

CHAPTER 5

EFFICIENCY OF HARYANA ROADWAYS AT DEPOTS LEVEL

In this present chapter, the efficiency score is computed for 20 depots of Haryana in order to know the OTE, PTE and SE. This is an attempt to calculate the overall efficiency of Haryana Roadways and the efficiency of each depot which were included in this study. The detailed methodology for calculating the efficiency scores already discussed in previous chapter 3

5.1 Overall Technical Efficiency

Overall Technical efficiency for 20 depots of Haryana Roadways is calculated with the help of CCR input oriented model. Output is assumed to be constant, to become a technical efficient depot there is need of reductions in inputs only. Overall Technical Efficiency scores is not net efficiency score for appropriate results, for adequate results OTE is decompose in PTE and SE. The score which were obtained from CCR input output model was based on constant return to scale.

Table 5.1.1 Overall Technical Efficiency Score for DMUs of Haryana Roadways from 2001 to 2013

DMUs	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
D1	0.84	0.84	0.84	0.94	0.91	0.74	0.87	0.86	0.82	0.76	0.71	0.76	0.79
D2	0.92	0.90	0.90	0.97	1.00	0.91	1.00	0.99	0.93	0.96	0.98	0.94	0.94
D3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
D4	0.82	0.82	0.82	0.89	0.79	0.69	0.80	0.84	0.86	0.77	0.90	0.96	0.87
D5	0.89	0.87	0.87	0.94	0.89	0.82	0.94	0.95	0.94	0.94	0.95	0.92	0.88
D6	0.91	0.87	0.87	0.96	0.94	0.90	1.00	1.00	0.99	0.92	1.00	0.99	1.00
D7	0.86	0.84	0.84	0.86	0.90	0.87	0.93	0.92	0.92	0.88	0.84	0.87	0.93
D8	0.91	0.85	0.85	0.97	1.00	0.82	0.99	0.98	0.97	0.86	0.91	0.90	0.84
D9	0.96	0.96	0.96	0.93	0.96	0.84	0.98	0.97	0.99	0.88	0.93	0.91	0.93
D10	0.82	0.81	0.81	0.96	0.89	0.81	0.93	0.90	0.85	0.82	0.92	0.93	0.94
D11	0.97	0.92	0.92	0.97	0.98	1.00	0.99	1.00	1.00	1.00	1.00	1.00	0.89
D12	0.98	0.91	0.91	0.91	0.93	0.80	0.91	0.91	0.86	0.83	0.87	0.91	0.86
D13	0.91	0.86	0.86	0.93	0.93	0.89	0.91	0.94	0.91	0.83	0.96	0.96	0.86

D14	0.91	0.91	0.91	0.95	0.97	0.78	0.90	0.95	0.87	0.88	0.81	0.90	0.86
D15	1.00	0.96	0.96	0.99	1.00	0.85	0.94	1.00	0.97	0.97	0.86	1.00	1.00
D16	0.90	0.93	0.93	0.97	0.96	0.80	0.92	0.97	0.92	0.91	0.90	0.93	0.94
D17	0.94	0.91	0.91	1.00	0.95	0.86	1.00	1.00	1.00	1.00	1.00	0.98	0.98
D18	0.93	0.91	0.91	0.87	0.84	0.79	1.00	0.92	0.88	0.86	0.86	0.87	0.83
D19	0.86	0.93	0.93	1.00	0.93	0.80	0.88	0.82	0.84	0.86	0.86	0.82	0.87
D20	0.90	0.82	0.82	0.88	0.89	0.75	0.87	0.85	0.77	0.71	0.67	0.70	0.82

Source: Researcher's calculation

Table 5.1.2 Overall Technical Efficiency Score from 2014 to 2016							
DMUs	2014	2015	2016	DMUs	2014	2015	2016
D1	1.00	1.00	1.00	D11	1.00	1.00	1.00
D2	0.95	0.92	0.90	D12	0.90	0.89	0.90
D3	1.00	1.00	1.00	D13	0.90	0.87	0.87
D4	0.89	0.90	0.88	D14	0.95	0.80	0.78
D5	0.88	0.89	0.91	D15	1.00	1.00	1.00
D6	0.91	0.95	0.91	D16	0.91	0.93	0.88
D7	0.87	0.88	0.89	D17	0.93	0.93	0.96
D8	0.86	0.87	0.93	D18	0.88	0.88	0.84
D9	0.90	0.92	0.86	D19	0.91	0.95	0.95
D10	0.89	0.95	1.00	D20	0.79	0.76	0.82

Source: Researcher's calculation

Above tables depicts the overall technical efficiency score for all depots from 2001 to 2016. Here

CCR input oriented model has been applied in order to know the scope of reduction in inputs without changing in total existing level of output. The efficiency scores lies between one and zero, if a DMU has a score one, it means the DMU is fully efficient, where as if a DMUs getting less than one score, they are less efficient. The CCR model is based on constant return to scale so that scores obtained from CCR model which are not sufficient for final conclusion.

Table 5.1.3 represents year wise Overall Technical Efficient DMUs. The efficiency score has been improving in these 16 years, earlier there were only two depots which worked efficiently other depots having a scope in reduction in their inputs. Among twenty depots only D3 (Chandigarh) depot is fully overall technical efficient over sixteen years. One important thing is

captured there that is the efficiency score of D11 (Sirsa) and D15 (Delhi) both eight times scored one (fully efficient). From above table it clearly showed that the score of D11 has been started improving from 2009, after 2009 the efficiency score was one till 2016 (except 2013). And D15 worked efficiently from 2001 and till 2016 but in between some years it worked inefficiently.

Year	OTE Efficient DMUs	Total
2001	D3, D15	2
2002	D3	1
2003	D3	1
2004	D3, D17, D19	3
2005	D2, D3, D8, D15	4
2006	D3, D11	2
2007	D2, D3, D6, D17, D18	5
2008	D3, D6, D12, D15, D17	5
2009	D3, D6, D11, D17	4
2010	D3, D11, D17	3
2011	D3, D6, D11, D17	4
2012	D3, D11, D15	3
2013	D3, D6, D15,	3
2014	D1, D3, D11, D15	4
2015	D1, D3, D11, D15	4
2016	D1, D3, D10, D11, D15	5

Source: Researcher's Calculation

5.2 Pure Technical Efficiency

Pure Technical Efficiency of Haryana Roadways obtained from another version of DEA, BCC (Bankar, Charnes, Cooper) model. The major differences between CCR and BCC model is the convexity constraint. CCR is constant return to scale model, contrary BCC model is variable return to scale model. In order to know the exact efficiency of DMUs BCC input oriented model also employed there. With the help of BCC model the Overall Technical Efficiency split into two

parts one Pure Technical Efficiency and other is scale efficiency. The efficiency calculated by BCC model is called Pure Technical Efficiency because it has a net effect on Scale Efficiency.

Table 5.2.1 Pure Technical Efficient Scores for DMUs from 2001 to 2013													
DMUs	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
D1	0.95	0.95	0.98	0.98	0.99	0.96	0.97	0.93	0.91	0.92	0.93	1.00	1.00
D2	1.00	0.98	1.00	1.00	1.00	0.98	1.00	0.99	0.94	0.96	1.00	0.95	0.95
D3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
D4	0.96	0.93	0.93	0.95	0.97	0.97	0.98	0.97	0.97	0.95	1.00	0.99	0.98
D5	0.98	0.97	0.97	0.99	0.97	0.98	0.98	0.98	0.96	0.95	0.98	0.97	0.96
D6	0.99	0.97	0.95	0.98	0.99	0.99	1.00	1.00	0.99	0.92	1.00	1.00	1.00
D7	0.97	0.97	0.98	0.99	0.97	0.98	1.00	0.98	0.95	1.00	0.97	1.00	1.00
D8	0.98	0.99	1.00	0.97	1.00	0.98	1.00	1.00	0.99	0.95	0.97	0.98	0.97
D9	0.98	1.00	1.00	0.99	0.99	0.98	0.98	0.97	1.00	0.93	0.95	0.95	0.97
D10	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.95	0.92	0.94	0.94	0.96
D11	1.00	0.98	1.00	0.98	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90
D12	1.00	1.00	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.98
D13	0.97	0.97	0.98	0.98	0.99	0.98	0.99	0.98	0.97	0.95	0.97	0.96	0.98
D14	0.98	0.95	0.95	0.96	0.98	0.95	0.96	0.98	0.95	0.98	1.00	0.91	0.91
D15	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
D16	1.00	1.00	0.99	1.00	1.00	0.98	0.97	0.99	0.95	0.97	0.98	1.00	1.00
D17	0.97	0.96	0.97	1.00	0.97	0.97	1.00	1.00	1.00	1.00	1.00	0.99	0.98
D18	1.00	1.00	1.00	1.00	0.98	1.00	1.00	1.00	0.98	0.99	1.00	1.00	0.98
D19	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.97	1.00	1.00	1.00	1.00
D20	1.00	1.00	1.00	1.00	0.99	1.00	0.99	1.00	0.99	0.98	0.98	1.00	1.00

Source: Researcher's calculation

Table 5.2.2 Pure Technical Efficient Score for 2014 to 2016							
DMUs	2014	2015	2016	DMUs	2014	2015	2016
D1	1.00	1.00	1.00	D11	1.00	1.00	1.00
D2	0.95	0.94	0.95	D12	0.99	1.00	1.00
D3	1.00	1.00	1.00	D13	0.94	0.94	0.95
D4	0.97	1.00	1.00	D14	1.00	0.84	0.87
D5	0.94	0.96	0.97	D15	1.00	1.00	1.00
D6	0.93	0.95	0.96	D16	0.98	0.99	0.98
D7	0.99	1.00	1.00	D17	0.94	0.94	0.97
D8	0.96	0.97	1.00	D18	0.99	1.00	1.00
D9	0.95	0.96	0.97	D19	1.00	1.00	1.00
D10	0.89	1.00	1.00	D20	1.00	1.00	1.00

Source: Researcher's calculation

In above table efficiency score are different with the OTE scale, because CCR model will not able to consider the efficiency related to scale size of DMUs. In order to find out the inefficiency which is related to scale size of DMUs, BCC input oriented model has been operated. The Efficiency Score of PTE is better than score of OTE. The DMUs those having scored one, denotes that the size of DMU is fully efficient. The above results showed that the score of PTE for all the depots is above 0.90 in all years.

Table 5.2.3 Yearly Pure Technical Efficient DMUs		
Year	Efficient DMUs (PTE)	Total
2001	D2, D3, D10, D11, D12, D15, D16, D18, D19, D20	10
2002	D3, D9, D10, D12, D15, D16, D18, D19, D20	9
2003	D2, D3, D8, D9, D10, D11, D15, D18, D19, D20	10
2004	D2, D3, D10, D12, D15, D16, D17, D18, D19, D20	10
2005	D2, D3, D8, D10, D12, D15, D16, D19	8
2006	D3, D10, D11, D12, D15, D18, D19, D20	8
2007	D2, D3, D6, D7, D8, D11, D12, D15, D17, D18, D19	11
2008	D3, D6, D8, D11, D12, D15, D17, D18, D19, D20	10
2009	D3, D9, D11, D11, D12, D15	6
2010	D3, D7, D11, D12, D15, D17, D19	7
2011	D2, D3, D4, D6, D11, D12, D14, D15, D17, D18	10
2012	D1, D3, D6, D7, D11, D12, D15, D16, D18, D19, D20	11
2013	D1, D3, D6, D7, D15, D16, D19, D20	8
2014	D1, D3, D11, D14, D15, D19, D20	7
2015	D1, D3, D4, D7, D10, D11, D12, D15, D18, D19, D20	11
2016	D1, D3, D4, D7, D8, D10, D11, D12, D15, D18, D19, D20	12

Source: Researcher's calculation

Table 5.2.3 revealed that in these 16 years on average 8 DMUs were pure technical efficient. In 2016, 12 DMUs were pure technical efficient. The pure technical efficient score of D3 (Chandigarh) and D15 (Delhi) were one, they are fully pure technical efficient for all 16 years. In 2009 there were only 6 DMUs which were pure technical efficient. The OTE score for DMUs can never exceed its PTE efficiency score. According to Charnes et al., the ratio of virtual output

to the virtual input of any DMUs is to be maximized with the condition that the ratio should be less than or equal to unity.

5.3 Scale Efficiency

With the usage of OTE and PTE efficiency scores the scale efficiency has been calculated in this present study. Above results of CCR and BCC gives an examination of whether the size a DMUs has an influence on its OTE. The SE of each DMU is the ratio of OTE to PTE scores. If a DMU have one, SE score then the DMU noticeable either large or small to its optimum scale size.

Table 5.3 depicted the SE scores of the DMUs.

DMUs	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
D1	0.88	0.88	0.86	0.96	0.92	0.77	0.90	0.93	0.91	0.82	0.76	0.76	0.79
D2	0.92	0.92	0.90	0.97	1.00	0.92	1.00	1.00	0.99	1.00	0.98	1.00	0.99
D3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
D4	0.86	0.88	0.87	0.93	0.81	0.71	0.82	0.87	0.88	0.82	0.90	0.96	0.88
D5	0.91	0.89	0.89	0.95	0.92	0.83	0.96	0.97	0.98	0.99	0.96	0.95	0.92
D6	0.92	0.90	0.91	0.98	0.96	0.90	1.00	1.00	0.99	1.00	1.00	0.99	1.00
D7	0.88	0.87	0.86	0.87	0.93	0.89	0.93	0.94	0.97	0.88	0.86	0.87	0.93
D8	0.93	0.86	0.85	1.00	1.00	0.84	0.99	0.99	0.98	0.91	0.94	0.91	0.86
D9	0.97	0.96	0.96	0.95	0.97	0.86	1.00	0.99	0.99	0.95	0.97	0.96	0.96
D10	0.82	0.81	0.81	0.96	0.89	0.81	0.94	0.91	0.89	0.90	0.99	0.99	0.98
D11	0.97	0.94	0.92	0.99	0.99	1.00	0.99	1.00	1.00	1.00	1.00	1.00	0.99
D12	0.98	0.91	0.91	0.91	0.93	0.80	0.91	0.91	0.86	0.83	0.87	0.92	0.87
D13	0.93	0.89	0.88	0.95	0.95	0.91	0.92	0.96	0.94	0.88	0.99	1.00	0.87
D14	0.93	0.96	0.96	0.99	0.99	0.82	0.94	0.97	0.91	0.90	0.81	0.99	0.95
D15	1.00	0.96	0.96	0.99	1.00	0.85	0.94	1.00	0.97	0.97	0.86	1.00	1.00
D16	0.90	0.93	0.94	0.97	0.96	0.81	0.95	0.98	0.96	0.94	0.92	0.93	0.94
D17	0.97	0.94	0.93	1.00	0.97	0.89	1.00	1.00	1.00	1.00	1.00	0.99	1.00
D18	0.93	0.91	0.91	0.87	0.86	0.79	1.00	0.92	0.89	0.87	0.86	0.87	0.85
D19	0.87	0.93	0.93	1.00	0.93	0.80	0.88	0.82	0.87	0.86	0.86	0.82	0.87
D20	0.90	0.82	0.82	0.88	0.89	0.75	0.88	0.85	0.78	0.72	0.69	0.70	0.82

DMUs	2014	2015	2016	DMUs	2014	2015	2016
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D1	1.00	1.00	1.00	D11	1.00	1.00	1.00
D2	1.00	0.98	0.94	D12	0.91	0.89	0.90
D3	1.00	1.00	1.00	D13	0.95	0.92	0.92
D4	0.91	0.91	0.88	D14	0.95	0.95	0.90
D5	0.94	0.92	0.94	D15	1.00	1.00	1.00
D6	0.98	1.00	0.95	D16	0.93	0.94	0.90
D7	0.88	0.88	0.89	D17	0.99	0.99	1.00
D8	0.90	0.90	0.93	D18	0.89	0.88	0.85
D9	0.95	0.95	0.89	D19	0.91	0.95	0.95
D10	1.00	0.95	1.00	D20	0.79	0.76	0.82

Source: Researcher's calculation

Scale Efficiency of each depots shows the clear picture of Haryana Roadways whether every depots working in efficient manner or not. The Score of scale efficiency also lies between one and zero. In above Overall Technical Efficiency and Pure Technical Efficiency has been calculated which are related with the technical efficiency and managerial efficiency. The scale size of each depot is efficient or not this analysis helpful to find out this question.

5.3.3 Yearly Scale Efficient DMUs		
Year	Efficient DMUs (SE)	Total
2001	D3,D15	2
2002	D3	1
2003	D3	1
2004	D3,D8,D17,D19	4
2005	D2,D3,D8,D15	4
2006	D3,D11	2
2007	D2, D3, D6, D9, D17, D18	6
2008	D2,D3,D6,D11,D15,D17	6
2009	D3,D11, D17	3
2010	D2,D3,D6,D11,D17	5
2011	D3, D11, D6, D7	4
2012	D2,D3,D11, D13, D15	5
2013	D3, D6, D15, D17	4
2014	D1, D2, D3, D10, D11, D15	6
2015	D1, D2, D3, D6, D11, D15	6
2016	D1, D3, D10, D11, D15, D17	6

Source: Researcher's calculation

Table 5.3 depicts the SE scores of the DMUs. In table 5.3.2 illustrates the scale efficient DMUs for each year. It is revealed that in 2001, out of 20 DMUs only D3 (Chandigarh) and D5 (Delhi) were efficient remaining 18 DMUs are scale inefficient. In 2007, 2008, 2014, 2015 and 2006 there were 6 DMUs are scale efficient. The SE scores of DMUs were improved in these years. 2003 and 2004 two years where only one DMU namely D3 (Chandigarh) was only Scale Efficient.

5.4 Projected Inputs and Outputs for the year 2015-16 and 2016-17

On the basis of CCR (Input oriented) projected inputs and output amount has been calculated for 2015 and 2016. Because of CCR input oriented model has been employed, there is no need of changes in output. This is clearly depicted in below table that the BU which has been taken as a output has not been changed.

Table 5.4.1 Projection Table for 2015-16 and 2016-17								
DMU	Score (2015)	Projection	Difference	%	Score (2016)	Projection	Difference	%
I/O	Data	Values	Values	%	Data	Values	Values	%
D1	1				1			
FS	367	367	0	0.00%	329	329	0	0.00%
TS	1316	1316	0	0.00%	1322	1322	0	0.00%
FC	4	4	0	0.00%	4.06	4.06	0	0.00%
BU	310.3	310.3	0	0.00%	308.6	308.6	0	0.00%
D2	0.92				0.90			
FS	227	208.41	-18.59	-8.19%	219	196.25	-22.75	-

								10.39%
TS	900	827.94	-72.06	-8.01%	878	786.79	-91.21	- 10.39%
FC	4.88	4.49	-0.39	-8.01%	4.84	4.34	-0.50	- 10.39%
BU	259.69	259.69	0.00	0.00%	249.89	249.89	0.00	0.00%
D3	1				1			
FS	270	270.00	0.00	0.00%	260	260	0.00	0.00%
TS	1105	1105.00	0.00	0.00%	1078	1078	0.00	0.00%
FC	4.33	4.33	0.00	0.00%	4.42	4.42	0.00	0.00%
BU	325.84	325.84	0.00	0.00%	323.99	323.99	0.00	0.00%
D4	0.90				0.88			
FS	186	168.09	-17.91	-9.63%	183	160.60	-22.40	- 12.24%
TS	943	711.38	-231.62	-24.56%	901	682.14	-218.86	- 24.29%
FC	4.65	4.20	-0.45	-9.63%	4.6	4.04	-0.56	- 12.24%
BU	214.1	214.10	0.00	0.00%	211.01	211.01	0.00	0.00%
D5	0.89				0.91			
FS	186	164.77	-21.23	-11.41%	183	166.47	-16.53	-9.03%
TS	778	689.20	-88.80	-11.41%	769	699.55	-69.45	-9.03%
FC	4.89	4.33	-0.56	-11.41%	4.83	4.39	-0.44	-9.03%
BU	211.36	211.36	0.00	0.00%	219.7	219.70	0.00	0.00%
D6	0.95				0.91			
FS	206	195.94	-10.06	-4.88%	212	192.54	-19.46	-9.18%

TS	955	825.11	-129.89	-13.60%	905	811.94	-93.06	-10.28%
FC	4.87	4.63	-0.24	-4.88%	4.81	4.37	-0.44	-9.18%
BU	247.59	247.59	0.00	0.00%	249.05	249.05	0.00	0.00%
D7	0.88				0.89			
FS	153	135.04	-17.96	-11.74%	152	135.54	-16.46	-10.83%
TS	639	564.00	-75.00	-11.74%	603	537.72	-65.28	-10.83%
FC	4.79	4.20	-0.59	-12.29%	4.82	4.20	-0.62	-12.86%
BU	177.99	177.99	0.00	0.00%	181.05	181.05	0.00	0.00%
D8	0.87				0.93			
FS	176	153.59	-22.41	-12.73%	160	148.93	-11.07	-6.92%
TS	897	655.88	-241.12	-26.88%	821	640.92	-180.08	-21.93%
FC	4.83	4.22	-0.61	-12.73%	4.74	4.41	-0.33	-6.92%
BU	198.44	198.44	0.00	0.00%	201.25	201.25	0.00	0.00%
D9	0.92				0.86			
FS	151	138.31	-12.69	-8.41%	143	123.29	-19.71	-13.78%
TS	719	603.10	-115.90	-16.12%	739	538.89	-200.11	-27.08%
FC	5.02	4.60	-0.42	-8.41%	5.01	4.32	-0.69	-13.78%
BU	184.68	184.68	0.00	0.00%	172.16	172.16	0.00	0.00%
D10	0.95				1			

FS	323	305.57	-17.43	-5.40%	335	335	0.00	0.00%
TS	1336	1220.72	-115.28	-8.63%	1291	1291	0.00	0.00%
FC	4.86	4.60	-0.26	-5.40%	4.87	4.87	0.00	0.00%
BU	347.48	347.48	0.00	0.00%	361.88	361.88	0.00	0.00%
D11	1				1			
FS	187	187.00	0.00	0.00%	192	192	0.00	0.00%
TS	725	725.00	0.00	0.00%	669	669	0.00	0.00%
FC	4.85	4.85	0.00	0.00%	4.84	4.84	0.00	0.00%
BU	238.88	238.88	0.00	0.00%	241.21	241.21	0.00	0.00%
D12	0.89				0.90			
FS	175	155.72	-19.28	-11.02%	166	149.01	-16.99	-10.24%
TS	726	646.02	-79.98	-11.02%	688	617.58	-70.42	-10.24%
FC	4.68	4.16	-0.52	-11.02%	4.7	4.22	-0.48	-10.24%
BU	200.22	200.22	0.00	0.00%	198.11	198.11	0.00	0.00%
D13	0.87				0.87			
FS	238	206.91	-31.09	-13.06%	230	199.50	-30.50	-13.26%
TS	997	859.83	-137.17	-13.76%	931	807.53	-123.47	-13.26%
FC	4.78	4.16	-0.62	-13.06%	4.8	4.16	-0.64	-13.26%
BU	255.95	255.95	0.00	0.00%	252.8	252.80	0.00	0.00%
D14	0.80				0.78			

FS	405	291.10	-113.90	-28.12%	410	249.67	-160.33	-39.10%
TS	1403	1124.62	-278.38	-19.84%	1273	991.99	-281.01	-22.07%
FC	4.98	3.99	-0.99	-19.84%	4.98	3.88	-1.10	-22.07%
BU	303.73	303.73	0.00	0.00%	286.62	286.62	0.00	0.00%
D15	1				1			
FS	141	141.00	0.00	0.00%	136	136.00	0.00	0.00%
TS	618	618.00	0.00	0.00%	596	596.00	0.00	0.00%
FC	4.89	4.89	0.00	0.00%	4.89	4.89	0.00	0.00%
BU	189.79	189.79	0.00	0.00%	190.95	190.95	0.00	0.00%
D16	0.93				0.88			
FS	153	141.91	-11.09	-7.25%	174	152.74	-21.26	-12.22%
TS	694	615.56	-78.44	-11.30%	660	579.38	-80.62	-12.22%
FC	4.86	4.51	-0.35	-7.25%	4.89	4.29	-0.60	-12.22%
BU	187.93	187.93	0.00	0.00%	198.75	198.75	0.00	0.00%
D17	0.93				0.96			
FS	193	180.15	-12.85	-6.66%	181	174.01	-6.99	-3.86%
TS	807	753.28	-53.72	-6.66%	746	717.17	-28.83	-3.86%
FC	5.02	4.69	-0.33	-6.66%	5.08	4.88	-0.20	-3.86%
BU	230.72	230.72	0.00	0.00%	230.72	230.72	0.00	0.00%
D18	0.88				0.84			

FS	144	126.62	-17.38	-12.07%	140	117.99	-22.01	-15.72%
TS	646	553.39	-92.61	-14.34%	631	515.45	-115.55	-18.31%
FC	4.88	4.29	-0.59	-12.07%	4.88	4.11	-0.77	-15.72%
BU	169.68	169.68	0.00	0.00%	164.58	164.58	0.00	0.00%
D19	0.95				0.95			
FS	148	139.76	-8.24	-5.57%	149	140.81	-8.19	-5.49%
TS	569	541.84	-27.16	-4.77%	585	552.86	-32.14	-5.49%
FC	4.81	3.62	-1.19	-24.64%	4.89	4.29	-0.60	-12.18%
BU	178.53	178.53	0.00	0.00%	187.14	187.14	0.00	0.00%
D20	0.76				0.82			
FS	157	119.56	-37.44	-23.85%	159	129.78	-29.22	-18.38%
TS	644	490.41	-153.59	-23.85%	629	513.42	-115.58	-18.38%
FC	4.79	3.57	-1.22	-25.56%	4.79	3.91	-0.88	-18.38%
BU	156.37	156.37	0.00	0.00%	172.42	172.42	0.00	0.00%

Source: Researcher's Calculation

Table 5.4 represents the projected values of inputs and outputs for inefficient DMUs. Percentage reduction in inputs also depicted in above table. From projected tables it can be revealed that an average has a remarkable scope to reduce in its inputs for same level of output. A scrutiny of the table shows that in 2015, D1 (Gurugram), D3 (Chandigarh), D11 (Sirsa), D15 (Delhi) these four

DMUs having 1 efficiency score it means that there is no scope of reduction in inputs. Furthermore, D20 (Jhajjar) is most inefficient DMU than others. Its efficiency score for the year 2015 was 0.76 which simply indicates that this DMU 76% efficient and 24% scope of reduction in inputs. The score of D6 (Hisar), D10 (Bhiwani), D19 (Narnaul) having 0.95 efficiency score, only 5% scope of reduction in inputs to become efficient. In 2016, D1 (Gurugram), D3 (Chandigarh), D10 (Bhiwani), D11 (Sirsa) and D15 (Delhi) worked efficiently their efficiency score also one, there is no need of reduction in inputs. The efficiency score of D5 (Karnal), D6 (Hisar), D8 (Jind), D12 (Bhiwani), D17 (Kurukshehra) and D19 (Narnaul) was above 0.90, they were above 90% worked efficiently.

5.5 Dynamic perspective of Haryana Roadways

In this study, for dynamic perspective DEAW has been operated. For choosing different reference set moving average method has been used. Through DEAW efficiency scores of depots are in form of average by term. Then with the help of these scores over the period change in efficiency score has been measured, which depicted in below table-

Year	Average
2001	0.77
2002	0.80
2003	0.81
2004	0.85
2005	0.84
2006	0.83
2007	0.85
2008	0.87
2009	0.82
2010	0.83
2011	0.79
2012	0.83

2013	0.80
2014	0.89
2015	0.89
2016	0.90

Source: Researcher's Calculation

Figure 5.5.2 Efficiency of Haryana from 2001 to 2016

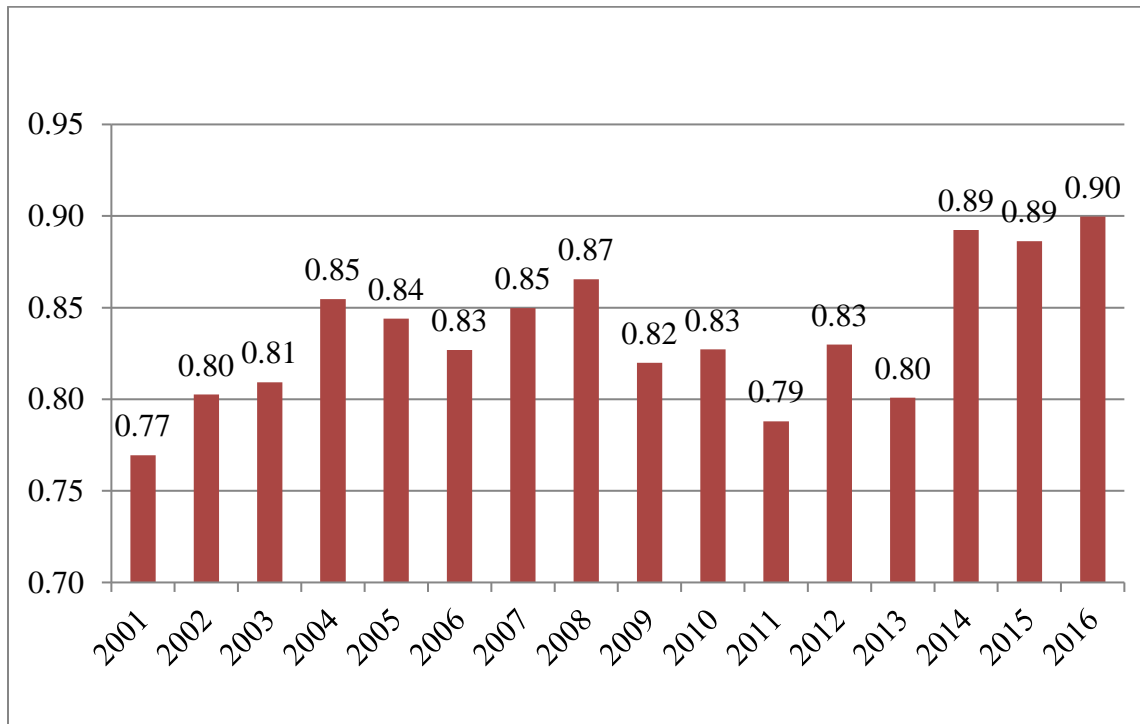


Table 5.4 and figure 5.4.1 captured the average relative efficiency score for Haryana Roadways. The result observed that in earlier the Haryana Roadways was not much relative efficient, the score of efficiency in 2001 was only 0.77. There was needed to changes in reductions in inputs, 33% scope of reduction in inputs for same level of output. But after 2001 the efficiency score has been improved, in 2016 the efficiency score reached at 0.90, there was only 10% reduction was necessary to become an efficient unit. Above figure described dynamic changes in 16 years.

5.6 Descriptive statistics and Correlation matrix

The descriptive statistics of the obtained data for selected output and inputs show in below table. There is a considerable variation in the inputs and output from one side to another side of DMUs,

which verified by the results of descriptive statistics by minimum, maximum and standard deviation values. The correlation matrix captured the relations between each input and output. It simply indicates, how each input and output is correlated with each other. Further, to found the exact impact of changes in one input, on the other inputs variables and output variable correlation matrix has been used.

Table 5.6.1 Descriptive statistics and correlation matrix for inputs and outputs									
Time period = 2001					Correlation (Time period = 2001)				
	FS	TS	FC	BU		FS	TS	FC	BU
Max	248.00	1258.00	4.61	296.01	FS	1.00	0.95	-0.02	0.96
Min	116.00	612.00	4.19	128.42	TS	0.95	1.00	-0.17	0.91
Average	175.75	953.75	4.48	192.18	FC	-0.02	-0.17	1.00	0.05
SD	38.61	198.62	0.10	43.14	BU	0.96	0.91	0.05	1.00
Time period = 2002					Correlation (Time period = 2002)				
	FS	TS	FC	BU		FS	TS	FC	BU
Max	232.00	1272.00	4.78	308.41	FS	1.00	0.96	-0.09	0.95
Min	110.00	599.00	4.36	132.81	TS	0.96	1.00	-0.19	0.93
Average	170.15	939.95	4.55	197.43	FC	-0.09	-0.19	1.00	-0.16
SD	36.19	193.28	0.10	44.11	BU	0.95	0.93	-0.16	1.00
Time period = 2003					Correlation (Time period = 2003)				
	FS	TS	FC	BU		FS	TS	FC	BU
Max	245	1279	4.92	304.99	FS	1	0.96489	-0.0508	0.96778
Min	110	572	4.52	134.79	TS	0.96489	1	-0.0475	0.93335
Average	170.45	921.35	4.683	199.449	FC	-0.0508	-0.0475	1	-0.0527
SD	36.0312	186.308	0.09849	43.1596	BU	0.96778	0.93335	-0.0527	1
Time period = 2004					Correlation (Time period = 2004)				
	FS	TS	FC	BU		FS	TS	FC	BU
Max	244	1257	5.02	308.76	FS	1	0.91347	0.00227	0.97382
Min	104	601	4.76	139.6	TS	0.91347	1	0.05173	0.92523
Average	164.7	917.7	4.8775	206.448	FC	0.00227	0.05173	1	0.04251
SD	35.8861	184.887	0.0707	41.6605	BU	0.97382	0.92523	0.04251	1
Time period = 2005					Correlation (Time period = 2005)				
	FS	TS	FC	BU		FS	TS	FC	BU
Max	242	1256	5.04	309.32	FS	1	0.95117	-0.1232	0.95825
Min	108	574	4.78	136.13	TS	0.95117	1	-0.2318	0.92827
Average	167.75	886.35	4.944	207.14	FC	-0.1232	-0.2318	1	-0.077

SD	34.4904	182.945	0.06674	42.0148	BU	0.95825	0.92827	-0.077	1
Time period = 2006					Correlation (Time period = 2006)				
	FS	TS	FC	BU		FS	TS	FC	BU
Max	258	1208	5.2	308.55	FS	1	0.94693	0.17344	0.90373
Min	109	562	4.91	131.88	TS	0.94693	1	0.15113	0.82566
Average	171.35	862	5.021	205.379	FC	0.17344	0.15113	1	0.08529
SD	39.5617	184.571	0.07661	44.1139	BU	0.90373	0.82566	0.08529	1
Time period = 2007					Correlation (Time period = 2007)				
	FS	TS	FC	BU		FS	TS	FC	BU
Max	224	1122	5.13	283.9	FS	1	0.91165	0.00256	0.94835
Min	107	572	4.81	129.51	TS	0.91165	1	-0.088	0.90697
Average	157.4	824.9	4.9645	197.305	FC	0.00256	-0.088	1	0.06809
SD	31.0522	151.121	0.08441	37.5311	BU	0.94835	0.90697	0.06809	1
Time period = 2008					Correlation (Time period = 2008)				
	FS	TS	FC	BU		FS	TS	FC	BU
Max	228	1175	5.09	271.42	FS	1	0.90736	-0.3038	0.93673
Min	96	564	4.71	127.68	TS	0.90736	1	-0.239	0.91079
Average	154.35	901.3	4.9075	195.796	FC	-0.3038	-0.239	1	-0.1433
SD	33.4145	178.653	0.10765	36.8206	BU	0.93673	0.91079	-0.1433	1
Time period = 2009					Correlation (Time period = 2009)				
	FS	TS	FC	BU		FS	TS	FC	BU
Max	236	1120	5.15	259.26	FS	1	0.87691	-0.2712	0.83417
Min	107	559	4.42	132.81	TS	0.87691	1	-0.1926	0.90019
Average	162.05	861.15	4.8055	191.441	FC	-0.2712	-0.1926	1	-0.1401
SD	32.8321	163.741	0.15958	34.8263	BU	0.83417	0.90019	-0.1401	1
Time period = 2010					Correlation (Time period = 2010)				
	FS	TS	FC	BU		FS	TS	FC	BU
Max	223	1076	5.11	262.66	FS	1	0.90022	-0.2791	0.83187
Min	114	548	4.41	124.78	TS	0.90022	1	-0.1345	0.87221
Average	159.95	815.35	4.786	189.871	FC	-0.2791	-0.1345	1	-0.1083
SD	33.1624	153.393	0.17319	37.2449	BU	0.83187	0.87221	-0.1083	1
Time period = 2011					Correlation (Time period = 2011)				
	FS	TS	FC	BU		FS	TS	FC	BU
Max	308	1151	5.14	241.85	FS	1	0.89909	-0.3203	0.6589
Min	116	538	4.49	119.81	TS	0.89909	1	-0.1994	0.80733
Average	173.9	822	4.8185	189.042	FC	-0.3203	-0.1994	1	0.08777
SD	47.3359	173.357	0.16584	37.8902	BU	0.6589	0.80733	0.08777	1
Time period = 2012					Correlation (Time period = 2012)				
	FS	TS	FC	BU		FS	TS	FC	BU
Max	381	1437	5.1	297.71	FS	1	0.94689	-0.4526	0.79427

Min	116	617	4.13	136.65	TS	0.94689	1	-0.4015	0.87335
Average	191.55	933.8	4.796	211.465	FC	-0.4526	-0.4015	1	-0.1603
SD	66.16	232.294	0.20314	48.8742	BU	0.79427	0.87335	-0.1603	1
Time period = 2013					Correlation (Time period = 2013)				
	FS	TS	FC	BU		FS	TS	FC	BU
Max	384	1320	5.1	305.67	FS	1	0.91617	-0.5274	0.79218
Min	126	618	4.13	139.81	TS	0.91617	1	-0.4406	0.87916
Average	198.6	906.85	4.7955	207.147	FC	-0.5274	-0.4406	1	-0.238
SD	71.2183	212.851	0.20296	46.7084	BU	0.79218	0.87916	-0.238	1
Time period = 2014					Correlation (Time period = 2014)				
	FS	TS	FC	BU		FS	TS	FC	BU
Max	393	1402	5.05	371.83	FS	1	0.96889	-0.42	0.92809
Min	140	597	3.91	158.87	TS	0.96889	1	-0.3826	0.92822
Average	208.75	897.75	4.785	236.471	FC	-0.42	-0.3826	1	-0.2689
SD	76.5897	239.976	0.25149	59.7613	BU	0.92809	0.92822	-0.2689	1
BU	0.79218	0.87916	-0.238	1					
Time period = 2015					Correlation (Time period = 2015)				
	FS	TS	FC	BU		FS	TS	FC	BU
Max	405	1403	5.02	347.48	FS	1	0.95691	-0.4064	0.88897
Min	141	569	4	156.37	TS	0.95691	1	-0.3906	0.91034
Average	209.3	870.85	4.783	229.464	FC	-0.4064	-0.3906	1	-0.4074
SD	74.2369	245.191	0.23091	54.3814	BU	0.88897	0.91034	-0.4074	1
SD	76.5897	239.976	0.25149	59.7613	BU	0.92809	0.92822	-0.2689	1
Time period = 2016					Correlation (Time period = 2016)				
	FS	TS	FC	BU		FS	TS	FC	BU
Max	410	1322	5.08	361.88	FS	1	0.93275	-0.3044	0.86239
Min	136	585	4.06	164.58	TS	0.93275	1	-0.4675	0.89128
Average	205.65	835.75	4.787	230.094	FC	-0.3044	-0.4675	1	-0.3996
SD	72.5598	231.871	0.2165	53.3854	BU	0.86239	0.89128	-0.3996	1

5.7 Findings of Chapter

This chapter measures the Overall Technical Efficiency, Pure Technical Efficiency and Scale Efficiency. The results revealed that among twenty DMUs, D3 (Chandigarh) is one of the depots whose Overall Technical Efficiency score, Pure Technical Efficiency Score and Scale Efficiency score was 1 in over the selected years. It is concluded that the size of scale of DMUs is 90 percent efficient. The core of PTE depicted that 10 percent reductions should be required for

making Efficient DMU. With the help of OTE and SE efficiency scores, it is obtained that except D3 remaining 19 depots required to reduce their inputs to become efficient DMUs. Further, with help of DEAW dynamic changes for 16 years have also evaluated and the result shows that the efficiency score of Haryana Roadways has been improved from 2001 to 2016. In 2001 Haryana Roadways 77% efficient there is 23% inputs had to be reduced, in 2016 this score was reached at 0.90 i.e., 90% Haryana Roadways worked efficiently.