = 2.00$

$E(X_5) = 1 \times (200/216) + 2 \times (16/216)$
$= 232/216 = 1.07$