APPENDIX A: DEA AND GOAL PROGRAMMING RESULTS

The following notations are used in representing the results in a tabular form.

1. **DMU:** A DMU represents a decision-making unit, which in this case is the monthly time period.
2. **P1-P11:** These represent the notation for the processes, Inner layer, Etch, Drill, Copper-Electroless, Copper-Plate, Multilayer, Lamination, Solder mask, Gold plating, Nickel Plating and Machine. This mapping is represented in the following table.

Time Period	Process 1				Process 2				Process 3			
	Output	**Target**	**Labor**	**RM**	**Output**	**Target**	**Labor**	**RM**	**Output**	**Target**	**Labor**	**RM**
1	12199	13727	4734	622830	12640	13505	1054	71626	14117	14347	3114	97185
2	20106	19818	4139	567520	20402	18463	962	58647	19870	18573	2447	124246
3	16855	17603	3804	513625	17420	17098	927	49464	17583	18062	2347	69705
4	15824	17328	4721	624389	15824	17328	1156	58141	18373	19337	3126	110930
5	16963	14933	4218	596216	17396	14708	825	55732	17267	17163	2949	125492
6	17679	17016	4188	638743	18544	13061	919	61541	17761	17236	2827	153337
7	14918	15390	5817	809302	18665	13490	1057	75413	18144	17200	3648	125120
8	20910	18200	4503	542976	21577	17521	740	58857	22215	21250	2767	110066
9	17923	16100	4874	669754	18855	15166	1021	122040	17998	18890	3083	137983
10	14026	11950	5579	720543	14746	12943	1365	82338	15041	16545	3153	92792
11	18432	16110	4198	641548	19507	17275	1074	60575	18624	18560	2522	109350
12	19540	17395	4434	721745	18939	17460	1042	68802	19525	19800	3034	159346
13	20987	20400	5147	872887	21124	20610	979	67915	20216	21450	3888	143841
14	18049	18250	4933	879210	19100	18450	832	61043	18743	19850	3201	146710
15	15661	13620	4342	627059	16528	14250	914	54483	15963	14000	2731	134295
16	20214	24000	4705	902520	20942	24000	1137	71303	20625	24000	3364	128427
17	12206	18000	3751	614783	12389	18000	842	54445	12680	18000	2329	96478
18	16028	20000	4691	924535	16508	20000	807	59805	15910	20000	2695	184243
19	22837	25000	7311	1302641	23127	25000	922	74169	22300	25000	3601	166939
20	16549	20000	5169	908164	16388	20000	807	57858	16304	20000	2646	147092
21	20992	20000	5397	851124	22853	20000	818	69690	20940	20000	3000	165342
22	17256	25000	6643	970490	19052	25000	990	82105	21054	25000	3103	211480
23	14158	20000	4928	744579	14324	20000	751	48418	13779	20000	2170	144603
Total	**400312**	**419840**	**112226**	**17267183**	**416850**	**413328**	**21941**	**1524410**	**415032**	**444263**	**67745**	**3085002**
	Process 4				**Process 5**				**Process 6**			
	Output	**Target**	**Labor**	**RM**	**Output**	**Target**	**Labor**	**RM**	**Output**	**Target**	**Labor**	**RM**
1	14294	14149	2103	70609	14218	14333	2103	55059	15555	16326	4187	289817
2	19195	18800	1798	58409	17146	18179	1798	48520	17492	18838	3844	244649
3	17446	18043	1698	48720	16724	17513	1698	59036	16549	18360	3361	266455
4	18310	19462	2303	73189	16321	16677	2303	58586	16630	15748	4163	290166
5	17080	17093	1848	83037	15471	13945	1848	64800	14815	14428	4250	272174
6	17568	16547	1668	70974	16838	15359	1668	54085	16762	17490	4158	289304
7	18593	17225	2283	97664	16117	14835	2283	69752	15270	15704	4922	362599
8	22281	20940	2007	60096	21284	20280	2007	65246	21674	21058	3745	294420
9	17217	18310	1775	72317	16557	16529	1775	67934	15670	17990	4134	319624
10	14974	17250	2111	63692	15138	16365	2111	89143	15797	17825	5160	353078
11	19463	18350	1690	50280	17663	17870	1690	82507	17761	19370	4464	273494
12	19587	20050	1943	62586	17461	18120	1943	70770	16780	17239	4854	351368
13	19288	21070	2253	68355	18906	20970	2253	73220	18889	21210	5807	397776
14	19915	20050	1981	62209	17455	18650	1981	62066	16677	18800	4886	317819
15	15977	13900	1671	53323	14721	13800	1671	37762	16192	13900	4178	295860
16	19783	24000	2225	75272	18170	24000	2225	107238	17431	24000	5696	386949
17	13689	18000	1879	45349	14284	18000	1879	32619	14654	18000	3762	260139
18	15991	20000	1949	62877	15544	20000	1949	58363	13874	20000	4117	316512
19	21347	25000	2481	73431	23377	25000	2481	75769	18603	25000	5505	479538
20	16402	20000	1853	57882	16468	20000	1853	44974	14856	20000	4377	397263
21	19897	20000	2021	63275	20375	20000	2021	66370	17078	20000	4783	483335
22	21791	25000	2414	74283	25757	25000	2414	73013	20967	25000	5440	393486
23	13810	20000	1747	48194	17431	20000	1747	38095	11147	20000	4116	307273
Total	**413898**	**443239**	**45701**	**1496023**	**403426**	**425425**	**45701**	**1454927**	**381123**	**436286**	**103909**	**7643098**

Table A.1 The Data

Time Period	Process 7				Process 8				Process 9			
	Output	Target	Labor	RM	Output	Target	Labor	RM	Output	Target	Labor	RM
1	14121	15282	3342	58116	14121	15282	3448	58123	13939	16081	3300	49312
2	17479	19824	2930	48689	18025	19455	3097	49850	17438	20271	2788	41301
3	16212	18270	2482	42578	15275	18159	2906	51736	15862	18599	1932	26837
4	16595	17124	2953	51663	16223	17335	3806	60796	16535	17932	2527	38280
5	15141	15340	2975	46020	14784	15415	3593	58690	14985	15670	2670	36781
6	16254	16235	3064	55960	15043	15991	3455	61276	15310	16468	2433	36752
7	15606	16940	3845	66042	16098	17538	4297	74912	16922	17065	2910	64317
8	21251	21672	3129	62160	19169	19807	3409	65789	19807	20666	2212	37178
9	15614	16819	3517	60056	15388	17300	3724	53209	15413	17224	2640	44065
10	14916	15963	3847	60315	15374	16335	4583	71043	15374	16335	2991	42217
11	18964	18110	2882	41448	16783	17575	3472	57574	18948	18110	2222	34826
12	16314	16725	3392	58169	15173	16760	3888	54429	16066	16260	2562	36267
13	18883	20000	3974	75920	17253	20945	4485	70303	18538	20815	2923	46849
14	17418	20000	3373	62935	15535	18300	4072	58695	16775	18300	2456	37075
15	14392	20000	3187	54294	13240	13725	3619	48779	13637	13625	2226	33325
16	18482	20000	3660	81077	14124	24000	4324	84668	17568	24000	2878	36478
17	14680	20000	2969	59486	12718	18000	3058	50572	13707	18000	2339	33785
18	13388	20000	3483	62972	9684	20000	3547	44034	12254	20000	2585	20582
19	19366	20000	4146	78191	15984	25000	4583	68407	17717	25000	3226	36463
20	14893	20000	3195	56586	9949	20000	3389	41596	14254	20000	2557	24103
21	17480	20000	3437	66929	13469	20000	3859	53006	16434	20000	2845	30073
22	21812	20000	4028	82348	15969	25000	5118	72500	19783	25000	3112	32239
23	11061	20000	2784	52175	7608	20000	3218	40051	10708	20000	2112	22077
Total	380322	428304	76594	1384129	336989	431922	86950	1350038	367974	435421	60446	841182
	Process 10				Process 11				Overall Plant Level Target per Time Period			
	Output	Target	Labor	RM	Output	Target	Labor	RM				
1	14292	14542	3300	20434	14326	13924	1751	25852	20000			
2	17679	18860	2788	15186	17369	16375	1545	18970	16000			
3	16251	17660	1932	8978	16268	16844	1288	16140	16000			
4	16512	16501	2527	25522	16724	15870	1715	21398	20000			
5	14769	14895	2670	35740	14923	14226	1553	24093	16000			
6	15581	15250	2433	33346	15095	14550	1520	37421	16000			
7	17273	16430	2910	32624	17696	16720	2011	30174	20000			
8	20229	19141	2212	13583	19906	19055	1687	24852	16000			
9	15198	16138	2640	27978	15152	15480	1763	25807	16000			
10	15720	15667	2991	19954	15345	15555	2250	30829	20000			
11	19661	18095	2222	11131	20130	18510	1706	25662	16000			
12	16373	15970	2562	13876	16124	16470	1854	25192	16000			
13	18480	20310	2923	23060	18733	20310	2269	26213	20000			
14	17141	18325	2456	23568	16359	18250	1895	24458	16000			
15	14491	13675	2226	25833	14991	13800	1580	19761	16000			
16	18305	24000	2878	30384	19217	24000	2053	26577	20000			
17	14288	18000	2339	15179	12933	18000	1473	22704	16000			
18	12404	20000	2585	18582	13647	20000	1637	24381	16000			
19	18672	25000	3226	20221	19983	25000	2085	26762	20000			
20	13958	20000	2557	20399	14591	20000	1584	22969	16000			
21	17041	20000	2845	26187	16869	20000	1745	25101	16000			
22	21544	25000	3112	18705	21955	25000	1970	34289	20000			
23	12717	20000	2112	19478	13416	20000	1432	19681	16000			
Total	378579	423459	60446	499948	381752	417939	40366	579286	400000			

Table A.2 The Data

DMU	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	Mean
1	0.8247	0.71	0.7511	0.7943	0.794	0.8733	0.754	0.8574	0.6093	0.5891	0.758	**0.7559**
2	0.9181	0.8255	0.9164	0.9292	0.9286	1	0.87	0.9682	0.6929	0.6929	0.8508	**0.8721**
3	1	0.9837	1	1	0.9823	1	1	1	1	1	1	**0.9969**
4	0.8371	0.8433	0.7413	0.726	0.7251	0.8746	0.9122	0.7954	0.7894	0.7645	0.8497	**0.8053**
5	0.9637	0.9354	0.7738	0.9025	0.9025	0.99	1	0.8968	0.7256	0.8753	0.8942	**0.8963**
6	0.9205	0.8801	0.802	1	1	0.9496	0.9517	0.9482	0.8634	0.9153	0.9173	**0.9226**
7	0.794	0.7755	0.6997	0.731	0.7308	0.7932	0.88	0.771	0.7748	0.7676	0.8205	**0.7762**
8	0.9976	1	0.8306	0.8407	0.831	1	0.9752	0.9449	0.9225	0.8734	0.8259	**0.9129**
9	0.8322	0.7401	0.8083	0.94	0.9397	0.9186	0.8133	0.8959	0.8117	0.8763	0.8646	**0.8582**
10	0.8289	0.6454	0.9176	0.7984	0.7904	0.7664	0.9829	0.7327	0.8207	0.7752	0.7584	**0.8015**
11	0.9343	0.7993	0.9033	0.9994	0.9869	0.894	1	0.8558	0.8694	0.8714	0.7805	**0.8995**
12	1	0.7902	0.8763	0.8599	0.8597	0.9667	0.9232	0.9178	0.7935	0.754	0.7682	**0.8645**
13	0.8256	0.947	0.8521	0.9556	0.9866	0.8542	0.929	0.988	1	0.7478	0.9566	**0.913**
14	0.8017	1	0.8984	1	1	1	0.9507	1	0.9921	1	0.916	**0.9599**
15	0.909	1	1	1	1	1	1	1	1	0.9857	1	**0.9904**
16	0.8694	0.8372	1	1	1	1	0.9173	1	0.9515	1	1	**0.9614**
17	1	0.9558	0.9822	1	1	0.9725	0.8732	0.9931	0.8259	0.8286	0.9185	**0.9409**
18	0.8376	0.9547	0.923	0.8573	0.8562	0.9525	0.8296	0.971	1	0.7939	0.9147	**0.8991**
19	0.6049	0.9742	0.9106	0.9848	0.9248	1	0.7896	1	0.9837	0.6175	0.8749	**0.8786**
20	0.7705	0.9619	0.8513	0.9047	0.9015	0.8503	0.8822	1	0.9066	0.9671	0.9283	**0.9022**
21	0.8006	1	0.9207	0.831	0.8928	0.9073	0.9099	0.937	0.9151	0.7385	0.9417	**0.8904**
22	0.6933	1	0.9459	0.9566	1	0.7984	1	0.7745	1	0.7967	0.9751	**0.9037**
23	0.7823	1	1	0.9952	0.9727	0.886	0.9175	1	1	0.9147	1	**0.9517**
Mean	**0.8585**	**0.8939**	**0.8828**	**0.9133**	**0.9133**	**0.9238**	**0.9157**	**0.9238**	**0.8804**	**0.8324**	**0.8919**	

Table A.3 Input Reducing BCC-Technical Efficiency Scores

DMU	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11
1	3	8,23	3,23	6,15	6,15	2,3	3,22	3,23	3,15	3,14	3,23
2	3,17	23	3,23	6,15	6,15	2	3,11	3,23	3	3	3
3	3	15,23	3	3	6	3	3	3,15	3	3,14	3
4	3,12	15,23	3,23	3,15	6,15	2,3	3,15,22	3,20,23	3,15	3	3,15
5	3,12	8,14,23	3,23	6	6	2,15	5,22	3,15	3,23	3,14	3,23
6	3,12,17	14,15,23	3,15,23	6	6,15	2,3,15	3,15,22	3,15	3,15	3,14	3,23
7	3,12	14,15,23	3,15,16	6,15	6,15	3,8,15	5,22	3,15	13,15	3	15,16
8	3,12	8,21	3,15,23	3,15	6	8	3,22	3,15	3,15	3,14	3,23
9	3,12	8,21	3,15,23	6,15	6	3,8,15	3,5,15	3,15,20	3,15	3,14	15,23
10	3,12	15,23	3,16	3,15	6,15	2,3,15	5,22	3,15	13,15,18	3,14	15,16
11	3,12,17	23	3,23	3,15	6	2	11	3,23	3	3,14	3,23
12	12	14,15,23	15,23	6,15	6,15	15,16,19	3,15,22	3,15	3,15,18	3	3,15,23
13	12,17	14,15,22	3,16	14,16	14,16,22	14,15,16	5,22	14,16,19	13	3,14	15,16
14	12,17	14	3,15,16	14,15	14,16	14,16	3,15,22	14,15,16	13,15,18	14	15,16
15	3,12,17	15,22	15	15	15	15	5,15,22	15	15	3,14	15
16	12,17	15,22	3,16	16	16	16	3,22	16	13,15,18	16	16
17	17	14,15,23	3,23	17	17	2,3	3,22	3,15,20	3	3,14	3,23
18	12,17	8,14,23	15,23	6,15	6,15	8,15	3,15,22	15,20	18,22	3,14	15,23
19	12,17	14,21,22	15,16	14,16	14,16,22	19	3,15,22	16,19	13,22	3,14	15,16
20	12,17	8,14,23	3,15,23	3,15	6,15	3,8	3,15,22	20	3,18,23	3,14	15,23
21	3,12	21	15,16	3,15,17	15,16	15,19	3,22	3,15	13,15,18	3,14	15,16
22	3,12	22	15,16	14,16	22	15,16,19	3,22	14,15	22	3,14	15,16
23	3,12,17	23	15,23	3,17	15,17	2,3,15	3,22	23	23	3	23

Table A.4 Input Reducing BCC- Peers

DMU	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	Mean
1	2.2132	1.8092	1.6529	1.7	1.1648	1.8058	1.509	1.4049	1.6572	1.9241	1.5893	**1.6755**
2	1.253	1.8015	1.4687	1.6733	1.7536	1	1.4043	1.2865	1.8939	1.6328	1.4306	**1.5089**
3	1	1.0921	1	1	1.4355	1	1	1	1	1	1	**1.048**
4	1.4639	1.638	2.0523	1.5402	1.6299	1.6184	1491	1.5344	1.4287	2.6892	1.277	**137.08**
5	1.0797	1.2405	1.6212	1.2898	1.266	1.0219	1	1.1955	1.6271	1.2262	1.2262	**1.254**
6	1.3325	1.3043	1.4022	1	1	1.1556	1.0752	1.0917	1.2275	1.2894	1.1728	**1.1865**
7	1.2874	1.2805	1.5548	1.2318	1.3221	1.2873	1.1103	1.3015	1.3032	1.4931	1.2771	**1.3136**
8	1.0052	1	1.3612	1.3071	1.3122	1	1.0385	1.099	1.1917	1.4875	1.3614	**1.1967**
9	1.4426	1.5404	1.3319	1.1733	1.2157	1.1838	1.2754	1.2075	1.2935	1.2505	1.219	**1.2849**
10	1.4195	1.2985	1.0839	1.2987	1.2588	1.4031	1.0145	1.2959	1.1768	1.2465	1.2549	**1.2501**
11	1.2558	1.8954	1.3962	1.4806	1.7698	1.3723	1	1.648	1.4281	1.1716	1.5273	**1.4496**
12	1	1.3268	1.1288	1.1043	1.0959	1.0219	1.0867	1.0678	1.3326	1.8414	1.4628	**1.2245**
13	1.1273	1.033	1.0455	1.0145	1.006	1.0969	1.0642	1.0062	1	1.3733	1.0492	**1.0742**
14	1.4151	1	1.0953	1	1	1	1.0735	1	1.0067	1	1.1145	**1.0641**
15	1.2381	1	1	1	1	1	1	1	1	1.0466	1	**1.0259**
16	1.2648	1.0725	1	1	1	1	1.1307	1	1.0376	1	1	**1.046**
17	1	1.1504	1.1483	1	1	1.1714	1.2428	1.0205	1.435	1.5075	1.1878	**1.1694**
18	1.4473	1.1601	1.115	1.2454	1.3014	1.0988	1.2927	1.0459	1	1.4161	1.1443	**1.2061**
19	1.007	1.0302	1.0214	1.0051	1.0234	1	1.2843	1	1.0116	1.7154	1.1549	**1.1139**
20	1.3814	1.135	1.3127	1.4253	1.373	1.303	1.2017	1	1.2848	1.0298	1.1319	**1.2344**
21	1.1066	1	1.0691	1.1315	1.0507	1.0724	1.1477	1.0345	1.0661	1.6899	1.0784	**1.1315**
22	1.1322	1	1.0464	1.015	1	1.1563	1	1.0856	1	1.2157	1.0311	**1.062**
23	1.6781	1	1	1.1755	1.5277	1.3655	1.1518	1	1	1.5518	1	**1.2228**
Mean	**1.2848**	**1.2525**	**1.2569**	**1.2092**	**1.2394**	**1.1798**	**65.918**	**1.1446**	**1.2349**	**1.426**	**1.2039**	

Table A.5 Output Increasing BCC -Technical Efficiency Scores

DMU	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	Mean
1	0.4518	0.5527	0.6050	0.5882	0.8585	0.5538	0.6627	0.7118	0.6034	0.5197	0.6292	**0.6124**
2	0.7981	0.5551	0.6809	0.5976	0.5703	1.0000	0.7121	0.7773	0.5280	0.6124	0.6990	**0.6846**
3	1.0000	0.9157	1.0000	1.0000	0.6966	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	**0.9648**
4	0.6831	0.6105	0.4873	0.6493	0.6135	0.6179	0.6707	0.6517	0.6999	0.3719	0.7831	**0.6217**
5	0.9262	0.8061	0.6168	0.7753	0.7899	0.9786	1.0000	0.8365	0.6146	0.8155	0.8155	**0.8159**
6	0.7505	0.7667	0.7132	1.0000	1.0000	0.8654	0.9301	0.9160	0.8147	0.7756	0.8527	**0.8531**
7	0.7768	0.7809	0.6432	0.8118	0.7564	0.7768	0.9007	0.7683	0.7673	0.6697	0.7830	**0.7668**
8	0.9948	1.0000	0.7346	0.7651	0.7621	1.0000	0.9629	0.9099	0.8391	0.6723	0.7345	**0.8523**
9	0.6932	0.6492	0.7508	0.8523	0.8226	0.8447	0.7841	0.8282	0.7731	0.7997	0.8203	**0.7835**
10	0.7045	0.7701	0.9226	0.7700	0.7944	0.7127	0.9857	0.7717	0.8498	0.8022	0.7969	**0.8073**
11	0.7963	0.5276	0.7162	0.6754	0.5650	0.7287	1.0000	0.6068	0.7002	0.8535	0.6548	**0.7113**
12	1.0000	0.7537	0.8859	0.9056	0.9125	0.9786	0.9202	0.9365	0.7504	0.5431	0.6836	**0.8427**
13	0.8871	0.9681	0.9565	0.9857	0.9940	0.9117	0.9397	0.9938	1.0000	0.7282	0.9531	**0.9380**
14	0.7067	1.0000	0.9130	1.0000	1.0000	1.0000	0.9315	1.0000	0.9933	1.0000	0.8973	**0.9493**
15	0.8077	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9555	1.0000	**0.9785**
16	0.7906	0.9324	1.0000	1.0000	1.0000	1.0000	0.8844	1.0000	0.9638	1.0000	1.0000	**0.9610**
17	1.0000	0.8693	0.8709	1.0000	1.0000	0.8537	0.8046	0.9799	0.6969	0.6633	0.8419	**0.8709**
18	0.6909	0.8620	0.8969	0.8030	0.7684	0.9101	0.7736	0.9561	1.0000	0.7062	0.8739	**0.8401**
19	0.9930	0.9707	0.9790	0.9949	0.9771	1.0000	0.7786	1.0000	0.9885	0.5830	0.8659	**0.9210**
20	0.7239	0.8811	0.7618	0.7016	0.7283	0.7675	0.8322	1.0000	0.7783	0.9711	0.8835	**0.8208**
21	0.9037	1.0000	0.9354	0.8838	0.9517	0.9325	0.8713	0.9667	0.9380	0.5918	0.9273	**0.9002**
22	0.8832	1.0000	0.9557	0.9852	1.0000	0.8648	1.0000	0.9211	1.0000	0.8226	0.9698	**0.9457**
23	0.5959	1.0000	1.0000	0.8507	0.6546	0.7323	0.8682	1.0000	1.0000	0.6444	1.0000	**0.8496**
Mean	**0.8069**	**0.8336**	**0.8272**	**0.8520**	**0.8355**	**0.8709**	**0.8788**	**0.8927**	**0.8391**	**0.7435**	**0.8463**	

Table A.6 Output Increasing BCC –Inverse Technical Efficiency Scores

DMU	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11
1	3,12	15,22	3,16	15,16	15,22	2,15	5,22	3,15	13	3,14	15,16
2	3,12	15,22	3,15,23	15,16	14,15,16	2	3,5,15	3,15,20	13,15,18	3,14	3,15
3	3	15,23	3	3	15,16	3	3	3	3,18	3	3
4	3,12	15,22	3,16	14,16	15,22	2,15	3,15,22	15,16	13,15,18	14,16	15,16
5	3,12	14,15,23	3,15,16	15,16	15,16	2,15	5	3,15	13,15,18	14,16	15,23
6	3,12	14,15,22	15,16	6	6	2,15	3,15,22	3,15	13,15,18	3,14	15,23
7	12	15,22	3,16	16	14,16,22	15,16,19	5,22	14,16,19	13,15	16	15,16
8	3,12	8	3,15,16	14,15	14,16,22	8	3,22	3,15	3,15	3,14	15,16
9	3,12	22	15,16	15,16	15,16	8,15	5,22	14,15,16	13,15	14,16	15,16
10	3,12	22	3,16	14,16	14,15,16	14,15,16	5,22	19	13,22	3,14	16
11	3,12	15,22	3,15,23	3,15,17	15,16	2,15	11	3,15	3,15	3,14	15,16
12	12	15,22	15,16	14,15,16	14,15,16	15,16,19	5,22	14,15	13,15,18	3,14	15,16
13	12	15,22	16	14,16	14,16,22	16,19	5,22	14,16,19	13	3,14	15,16
14	12	14	15,16	14	14,16	14	3,15,22	14,19	13,15,18	14	15,16
15	3,12	15	15	15	15	15	5,15,22	15	13,1513	3,14	15
16	12	15,22	16	16	16	16	3,22	16	13,18,22	16	16
17	17	14,15,23	3,15,23	17	17	2,3,15	3,22	3,15,20	13,15,18	3,14	15,23
18	12	8,14,23	15,23	14,15,16	14,15,22	8,15	5,22	15,20	18	3,14	15,16
19	12	14,21,22	16	14,16	22	19	5,22	19	13,22	3,14	16
20	12	8,14,23	15,23	14,15	15,22	15,19	3,15,22	20	13,15,18	3,14	15,16
21	12	21	15,16	14,16	14,16,22	15,19	3,15,22	14,15	13,18,22	14,16	15,16
22	12	22	15,16	14,16	22	15,16,19	22	19	22	3,14	15,16
23	12	14,23	23	3,15,17	15,22	8,15	3,22	23	3,18,23	3,14	23

Table A.7 Output Increasing BCC -Peers

DMU	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	Mean
1	0.8345	0.71	0.7511	0.7943	0.794	0.8733	0.7558	0.8574	0.6235	0.6029	0.7686	**0.7605**
2	0.9181	0.8304	0.9164	0.9292	0.9286	1	0.8705	0.7478	0.7201	0.7034	0.9384	**0.8639**
3	1	1	1	1	0.9841	1	1	1	1	1	1	**0.9986**
4	0.8375	1	0.5539	0.6511	0.7252	0.8746	0.9122	0.701	0.8147	0.8518	0.8537	**0.7978**
5	0.964	0.9354	0.6692	1	0.9141	1	1	0.9041	0.7256	1	0.9084	**0.911**
6	0.9205	0.8801	0.802	1	1	0.9496	0.9517	0.9756	0.8788	1	1	**0.9417**
7	0.8131	0.7905	0.6697	1	0.7308	0.7932	0.8828	0.7925	1	0.7767	0.8351	**0.8259**
8	1	1	0.8027	0.8407	0.8183	1	1	1	1	0.8984	0.8338	**0.9267**
9	0.8326	1	0.7922	0.94	0.9896	0.9186	0.8133	0.8959	0.8668	0.8827	0.8769	**0.8917**
10	1	0.6456	1	0.7984	0.882	0.7664	1	0.7383	0.8207	0.833	0.7628	**0.8407**
11	0.9343	0.811	0.7211	0.9994	1	1	1	0.8558	0.9379	0.8754	0.7928	**0.9025**
12	1	0.7902	0.8813	0.8599	0.9494	0.9667	0.9232	0.9206	0.7935	0.765	0.7682	**0.8744**
13	0.851	0.947	1	0.9798	0.9866	0.8543	0.9292	0.988	1	0.7492	1	**0.935**
14	0.8595	1	0.8984	1	1	1	0.9507	1	0.9921	1	0.9171	**0.9653**
15	0.909	1	1	1	1	1	1	1	1	1	1	**0.9917**
16	1	1	1	1	1	1	1	1	0.9515	1	1	**0.9956**
17	0.9286	0.9558	0.835	1	1	0.8251	1	0.9931	0.8451	0.8555	0.9344	**0.9248**
18	1	0.9547	1	0.8573	0.8562	0.9584	0.8296	1	1	0.797	0.928	**0.9256**
19	1	0.9742	1	1	0.9248	1	0.7896	1	1	0.6194	0.8752	**0.9257**
20	0.8161	0.9619	0.8513	0.9047	0.9015	0.9162	0.8822	1	0.9066	1	0.9369	**0.9161**
21	0.8006	1	0.9388	0.831	0.9121	1	0.9212	0.9396	0.9152	0.7453	0.9536	**0.9052**
22	1	1	1	0.9655	1	0.7984	1	0.7761	1	1	1	**0.9582**
23	0.7823	1	1	0.9952	0.9727	0.886	0.9814	1	1	1	1	**0.9652**
Mean	**0.9131**	**0.9212**	**0.8732**	**0.9281**	**0.9248**	**0.9296**	**0.9301**	**0.9168**	**0.904**	**0.8676**	**0.908**	

Table A.8 Input Based Input Disposability -Technical Efficiency Scores

DMU	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	Mean
1	1	0.7101	1	0.8004	0.8241	1	0.754	0.8596	0.6093	0.5891	0.758	**0.8095**
2	0.9188	0.9027	1	0.9375	1	1	1	1	0.7192	0.7527	1	**0.9301**
3	1	0.9837	1	1	0.9997	1	1	1	1	1	1	**0.9985**
4	0.8371	0.8433	1	0.73	0.7515	0.8999	0.9122	0.7954	0.7894	0.9127	0.8497	**0.8474**
5	0.9637	0.9354	0.7834	0.9054	0.9035	0.99	1	0.8968	0.7385	0.8753	0.8942	**0.8987**
6	0.9205	0.8801	0.802	1	1	0.9496	0.9517	0.9482	0.8634	0.915	0.9173	**0.9225**
7	0.7764	0.7755	0.6697	0.731	0.7319	0.7932	0.8806	0.771	0.7748	0.7678	0.8205	**0.772**
8	0.9977	1	0.8306	0.8407	0.8338	1	0.9752	0.9449	0.9225	0.9467	0.8259	**0.9198**
9	0.8322	0.7401	0.8083	0.9408	0.9399	0.9186	0.8133	0.8959	0.8117	0.8763	0.8646	**0.8583**
10	0.8289	0.6454	0.9176	0.7984	0.7904	0.7664	0.9825	0.7327	0.8207	0.7752	0.7584	**0.8015**
11	0.9343	1	0.9496	1	1	0.9296	1	0.9035	0.8802	0.8714	0.7805	**0.9317**
12	1	0.7902	0.8763	0.8605	0.8597	0.9667	0.9232	0.9178	0.7935	1	0.7682	**0.8869**
13	0.8256	0.947	0.8522	0.9556	0.9866	0.8543	0.929	0.988	1	0.7478	0.9566	**0.913**
14	0.8017	1	0.8984	1	1	1	0.9507	1	0.9927	1	0.916	**0.96**
15	0.909	1	1	1	1	1	1	1	1	0.9857	1	**0.9904**
16	0.8697	0.8372	1	1	1	1	0.9173	1	0.9515	1	1	**0.9614**
17	1	0.9558	1	1	1	1	0.8732	0.9931	0.8323	0.8286	0.9185	**0.9456**
18	0.8376	0.9547	0.923	0.86	0.8633	0.9525	0.8296	0.971	1	0.7938	0.9147	**0.9**
19	0.6049	0.9742	0.9106	0.9848	0.9248	1	0.7896	1	0.9837	0.6175	0.8749	**0.8786**
20	0.7705	0.9619	0.8513	0.9077	0.9266	0.8503	0.8822	1	0.9066	0.9671	0.9284	**0.9048**
21	0.8006	1	0.9208	0.831	0.8928	0.9073	0.9099	0.937	0.9152	0.7385	0.9417	**0.8904**
22	0.6933	1	0.9459	0.9566	1	0.7984	1	0.7745	1	0.7967	0.9751	**0.9037**
23	0.7823	1	1	1	1	0.886	0.9175	1	1	1	1	**0.9623**
Mean	**0.8654**	**0.906**	**0.9104**	**0.9148**	**0.923**	**0.9332**	**0.9214**	**0.9274**	**0.8828**	**0.859**	**0.8984**	

Table A.9 Input Based Output Disposability -Technical Efficiency Scores

DMU	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	Mean
1	2.013	1.745	1.565	1.6987	1.5707	1.7986	1.5082	1.3506	1	1	1.5667	**1.5288**
2	1.2513	1.7743	1.4687	1.6727	1.7536	1	1.4043	1.2865	1.8939	1	1.3535	**1.4417**
3	1	1	1	1	1.2016	1	1	1	1	1	1	**1.0183**
4	1.3382	1	2.0308	1.537	1	1.6154	1.1491	1.519	1.4287	206411	1.2704	**18766**
5	1.0785	1.2405	1.6212	1	1.2138	1	1	1.1463	1.6271	1	1.1834	**1.1919**
6	1.3324	1.3043	1.3856	1	1	1.1534	1.0752	1.0341	1.2275	1	1	**1.1375**
7	1.0333	1.2396	1	1	1.3221	1.2873	1.1009	1.3015	1	1	1.2593	**1.1404**
8	1	1	1.3612	1.2484	1.3122	1	1	1	1	1.4502	1.3367	**1.1553**
9	1.263	1	1.3268	1.0715	1.0253	1.1459	1.27	1.2075	1.2427	1.2121	1.2028	**1.1789**
10	1	1	1	1.2626	1.2588	1.4031	1	1.2884	1.1762	1.0748	1	**1.1331**
11	1.2557	1.5645	1.3962	1.4806	1	1	1	1.5882	1.3412	1	1.4962	**1.2839**
12	1	1.2812	1.1111	1.1043	1.0959	1.0219	1.0844	1.0669	1.3326	1.4593	1.4549	**1.183**
13	1.1119	1.0224	1	1.0116	1.006	1	1.0606	1.0062	1	1.219	1	**1.0398**
14	1.2805	1	1.0855	1	1	1	1.0735	1	1.0067	1	1.1139	**1.0509**
15	1.2366	1	1	1	1	1	1	1	1	1	1	**1.0215**
16	1	1	1	1	1	1	1	1	1.0376	1	1	**1.0034**
17	1	1.1504	1.1483	1	1	1.1714	1	1.0205	1.435	1.4485	1.1565	**1.1391**
18	1	1.1601	1	1.2454	1.3014	1.0679	1.2921	1	1	1.3364	1.1163	**1.1381**
19	1	1.0302	1	1	1	1	1	1	1	1.0781	1.1408	**1.0226**
20	1.292	1.135	1.2904	1.4114	1.3427	1.2063	1.2017	1	1.2848	1	1.1041	**1.2062**
21	1.0634	1	1.0488	1.1311	1.0507	1	1.1477	1.0215	1.0661	1.6031	1.0658	**1.1089**
22	1	1	1	1.0063	1	1.1563	1	1	1	1	1	**1.0148**
23	1.5341	1	1	1.1755	1.4473	1.3441	1.1108	1	1	1	1	**1.1465**
Mean	**1.1776**	**1.1586**	**1.2104**	**1.1764**	**1.1697**	**1.1466**	**1.1078**	**1.1234**	**1.1783**	**8975.5**	**1.1661**	

Table A.10 Output Based Input Disposability -Technical Efficiency Scores

DMU	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	Mean
1	0.497	0.573	0.639	0.589	0.637	0.556	0.663	0.74	1	1	0.638	**0.685**
2	0.799	0.564	0.681	0.598	0.57	1	0.712	0.777	0.528	1	0.739	**0.724**
3	1	1	1	1	0.832	1	1	1	1	1	1	**0.985**
4	0.747	1	0.492	0.651	1	0.619	0.87	0.658	0.7	0.484	0.787	**0.728**
5	0.927	0.806	0.617	1	0.824	1	1	0.872	0.615	1	0.845	**0.864**
6	0.751	0.767	0.722	1	1	0.867	0.93	0.967	0.815	1	1	**0.893**
7	0.968	0.807	1	1	0.756	0.777	0.908	0.768	1	1	0.794	**0.889**
8	1	1	0.735	0.801	0.762	1	1	1	1	0.69	0.748	**0.885**
9	0.792	1	0.754	0.933	0.975	0.873	0.787	0.828	0.805	0.825	0.831	**0.855**
10	1	1	1	0.792	0.794	0.713	1	0.776	0.85	0.93	1	**0.896**
11	0.796	0.639	0.716	0.675	1	1	1	0.63	0.746	1	0.668	**0.806**
12	1	0.781	0.9	0.906	0.912	0.979	0.922	0.937	0.75	0.685	0.687	**0.86**
13	0.899	0.978	1	0.989	0.994	1	0.943	0.994	1	0.82	1	**0.965**
14	0.781	1	0.921	1	1	1	0.932	1	0.993	1	0.898	**0.957**
15	0.809	1	1	1	1	1	1	1	1	1	1	**0.983**
16	1	1	1	1	1	1	1	1	0.964	1	1	**0.997**
17	1	0.869	0.871	1	1	0.854	1	0.98	0.697	0.69	0.865	**0.893**
18	1	0.862	1	0.803	0.768	0.936	0.774	1	1	0.748	0.896	**0.89**
19	1	0.971	1	1	1	1	1	1	1	0.928	0.877	**0.98**
20	0.774	0.881	0.775	0.709	0.745	0.829	0.832	1	0.778	1	0.906	**0.839**
21	0.94	1	0.953	0.884	0.952	1	0.871	0.979	0.938	0.624	0.938	**0.916**
22	1	1	1	0.994	1	0.865	1	1	1	1	1	**0.987**
23	0.652	1	1	0.851	0.691	0.744	0.9	1	1	1	1	**0.894**
Mean	**0.875**	**0.891**	**0.86**	**0.877**	**0.879**	**0.896**	**0.915**	**0.909**	**0.877**	**0.888**	**0.875**	

Table A.11 Output Based Input Disposability –Inverse Technical Efficiency Scores

DMU	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	Mean
1	2.2132	1.8092	1.6529	1.7002	1.6488	1.8058	1.509	1.4049	1.6572	1.9241	1.5893	**1.7195**
2	1.2529	1.8015	1.4687	1.6733	1.7536	1	1.4043	1.2865	1.8939	1.6328	1.4306	**1.5089**
3	1	1.0921	1	1	1.4355	1	1	1	1	1	1	**1.048**
4	1.4639	1.638	2.0523	1.5402	1.6299	1.6184	1.1491	1.5344	1.4287	2.6892	1.277	**1.6383**
5	1.0797	1.2405	1.6212	1.2898	1.266	1.0219	1	1.1955	1.6271	1.2262	1.2262	**1.254**
6	1.3325	1.3043	1.4022	1	1	1.1556	1.0752	1.0917	1.2275	1.2894	1.1728	**1.1865**
7	1.2873	1.2805	1.5548	1.2318	1.3221	1.2873	1.1103	1.3015	1.3032	1.4931	1.2771	**1.3135**
8	1.0052	1	1.3614	1.3071	1.3122	1	1.0385	1.099	1.1917	1.4875	1.3614	**1.1967**
9	1.4426	1.5404	1.3319	1.1733	1.2157	1.1838	1.2754	1.2075	1.2935	1.2505	1.219	**1.2849**
10	1.4195	1.2985	1.0839	1.2987	1.2588	1.4031	1.0145	1.2959	1.1768	1.2465	1.2549	**1.2501**
11	1.2558	1.8954	1.3962	1.4806	1.7698	1.3723	1	1.648	1.4281	1.1716	1.5273	**1.4496**
12	1	1.3268	1.1288	1.1043	1.0959	1.0219	1.0867	1.0678	1.3326	1.8414	1.4628	**1.2245**
13	1.1273	1.0338	1.0455	1.0145	1.006	1.0969	1.0642	1.0062	1	1.3733	1.0492	**1.0743**
14	1	1	1.0953	1	1	1	1.0735	1	1.0067	1	1.1145	**1.0264**
15	1.2381	1	1	1	1	1	1	1	1	1.0466	1	**1.0259**
16	1.2648	1.0725	1	1	1	1	1.1307	1	1.0376	1	1	**1.046**
17	1	1.1504	1.1483	1	1	1.1714	1.2428	1.0205	1.435	1.5075	1.1878	**1.1694**
18	1.4472	1.1601	1.115	1.2454	1.3014	1.0988	1.2927	1.0459	1	1.4161	1.1443	**1.2061**
19	1.007	1.0302	1.0214	1.0051	1.0234	1	1.2843	1	1.0116	1.7154	1.1549	**1.1139**
20	1.3814	1.135	1.3127	1.4253	1.373	1.303	1.2017	1	1.2848	1.0298	1.1319	**1.2344**
21	1.1066	1	1.0691	1.1315	1.0507	1.0724	1.1477	1.0345	1.0661	1.6899	1.0784	**1.1315**
22	1.1322	1	1.0464	1.015	1	1.1563	1	1.0856	1	1.2157	1.0311	**1.062**
23	1.6781	1	1	1.1755	1.5277	1.3655	1.1518	1	1	1.5518	1	**1.2228**
Mean	**1.2668**	**1.2526**	**1.2569**	**1.2092**	**1.2605**	**1.1798**	**1.1414**	**1.1446**	**1.2349**	**1.426**	**1.2039**	

Table A.12 Output Based Output Disposability -Technical Efficiency Scores

DMU	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	Mean
1	0.452	0.553	0.605	0.588	0.607	0.554	0.663	0.712	0.603	0.52	0.629	**0.59**
2	0.798	0.555	0.681	0.598	0.57	1	0.712	0.777	0.528	0.612	0.699	**0.685**
3	1	0.916	1	1	0.697	1	1	1	1	1	1	**0.965**
4	0.683	0.611	0.487	0.649	0.614	0.618	0.87	0.652	0.7	0.372	0.783	**0.64**
5	0.926	0.806	0.617	0.775	0.79	0.979	1	0.836	0.615	0.816	0.816	**0.816**
6	0.75	0.767	0.713	1	1	0.865	0.93	0.916	0.815	0.776	0.853	**0.853**
7	0.777	0.781	0.643	0.812	0.756	0.777	0.901	0.768	0.767	0.67	0.783	**0.767**
8	0.995	1	0.735	0.765	0.762	1	0.963	0.91	0.839	0.672	0.735	**0.852**
9	0.693	0.649	0.751	0.852	0.823	0.845	0.784	0.828	0.773	0.8	0.82	**0.783**
10	0.704	0.77	0.923	0.77	0.794	0.713	0.986	0.772	0.85	0.802	0.797	**0.807**
11	0.796	0.528	0.716	0.675	0.565	0.729	1	0.607	0.7	0.854	0.655	**0.711**
12	1	0.754	0.886	0.906	0.912	0.979	0.92	0.937	0.75	0.543	0.684	**0.843**
13	0.887	0.967	0.956	0.986	0.994	0.912	0.94	0.994	1	0.728	0.953	**0.938**
14	1	1	0.913	1	1	1	0.932	1	0.993	1	0.897	**0.976**
15	0.808	1	1	1	1	1	1	1	1	0.955	1	**0.978**
16	0.791	0.932	1	1	1	1	0.884	1	0.964	1	1	**0.961**
17	1	0.869	0.871	1	1	0.854	0.805	0.98	0.697	0.663	0.842	**0.871**
18	0.691	0.862	0.897	0.803	0.768	0.91	0.774	0.956	1	0.706	0.874	**0.84**
19	0.993	0.971	0.979	0.995	0.977	1	0.779	1	0.989	0.583	0.866	**0.921**
20	0.724	0.881	0.762	0.702	0.728	0.767	0.832	1	0.778	0.971	0.883	**0.821**
21	0.904	1	0.935	0.884	0.952	0.932	0.871	0.967	0.938	0.592	0.927	**0.9**
22	0.883	1	0.956	0.985	1	0.865	1	0.921	1	0.823	0.97	**0.946**
23	0.596	1	1	0.851	0.655	0.732	0.868	1	1	0.644	1	**0.85**
Mean	**0.82**	**0.834**	**0.827**	**0.852**	**0.825**	**0.871**	**0.888**	**0.893**	**0.839**	**0.744**	**0.846**	

Table A.13 Output Based Output Disposability –Inverse Technical Efficiency Scores

DMU	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	
	Labor	Labor	Labor	Labor	Labor	Labor	Labor	Labor	Labor	Labor	Labor	Mean
1	0.8	0.72	0.75	0.81	.79	.8	0.76	0.95	0.6	0.59	0.76	**0.748888**
2	0.92	0.78	0.96	0.94	.93	1	0.85	1	0.71	0.69	0.83	**0.853333**
3	1	0.82	1	1	.98	1	1	1	1	1	1	**0.98**
4	0.81	0.66	0.75	0.74	.73	.82	0.92	0.87	0.78	0.76	0.85	**0.793333**
5	0.95	0.96	0.8	0.91	.9	.94	1	0.95	0.73	0.88	0.9	**0.897777**
6	0.94	0.91	0.88	1	1	.96	0.96	1	0.86	0.92	0.92	**0.932222**
7	0.71	0.82	0.68	0.73	.73	.82	0.86	0.8	0.77	0.77	0.82	**0.773333**
8	0.86	1	0.86	0.84	.83	1	0.99	1	0.92	0.87	0.83	**0.907777**
9	0.81	0.77	0.86	0.95	.94	.97	0.83	0.92	0.81	0.88	0.87	**0.855555**
10	0.73	0.64	0.83	0.8	.79	.77	0.87	0.76	0.77	0.72	0.76	**0.764444**
11	0.94	0.7	0.93	1	.99	.8	1	0.93	0.88	0.87	0.78	**0.892222**
12	1	0.81	0.97	0.86	.86	.99	0.92	0.92	0.79	0.75	0.77	**0.865555**
13	0.83	0.96	0.84	0.91	.99	.87	0.92	0.99	1	0.75	0.85	**0.894444**
14	0.82	1	0.96	1	1	1	0.95	1	0.98	1	0.91	**0.957777**
15	0.91	1	1	1	1	1	1	1	1	0.99	1	**0.988888**
16	0.88	0.82	1	1	1	1	0.92	1	0.82	1	1	**0.937777**
17	1	0.97	1	1	1	.93	0.88	1	0.83	0.83	0.92	**0.92875**
18	0.86	1	1	0.86	.86	.99	0.85	0.96	1	0.79	0.91	**0.914444**
19	0.6	1	0.92	0.87	.93	1	0.79	1	0.81	0.62	0.87	**0.831111**
20	0.79	1	0.93	0.92	1	.86	0.89	1	0.93	0.91	0.93	**0.922222**
21	0.79	1	1	0.83	.9	.92	0.92	0.93	0.83	0.73	0.94	**0.885555**
22	0.64	1	1	0.89	1	.8	1	0.77	1	0.68	0.97	**0.883333**
23	0.79	1	1	0.99	1	0.94	0.92	1	1	0.91	1	**0.955**
Mean	**0.842608**	**0.884347**	**0.909565**	**0.902272**	**0.91**	**0.94**	**0.913043**	**0.945652**	**0.861739**	**0.822173**	**0.886521**	
DMU	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**	**P11**	
	RM	**RM**	**RM**	**RM**	**RM**	**RM**	**RM**	**RM**	**RM**	**RM**	**RM**	**Mean**
1	0.82	0.68	0.72	0.69	.69	.92	0.74	0.7	0.57	0.46	0.64	**0.668889**
2	0.91	0.83	0.56	0.85	.76	1	0.87	0.89	0.6	0.59	0.85	**0.772222**
3	1	0.98	1	1	.64	1	1	1	1	1	1	**0.997778**
4	0.84	0.84	0.63	0.67	.64	.91	0.86	0.67	0.73	0.35	0.85	**0.715556**
5	0.96	0.9	0.56	0.61	.58	.99	1	0.73	0.7	0.57	0.73	**0.751111**
6	0.87	0.84	0.5	1	1	.93	0.83	0.71	0.83	0.51	0.47	**0.728889**
7	0.78	0.7	0.63	0.53	.54	.76	0.88	0.59	0.52	0.53	0.69	**0.65**
8	1	1	0.65	0.84	.58	1	0.82	0.66	0.78	0.66	0.71	**0.791111**
9	0.83	0.45	0.64	0.71	.56	.84	0.76	0.81	0.71	0.7	0.74	**0.705556**
10	0.83	0.65	0.92	0.8	.42	.76	0.99	0.63	0.83	0.78	0.7	**0.792222**
11	0.89	0.8	0.64	1	.46	.94	1	0.69	0.75	0.82	0.65	**0.804444**
12	1	0.75	0.65	0.84	.53	.9	0.9	0.88	0.79	0.65	0.71	**0.796667**
13	0.77	0.92	0.85	0.96	.88	.83	0.93	0.94	1	0.7	0.95	**0.891111**
14	0.68	1	0.76	1	1	1	0.88	1	0.99	1	0.89	**0.911111**
15	0.9	1	1	1	1	1	1	1	1	0.63	1	**0.947778**
16	0.7	0.84	1	1	1	1	0.75	1	0.98	1	1	**0.918889**
17	1	0.93	0.8	1	1	1	0.73	0.97	0.78	0.6	0.74	**0.81875**
18	0.64	0.88	0.55	0.81	.65	.88	0.72	0.97	1	0.66	0.77	**0.777778**
19	0.55	0.88	0.75	0.98	.89	1	0.74	1	1	0.53	0.86	**0.81**
20	0.66	0.89	0.52	0.85	.74	.71	0.8	1	0.88	0.97	0.8	**0.818889**
21	0.8	1	0.66	0.83	.68	.63	0.8	0.91	0.94	0.52	0.82	**0.808889**
22	0.69	1	0.54	0.96	1	.76	1	0.77	1	0.79	0.71	**0.828889**
23	0.74	1	1	1	.94	0.82	0.82	1	1	0.46	1	**0.884**
Mean	**0.82**	**0.85913**	**0.718696**	**0.860455**	**0.74**	**0.82**	**0.861739**	**0.848696**	**0.842609**	**0.673043**	**0.794783**	

Table A.14 Input Reducing Non-Radial -Technical Efficiency Scores

DMU	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11
1	3	8,23	3,23	6,15	6,15	2,3	3,22	3,23	3,15	3,14	3,23
2	3,17	23	3,23	6,15	6,15	2	3,11	3,23	3	3	3
3	3	15,23	3	3	6	3	3	3	3	3	3
4	3,12	15,23	3,23	3,15	6,15	2,3	3,15,22	3,20,23	3,15	3	3,15
5	3,12	8,14,23	3,23	6	6	2,15	5	3,15	3,23	3,14	3,23
6	3,12,17	14,15,23	3,15,23	6	6	2,3,15	3,15,22	3,15	3,15	3,14	3,23
7	3,12	14,15,23	3,15,16	6,15	6,15	3,8,15	5,22	3,15	13,15	3,14	15,16
8	3,12	8	3,15,23	3,15	6	8	3,22	3,15	3,15	3	3,23
9	3,12	8,21	3,15,23	6,15	6	3,8,15	3,5,15	3,15,20	3,15	3,14	15,23
10	3,12	15,23	3,16	3,15	6,15	2,3,15	5,22	3,15	13,15,18	3,14	15,16
11	3,12,17	23	3,23	3,15	6	2	11	3,23	3	3,14	3,23
12	12	14,15,23	15,23	6,15	6,15	15,16,19	3,15,22	3,15	3,15,18	3	3,15,23
13	12,17	14,15,22	3,16	14,16	14,16,22	14,15,16	5,22	14,16,19	13	3,14	15,16
14	12,17	14	3,15,16	14	14	14	3,15,22	14	13,15,18	14	15,16
15	3,12,17	15	15	15	15	15	15	15	15	3,14	15
16	12,17	15,22	16	16	16	16	3,22	16	13,15,18	16	16
17	17	14,15,22	3,23	17	17	2,3	3,22	3,15,20	3	3,14	3,23
18	12,17	8,14,23	15,23	6,15	6,15	8,15	3,15,22	15,20	18	3,14	15,23
19	12,17	14,21,22	15,16	14,16	14,16,22	19	3,15,22	19	13,22	3,14	15,16
20	12,17	8,14,23	3,15,23	3,15	6,15	3,8	3,15,22	20	3,18,23	3,14	15,23
21	3,12	21	15,16	3,15,17	15,16	15,19	3,22	3,15	13,15,18	3,14	15,16
22	3,12	22	15,16	14,16	22	15,16,19	22	14,15	22	3,14	15,16
23	3,12,17	23	23	3,17	15,17	2,3,15	3,22	23	23	3	23

Table A.15 Input Reducing Non-Radial -Peers

DMU	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	Mean
1	0.452	0.552	0.606	0.588	0.606	0.552	0.662	0.714	0.602	0.521	0.629	**0.59**
2	0.8	0.556	0.68	0.599	0.571	1	0.714	0.775	0.529	0.613	0.699	**0.685**
3	1	0.917	1	1	0.694	1	1	1	1	1	1	**0.965**
4	0.685	0.61	0.488	0.649	0.613	0.617	0.87	0.654	0.699	5E-04	0.781	**0.606**
5	0.926	0.806	0.617	0.775	0.787	0.98	1	0.833	0.613	0.813	0.813	**0.815**
6	0.752	0.769	0.714	1	1	0.862	0.926	0.917	0.813	0.775	0.855	**0.853**
7	0.775	0.781	0.645	0.813	0.758	0.775	0.901	0.769	0.769	0.671	0.781	**0.767**
8	0.99	1	0.735	0.763	0.763	1	0.962	0.909	0.84	0.671	0.735	**0.852**
9	0.694	0.649	0.752	0.855	0.82	0.847	0.781	0.826	0.775	0.8	0.82	**0.784**
10	0.704	0.769	0.926	0.769	0.794	0.714	0.99	0.769	0.847	0.8	0.8	**0.808**
11	0.794	0.528	0.714	0.676	0.565	0.73	1	0.606	0.699	0.855	0.654	**0.711**
12	1	0.758	0.885	0.909	0.909	0.98	0.917	0.935	0.752	0.543	0.685	**0.843**
13	0.885	0.971	0.952	0.99	0.99	0.909	0.943	0.99	1	0.73	0.952	**0.938**
14	0.704	1	0.909	1	1	1	0.935	1	0.99	1	0.901	**0.949**
15	0.806	1	1	1	1	1	1	1	1	0.952	1	**0.978**
16	0.794	0.935	1	1	1	1	0.885	1	0.962	1	1	**0.961**
17	1	0.87	0.87	1	1	0.855	0.806	0.98	0.694	0.662	0.84	**0.871**
18	0.69	0.862	0.893	0.806	0.769	0.909	0.775	0.952	1	0.704	0.877	**0.84**
19	0.99	0.971	0.98	1	0.98	1	0.781	1	0.99	0.581	0.87	**0.922**
20	0.725	0.885	0.763	0.704	0.73	0.769	0.833	1	0.781	0.971	0.885	**0.822**
21	0.901	1	0.935	0.885	0.952	0.935	0.87	0.971	0.935	0.592	0.926	**0.9**
22	0.885	1	0.952	0.99	1	0.862	1	0.917	1	0.82	0.971	**0.945**
23	0.595	1	1	0.855	0.658	0.73	0.87	1	1	0.645	1	**0.85**
Mean	**0.806**	**0.834**	**0.827**	**0.853**	**0.824**	**0.871**	**0.888**	**0.892**	**0.839**	**0.727**	**0.847**	

Table A.16 Output Increasing Non-Radial - Inverse Technical Efficiency Scores

DMU	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11
1	3,12	15,22	3,16	15,16	15,22	2,15	5,22	3,15	13	3,14	15,16
2	3,12	15,22	3,15,23	15,16	14,15,16	2	3,5	3,15,20	13,15,18	3,14	3,15
3	3	15,23	3	3	15,16	3	3	3	3	3	3
4	3,12	15,22	3,16	14,16	15,22	2,15	3,15,22	15,16	13,15,18	14,16	15,16
5	3,12	14,15,23	3,15,16	15,16	15,16	2,15	5	3,15	13,15,18	14,16	15,23
6	3,12	14,15,22	15,16	6	6	2,15	3,15,22	3,15	13,15,18	3,14	15,23
7	12	15,22	3,16	16	14,16,22	15,16,19	5,22	14,16,19	13,15	16	15,16
8	3,12	8	3,15,16	14,15	14,16,22	8	3,22	3,15	3,15	3,14	15,16
9	3,12	22	15,16	15,16	15,16	8,15	5,22	14,15,16	13,15	14,16	15,16
10	3,12	22	3,16	14,16	14,15,16	14,15,16	5,22	19	13,22	3,14	16
11	3,12	15,22	3,15,23	3,15,17	15,16	2,15	11	3,15	3,15	3,14	15,16
12	12	15,22	15,16	14,15,16	14,15,16	15,16,19	5,22	14,15	13,15,18	3,14	15,16
13	12	15,22	16	14,16	14,16,22	16,19	5,22	14,16,19	13	3,14	15,16
14	12	14	15,16	14	14	14	3,15,22	14	13,15,18	14	15,16
15	3,12	15	15	15	15	15	15	15	15	3,14	15
16	12	15,22	16	16	16	16	3,22	16	13,18,22	16	16
17	17	14,15,23	3,15,23	17	17	2,3,15	3,22	3,15,20	13,15,18	3,14	15,23
18	12	8,14,23	15,23	14,15,16	14,15.22	8,15	5,22	15,20	18	3,14	15,16
19	12	14,21,22	16	14,16	22	19	5,22	19	13,22	3,14	16
20	12	8,14,23	15,23	1415	15,22	15,19	3,15,22	20	13,15,18	3,14	15,16
21	12	21	15,16	14,16	14,16,22	15,19	3,15,22	14,15	13,18,22	14,16	15,16
22	12	22	15,16	14,16	22	15,16,19	22	19	22	3,14	15,16
23	12	23	23	3,15,17	15,22	8,15	3,22	23	23	3,14	23

Table A.17 Output Increasing Non-Radial -Peers

DMU	Efficiency	Peers
1	0.8127	3
2	0.9038	3
3	1	3
4	0.8245	3,15
5	0.8869	3,15
6	0.934	3,15
7	0.767	3,15
8	0.9323	3,15
9	0.8635	3,15
10	0.8229	3,15
11	0.8661	3
12	0.8877	3,15
13	1	13,15
14	0.9717	15,16
15	1	15
16	1	16
17	0.9317	3,15
18	0.885	3,15
19	0.8702	15,16
20	0.8635	3,15
21	0.8869	15,16
22	0.9099	13,15,16
23	0.8988	3
Mean	**0.9008**	

Table A.18 Input Reducing BCC- Aggregate Technical Efficiency Scores

DMU	Efficiency	Inverse	Peers
1	1.5725	0.6359	13,15
2	1.3655	0.7323	3,15
3	1	1.0000	3
4	1.4553	0.6871	13,15
5	1.2573	0.7954	13,15
6	1.1789	0.8482	3,15
7	1.2293	0.8135	13,15
8	1.156	0.8651	3,15
9	1.2278	0.8145	15,16
10	1.164	0.8591	13,15
11	1.5479	0.6460	3,15
12	1.1109	0.9002	13,15,16
13	1	1.0000	13
14	1.0215	0.9790	15,16
15	1	1.0000	15
16	1	1.0000	16
17	1.2069	0.8286	3,15
18	1.2163	0.8222	15,16
19	1.0184	0.9819	13
20	1.3	0.7692	15,16
21	1.0926	0.9152	15,16
22	1.0171	0.9832	13
23	1.3425	0.7449	3,15
Mean	**1.194813**	**0.8531**	

Table A.19 Output Increasing BCC- Aggregate Technical Efficiency Scores

DMU	Efficiency
1	1
2	1
3	1
4	0.9451
5	0.9032
6	0.9119
7	0.8024
8	0.9803
9	0.8665
10	1
11	0.6576
12	0.9533
13	1
14	1
15	1
16	1
17	0.9394
18	1
19	1
20	1
21	1
22	0.9099
23	1
Mean	**0.950852**

Table A.20 Input Based Input Disposability- Aggregate Technical Efficiency Scores

DMU	Efficiency
1	0.8648
2	1
3	1
4	0.8245
5	0.8869
6	0.934
7	0.767
8	0.9323
9	0.8635
10	0.8229
11	0.9668
12	0.8877
13	1
14	0.9717
15	1
16	1
17	0.9317
18	0.885
19	0.8702
20	0.8635
21	0.8869
22	0.9099
23	0.9166
Mean	**0.91243**

Table A.21 Input Based Output Disposability- Aggregate Technical Efficiency Scores

DMU	Efficiency
1	1
2	1
3	1
4	1.0985
5	1.1639
6	1.0563
7	1.2238
8	1.0306
9	1.2242
10	1
11	1.5247
12	1.1109
13	1
14	1
15	1
16	1
17	1.205
18	1
19	1
20	1
21	1
22	1
23	1
Mean	**1.071213**

Table A.22 Output Based Input Disposability- Aggregate Technical Efficiency Scores

DMU	Efficiency
1	1.5725
2	1.3655
3	1
4	1.4553
5	1.2573
6	1.2268
7	1.2293
8	1.156
9	1.2427
10	1.164
11	1.576
12	1.1211
13	1
14	1.0531
15	1
16	1.0027
17	1.2095
18	1.3334
19	1.0184
20	1.4286
21	1.1552
22	1.0171
23	1.5457
Mean	**1.2230521**

Table A.23 Output Based Output Disposability- Aggregate Technical Efficiency Scores

DMU	Labor	RM	Peers
1	0.75	0.81	3
2	0.87	0.9	3
3	1	1	3
4	0.79	0.82	3,15
5	0.88	0.89	3,15
6	0.93	0.85	3,15
7	0.77	0.74	3,15
8	0.91	0.93	3,15
9	0.86	0.81	3,15
10	0.76	0.82	3,15
11	0.87	0.83	3
12	0.89	0.84	3,15
13	1	1	13
14	0.97	0.93	15,16
15	1	1	15
16	1	1	16
17	0.93	0.92	3,15
18	0.89	0.72	3,15
19	0.87	0.78	15,16
20	0.86	0.7	3,15
21	0.89	0.76	15,16
22	0.9	0.92	15,16
23	0.9	0.78	3
Mean	**0.89**	**0.85**	

Table A.24 Input Reducing Non-Radial- Aggregate Technical Efficiency Scores

DMU	Efficiency	Peers
1	0.64	13,15
2	0.73	3,15
3	1.00	3
4	0.68	13,15
5	0.79	13,15
6	0.85	3,15
7	0.81	13,15
8	0.86	3,15
9	0.81	15,16
10	0.86	13,15
11	0.65	3,15
12	0.90	13,15,16
13	1.00	13
14	0.98	15,16
15	1.00	15
16	1.00	16
17	0.83	3,15
18	0.82	15,16
19	0.98	13
20	0.77	15,16
21	0.92	15,16
22	0.98	13
23	0.75	3,15
Mean	**0.85**	

Table A.25 Output-Increasing Non-Radial- Aggregate Technical Efficiency Scores

Time Period	Process 1			Process 2			Process 3			Process 4			Process 5			Process 6		
	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r
	0.05			0.09			0.13			0.12			0.09			0.11		
1																	0.10	
2					0.09			0.07			0.06			0.03				0.04
3									0.03									
4														0.10			0.04	
5					0.15			0.01			0.01			0.22			0.07	
6					0.35			0.08			0.07			0.14				
7					0.11			0.09			0.05			0.25			0.03	
8		0.06			0.19			0.02			0.06			0.06			0.03	
9					0.18									0.04				
10					0.08													
11					0.07			0.05			0.01			0.01				
12					0.12									0.08			0.01	
13					0.02													
14														0.07				
15					0.10			0.18			0.15			0.16			0.11	
16			0.05												0.01			
17												0.02			0.17		0.06	
18																		
19																		
20															0.06			
21					0.05			0.14			0.05						0.02	
22																	0.03	
23						0.11			0.12			0.07			0.13			
	Process 7			**Process 8**			**Process 9**			**Process 10**			**Process 11**					
	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r			
	0.08			0.04			0.003			0.06			0.06					
1		0.02												0.03				
2			0.01			0.07								0.08				
3			0.09			0.07			0.12			0.08			0.03			
4											0.002			0.04				
5											0.01			0.04				
6		0.03			0.02						0.004			0.07				
7											0.03			0.03				
8			0.02		0.00						0.03			0.06				
9																		
10														0.01				
11					0.08						0.05			0.06				
12		0.003									0.01							
13																		
14																		
15		0.12			0.05			0.19			0.06			0.05				
16									0.09									
17						0.01												
18						0.20			0.37									
19						0.01			0.12									
20						0.25			0.26									
21						0.04			0.08									
22									0.21						0.00			
23			0.06			0.28			0.32			0.03			0.10			

Table A.26 Percent Deviations from Output Targets for Plant and Process Levels (Z>0)

Time Period	Process 1			Process 2			Process 3			Process 4			Process 5			Process 6		
	N_r	p^t_r	n^t_r	N_r	p^t_r	n^t_r	N_r	p^t_r	n^t_r	N_r	P^t_r	n^t_r	N_r	p^t_r	n^t_r	N_r	P^t_r	n^t_r
	0.14			0.13			0.05			0.05			0.04			0.09		
1			0.28			0.39			0.24			0.27			0.10			
2			0.01			0.02												0.19
3			0.02			0.13						0.06						
4			0.15			0.30			0.16			0.01			0.16			0.03
5			0.20						0.04						0.04			0.02
6						0.11												0.05
7			0.32			0.26			0.18			0.28			0.14			0.43
8			0.12									0.00050						
9			0.32			0.03			0.01									
10			0.51			0.49			0.106			0.08			0.23			0.20
11			0.21			0.39						0.01						0.22
12			0.19			0.02						0.07						0.38
13									0.01			0.07						0.07
14			0.16															0.07
15			0.29			0.00			0.18									
16									0.05									0.14
17			0.01			0.24						0.19			0.20			0.12
18			0.01			0.12									0.04			
19			0.12									0.02						
20			0.01			0.10												
21			0.08															
22			0.07															0.04
23			0.01			0.19						0.07						
	Process 7			**Process 8**			**Process 9**			**Process 10**			**Process 11**					
	N_r	p^t_r	n^t_r	N_r	p^t_r	n^t_r	N_r	p^t_r	n^t_r	N_r	P^t_r	n^t_r	N_r	p^t_r	n^t_r			
	0.04			0.11			0.07			0.05			0.06					
1						0.16			0.15			0.259			0.15			
2									0.05						0.00			
3																		
4						0.15			0.02						0.03			
5			0.10			0.08			0.08			0.12						
6						0.08			0.01			0.005						
7			0.33			0.06			0.33			0.31			0.24			
8												0.01						
9			0.08			0.10						0.03						
10			0.11						0.06			0.00			0.28			
11			0.02			0.02			0.06									
12			0.25			0.15			0.16			0.25			0.21			
13						0.17									0.02			
14			0.04			0.21			0.10						0.17			
15						0.21			0.06						0.22			
16												0.01						
17									0.14			0.01						
18						0.23			0.23									
19						0.07												
20						0.24			0.09									
21						0.15												
22						0.14												
23						0.23												

Table A.27 Percent Deviations from Labor (Input) Targets for Plant and Process Levels (Z>0)

Time Period	Process 1			Process 2			Process 3			Process 4			Process 5			Process 6		
	N_r	p^t_r	n^t_r	N_r	p^t_r	n^t_r	N_r	p^t_r	n^t_r	N_r	P^t_r	n^t_r	N_r	p^t_r	n^t_r	N_r	P^t_r	n^t_r
	0.14			0.12			0.10			0.09			0.12			0.05		
1			0.23			0.40						0.03						
2																		
3						0.01												0.06
4						0.04						0.06						
5			0.07						0.14			0.19						
6						0.08			0.19			0.29						
7			0.23			0.33						0.50			0.14			0.40
8						0.02									0.07			
9			0.32			0.47						0.258			0.43			
10			0.42			0.40						0.04			0.40			
11			0.29			0.07									0.38			
12			0.32			0.04			0.20			0.14			0.06			0.32
13												0.02						
14			0.28			0.06									0.26			
15			0.24						0.28			0.00						
16			0.29			0.06			0.26			0.14			0.37			0.00
17			0.17						0.05									
18			0.03						0.29			0.04			0.03			
19			0.22															0.17
20			0.11						0.01									
21						0.06			0.01									0.07
22						0.13			0.37									
23									0.24									0.07
	Process 7			**Process 8**			**Process 9**			**Process 10**			**Process 11**					
	N_r	p^t_r	n^t_r	N_r	p^t_r	n^t_r	N_r	p^t_r	n^t_r	N_r	P^t_r	n^t_r	N_r	p^t_r	n^t_r			
	0.10			0.03			0.04			0.24			0.13					
1						0.11									0.11			
2																		
3						0.10												
4												0.47						
5												0.30			0.17			
6												0.43			0.49			
7			0.44						0.49			0.71			0.37			
8						0.17												
9												0.28			0.12			
10															0.24			
11																		
12			0.37									0.36			0.29			
13			0.14									0.34						
14																		
15															0.07			
16			0.21			0.14						0.56			0.03			
17			0.26			0.03									0.07			
18															0.03			
19																		
20			0.13									0.20			0.135			
21			0.17									0.40						
22			0.27												0.28			
23												0.33			0.09			

Table A.28 Percent Deviations from Output Targets for Plant and Process Levels (Z>0)

Time Period	Process 2		Process 3		Process 4		Process 5		Process 6	
	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t
1	0.11		0.14		0.002		0.003		0.27	
2				0.03				0.03	0.05	
3	0.01		0.01		0.03		0.004		0.10	
4	0.10		0.22		0.06					
5										
6									0.04	
7										
8								0.04	0.02	
9			0.002		0.02				0.09	
10			0.12		0.15		0.09		0.18	
11								0.07	0.10	
12			0.05		0.03					
13			0.02		0.04		0.09		0.12	
14	0.02		0.04		0.07				0.08	
15									0.05	
16	0.19		0.15		0.16		0.20		0.32	
17	0.47		0.45		0.38		0.09		0.34	
18	0.25		0.21		0.26		0.25		0.29	
19	0.09		0.08		0.12		0.17		0.07	
20	0.21		0.22		0.23		0.15		0.21	
21							0.01			
22	0.45		0.31		0.19		0.15			
23	0.25		0.23		0.35		0.26		0.15	
	Process 7		**Process 8**		**Process 9**		**Process 10**		**Process 11**	
	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t
1			0.08		0.08		0.04			
2	0.12		0.03		0.08		0.08			
3	0.00		0.04		0.04		0.02		0.001	
4	0.03		0.04		0.07					
5	0.04		0.02		0.04					
6					0.06					
7	0.11		0.12		0.09					
8		0.02		0.07	0.03					
9	0.07		0.11		0.12		0.05		0.02	
10	0.01		0.10		0.06		0.02			
11	0.02				0.05					
12			0.03		0.27				0.01	
13	0.10		0.11		0.21		0.10		0.10	
14	0.10		0.05		0.18		0.09		0.06	
15					0.04		0.063			
16	0.38		0.30		0.54		0.37		0.31	
17	0.23		0.21		0.42		0.31		0.26	
18	0.44		0.19		0.30		0.63		0.61	
19	0.34		0.28		0.38		0.41		0.34	
20	0.35		0.01		0.49		0.40		0.43	
21	0.17		0.10		0.37		0.22		0.17	
22	0.19		0.15		0.24		0.26		0.15	
23	0.69		0.31		0.78		0.80		0.42	

Table A.29 Percent Deviations from Process Line Balance (Z>0)

Time Period	Process 1			Process 2			Process 3			Process 4			Process 5			Process 6		
	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r
	0.05			0.09			0.13			0.12			0.09			0.13		
1																	0.10	
2					0.09			0.07			0.06			0.03				0.04
3									0.03									
4														0.10			0.04	
5					0.15			0.01			0.01			0.22			0.07	
6					0.35			0.08			0.07			0.14				
7					0.11			0.09			0.05			0.25			0.03	
8					0.19			0.02			0.06			0.06			0.01	
9					0.18									0.04			0.06	
10					0.08													
11					0.07			0.05			0.01			0.01				
12					0.12									0.08			0.01	
13					0.02													
14														0.07				
15					0.10			0.18			0.15			0.16			0.56	
16			0.05												0.01			
17												0.02			0.17			
18																		
19																	0.09	
20															0.06			
21					0.05			0.14			0.05						0.02	
22																	0.03	
23						0.11			0.12			0.07			0.13			
	Process 7			**Process 8**			**Process 9**			**Process 10**			**Process 11**					
	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r			
	0.09			0.07			0.00			0.06			0.06					
1		0.02			0.10									0.03				
2			0.01			0.07								0.07				
3			0.09			0.07			0.12			0.08			0.03			
4											0.002			0.04				
5		0.12			0.34						0.01			0.04				
6		0.18			0.12						0.004			0.07				
7					0.19						0.03			0.03				
8			0.02			0.001					0.03			0.04				
9																		
10					0.06									0.01				
11					0.08						0.05			0.06				
12		0.003									0.01							
13																		
14																		
15		0.12			0.05			0.10						0.05				
16									0.09									
17						0.01												
18						0.20			0.37									
19						0.06			0.12									
20						0.25			0.26						0.01			
21						0.05			0.08									
22						0.01			0.21						0.03			
23			0.06			0.28			0.32			0.03			0.10			

Table A.30 Percent Deviations from Output Targets for Plant and Process Levels (Z<1)

Time Period	Process 1			Process 2			Process 3			Process 4			Process 5			Process 6		
	N_r	p^t_r	n^t_r	N_r	p^t_r	n^t_r	N_r	p^t_r	n^t_r	N_r	P^t_r	n^t_r	N_r	p^t_r	n^t_r	N_r	P^t_r	n^t_r
	0.13			0.13			0.03			0.06			0.04			0.08		
1			0.28			0.39			0.26			0.27			0.04			
2			0.01			0.02												0.19
3						0.13						0.06						
4			0.12			0.30			0.16			0.01			0.07			0.07
5			0.20						0.04						0.04			0.02
6			0.10			0.11												0.05
7			0.32			0.27			0.18			0.28			0.23			0.15
8			0.17									0.00050						
9			0.18			0.03			0.01									
10			0.51			0.49			0.002			0.06			0.18			0.20
11			0.07			0.39						0.01						0.22
12			0.11			0.08						0.07			0.05			0.38
13			0.18			0.06						0.07						0.07
14			0.16															0.16
15			0.29			0.10						0.14			0.06			0.10
16																		0.07
17												0.19			0.20			
18			0.01			0.07												
19												0.02						
20						0.13												
21																		
22			0.11															0.01
23			0.01			0.19						0.07						
	Process 7			**Process 8**			**Process 9**			**Process 10**			**Process 11**					
	N_r	p^t_r	n^t_r	N_r	p^t_r	n^t_r	N_r	p^t_r	n^t_r	N_r	P^t_r	n^t_r	N_r	p^t_r	n^t_r			
	0.04			0.10			0.05			0.07			0.06					
1						0.01			0.22			0.352			0.04			
2									0.05						0.00			
3																		
4						0.11									0.03			
5			0.10						0.05			0.12						
6			0.08			0.08			0.04			0.005						
7			0.33									0.30			0.24			
8												0.01						
9			0.01			0.16			0.05			0.03						
10			0.09			0.01			0.09			0.11			0.25			
11			0.04			0.02			0.09									
12						0.15						0.25			0.21			
13						0.17			0.02						0.12			
14						0.10			0.09						0.04			
15			0.06			0.29						0.33			0.22			
16																		
17			0.07															
18			0.11			0.23			0.23									
19						0.10						0.06			0.02			
20			0.05			0.24			0.09									
21						0.15												
22						0.15												
23						0.23												

Table A.31 Percent Deviations from Labor (Input) Targets for Plant and Process Levels (Z<1)

Time Period	Process 1			Process 2			Process 3			Process 4			Process 5			Process 6		
	N_r	p^t_r	n^t_r	N_r	p^t_r	n^t_r	N_r	p^t_r	n^t_r	N_r	P^t_r	n^t_r	N_r	p^t_r	n^t_r	N_r	P^t_r	n^t_r
	0.11			0.11			0.09			0.10			0.12			0.05		
1			0.23			0.40						0.03			0.07			
2												0.07						
3						0.01												0.06
4						0.04						0.06						
5			0.07						0.14			0.27						
6						0.08			0.19			0.29						
7			0.23			0.33						0.50			0.18			0.17
8			0.05			0.02									0.07			0.01
9			0.16			0.47						0.258			0.15			
10			0.42			0.40						0.03			0.40			
11						0.07									0.38			
12						0.05			0.20			0.14			0.15			0.32
13			0.33															
14			0.28			0.02									0.26			
15			0.24						0.10			0.19						0.00
16			0.30			0.01									0.37			
17			0.13			0.07												0.04
18			0.03						0.22			0.04						
19			0.05						0.24									
20																		
21									0.01						0.13			0.31
22						0.06			0.37			0.02						
23									0.24									0.01
	Process 7			**Process 8**			**Process 9**			**Process 10**			**Process 11**					
	N_r	p^t_r	n^t_r	N_r	p^t_r	n^t_r	N_r	p^t_r	n^t_r	N_r	P^t_r	n^t_r	N_r	p^t_r	n^t_r			
	0.10			0.01			0.02			0.23			0.09					
1																		
2																		
3						0.10												
4												0.25						
5						0.0002			0.13			0.30						
6									0.04			0.43			0.06			
7			0.44						0.02			0.70			0.37			
8						0.15												
9			0.01						0.14			0.28			0.12			
10															0.21			
11			0.05															
12												0.36			0.29			
13			0.08									0.29						
14			0.05															
15									0.12			0.64			0.08			
16			0.32			0.03						0.54						
17			0.22			0.03									0.19			
18			0.29												0.15			
19																		
20			0.22												0.107			
21			0.20															
22			0.25												0.24			
23												0.33			0.07			

Table A.32 Percent Deviations from RM (Input) Targets for Plant and Process Levels (Z<1)

Time Period	Process 2		Process 3		Process 4		Process 5		Process 6	
	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t
1	0.11		0.14		0.002		0.003		0.27	
2				0.03				0.03	0.05	
3	0.01		0.01		0.03		0.004		0.10	
4	0.10		0.22		0.06					
5										
6									0.04	
7										
8	0.03							0.04		
9			0.002		0.02				0.15	
10			0.12		0.15		0.09		0.18	
11								0.07	0.10	
12			0.05		0.03					
13			0.02		0.04		0.09		0.12	
14	0.02		0.04		0.07				0.08	
15									0.47	
16	0.14		0.15		0.16		0.20		0.32	
17	0.47		0.45		0.38		0.09		0.26	
18	0.25		0.21		0.26		0.25		0.29	
19	0.01		0.08		0.12		0.17		0.17	
20	0.21		0.22		0.23		0.15		0.21	
21							0.01			
22	0.34		0.31		0.19		0.15			
23	0.41		0.23		0.35		0.26		0.15	
	Process 7		**Process 8**		**Process 9**		**Process 10**		**Process 11**	
	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t
1			0.19		0.08		0.04		0.11	
2	0.12		0.03		0.08		0.08			
3	0.00		0.04		0.04		0.02		0.001	
4	0.03		0.04		0.07					
5	0.16		0.36		0.04					
6	0.14		0.10		0.06					
7	0.11		0.34		0.09					
8		0.02		0.07	0.03					
9	0.07		0.11		0.12		0.05		0.02	
10	0.01		0.16		0.06		0.02			
11	0.02				0.05					
12			0.03		0.10				0.01	
13	0.10		0.11		0.21		0.10		0.10	
14	0.10		0.05		0.18		0.09		0.06	
15					0.14		0.003			
16	0.38		0.30		0.54		0.37		0.31	
17	0.23		0.21		0.42		0.31		0.26	
18	0.44		0.19		0.30		0.63		0.61	
19	0.34		0.21		0.38		0.41		0.34	
20	0.35		0.01		0.49		0.40		0.42	
21	0.17		0.08		0.37		0.22		0.17	
22	0.19		0.13		0.24		0.26		0.13	
23	0.69		0.31		0.78		0.80		0.41	

Table A.33 Percent Deviations from Process Line Balance(Z<1)

Time Period	Process 1			Process 2			Process 3			Process 4			Process 5			Process 6		
	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r
	0.03			0.08			0.12			0.11			0.09			0.08		
1																		
2					0.09			0.07			0.06			0.01				
3			0.04						0.03									
4														0.10			0.04	
5					0.15			0.01			0.01			0.22			0.07	
6					0.35			0.08			0.06			0.10				
7					0.11			0.09			0.05			0.25			0.03	
8					0.23			0.02			0.06			0.05			0.01	
9					0.18									0.04				
10		0.02			0.08													
11					0.07			0.05			0.01							
12					0.12									0.08			0.01	
13					0.02													
14														0.07				
15					0.10			0.18			0.15			0.07			0.06	
16			0.12			0.04			0.07			0.07						0.10
17															0.03			
18																		
19			0.09			0.07			0.11			0.11						0.13
20															0.06			
21					0.05			0.11			0.05						0.02	
22			0.12			0.07			0.11			0.11						0.13
23									0.01			0.03			0.13			
	Process 7			**Process 8**			**Process 9**			**Process 10**			**Process 11**					
	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r			
	0.06			0.01						0.05			0.02					
1		0.02												0.03				
2			0.00			0.07		0.02						0.07				
3			0.11			0.01			0.12			0.11			0.03			
4								0.14						0.04				
5								0.0001						0.04				
6		0.03			0.02									0.07				
7														0.03				
8			0.02			0.03								0.04				
9																		
10								0.21						0.01				
11		0.05			0.06						0.08			0.06				
12		0.003																
13						0.08			0.05						0.003			
14																		
15		0.12			0.05									0.05				
16			0.12			0.20			0.17			0.12			0.15			
17															0.001			
18						0.10			0.39						0.03			
19			0.17			0.23			0.21			0.14			0.19			
20						0.10			0.28						0.05			
21						0.09			0.08						0.001			
22			0.16			0.23			0.21			0.14			0.12			
23			0.07			0.10			0.26						0.12			

Table A.34 Percent Deviations from Output Targets for Plant and Process Levels (SUMZ=1, Strategy III)

Time Period	Process 1			Process 2			Process 3			Process 4			Process 5			Process 6		
	N_I	p^t_i	n^t_i	N_I	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_I	p^t_i	n^t_i	N_i	p^t_i	n^t_i
	0.05			0.10			0.07			0.06			0.02			0.10		
1						0.19			0.23			0.16			0.01			
2						0.09												0.01
3						0.02								0.01			0.04	
4			0.03			0.22			0.01			0.13			0.19			
5			0.04						0.12									0.08
6																		
7			0.14			0.15			0.31			0.10						0.11
8			0.05									0.00100						
9			0.02			0.24												
10			0.15			0.27			0.20			0.09						0.23
11						0.15								0.01				0.15
12						0.18			0.14									
13						0.06			0.31			0.15			0.02			0.34
14			0.02						0.14			0.11						0.13
15																		0.01
16						0.25			0.10			0.10		0.01				0.34
17		0.05						0.02				0.08			0.07			
18			0.12															
19												0.19			0.04			0.32
20			0.15			0.01												
21			0.10												0.03			
22			0.08			0.07						0.17						0.31
23			0.15					0.13				0.03						
	Process 7			**Process 8**			**Process 9**			**Process 10**			**Process 11**					
	N_I	p^t_i	n^t_i	N_I	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_I	p^t_i	n^t_i			
	0.04			0.12			0.05			0.04			0.07					
1			0.17						0.18			0.307			0.14			
2		0.01										0.07			0.08			
3					0.07													
4						0.03									0.02			
5									0.06			0.04						
6																		
7			0.20			0.16			0.04			0.05			0.15			
8																		
9			0.03			0.08												
10			0.18			0.25						0.17			0.24			
11						0.06												
12			0.04			0.16									0.02			
13			0.05			0.24			0.24						0.24			
14			0.13			0.19						0.09			0.14			
15			0.003			0.04									0.05			
16						0.21			0.19						0.16			
17					0.01													
18						0.13												
19			0.07			0.26			0.27			0.04			0.17			
20			0.04			0.09												
21						0.18									0.03			
22						0.33												
23		0.01				0.04					0.04							

Table A.35 Percent Deviations from Labor (Input) Targets for Plant and Process Levels (SUMZ=1, Strategy III)

Time Period	Process 1			Process 2			Process 3			Process 4			Process 5			Process 6		
	N_I	p^t_i	n^t_i	N_I	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_I	p^t_i	n^t_i	N_i	p^t_i	n^t_i
	0.11			0.08			0.12			0.10			0.08			0.10		
1						0.21						0.27						
2																	0.07	
3											0.01						0.04	
4												0.15						
5												0.37			0.31			
6			0.08						0.30									
7						0.14						0.35						
8																		0.01
9						0.53			0.17			0.002			0.20			0.15
10			0.14			0.32									0.41			0.14
11			0.14												0.01			
12						0.07			0.25									
13			0.21			0.04			0.28			0.13			0.11			0.27
14			0.20									0.16						0.12
15			0.06															
16			0.34									0.20			0.35			0.24
17			0.13								0.08			0.17				
18			0.39						0.28									
19												0.18			0.05			0.39
20			0.36						0.14						0.05			0.17
21			0.06						0.24									0.21
22						0.10			0.37			0.19						0.25
23			0.20		0.17				0.14		0.04							0.04
	Process 7			**Process 8**			**Process 9**			**Process 10**			**Process 11**					
	N_I	p^t_i	n^t_i	N_I	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_I	p^t_i	n^t_i			
	0.05			0.03			0.09			0.19			0.03					
1			0.23						0.26						0.14			
2									0.18									
3						0.04												
4									0.07									
5						0.01			0.06			0.58			0.09			
6						0.08						0.34			0.06			
7			0.14			0.16			0.46			0.19						
8																		
9			0.01															
10			0.14			0.12			0.22						0.20			
11																		
12									0.17									
13			0.02			0.06			0.21			0.23						
14			0.31									0.36						
15												0.31						
16			0.09			0.22						0.43						
17			0.02			0.01									0.10			
18					0.13										0.01			
19						0.04						0.07						
20					0.20							0.31			0.004			
21												0.28						
22						0.09												
23					0.24			0.14				0.32			0.01			

Table A.36 Percent Deviations from RM (Input) Targets for Plant and Process Levels (SUMZ=1, Strategy III)

Time Period	Process 2		Process 3		Process 4		Process 5		Process 6	
	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t
1	0.11		0.14		0.002		0.003		0.15	
2				0.03				0.05	0.10	
3	0.01		0.01		0.03		0.004		0.10	
4	0.10		0.22		0.06					
5										
6						0.01		0.04	0.04	
7										
8	0.03							0.04		
9			0.002		0.02				0.09	
10			0.12		0.15		0.09		0.18	
11								0.08	0.10	
12			0.05		0.03					
13			0.02		0.04		0.09		0.12	
14	0.02		0.04		0.07				0.08	
15					0.001			0.08		
16	0.14		0.06		0.08		0.21		0.19	
17	0.47		0.45		0.42		0.27		0.26	
18	0.25		0.21		0.26		0.25		0.29	
19	0.01			0.04		0.001	0.17			0.07
20	0.21		0.22		0.23		0.15		0.21	
21				0.03			0.01			
22	0.34		0.17		0.06		0.15			0.16
23	0.41		0.39		0.41		0.26		0.15	
	Process 7		**Process 8**		**Process 9**		**Process 10**		**Process 11**	
	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t
1			0.08		0.08		0.10			
2	0.13		0.03		0.10		0.12			0.01
3		0.02	0.11		0.04		0.02		0.001	
4	0.03		0.04		0.22		0.05			
5	0.04		0.02		0.04		0.03			
6					0.06		0.04			
7	0.11		0.12		0.09		0.04			
8		0.02		0.10	0.03					0.02
9	0.07		0.11		0.12		0.12		0.02	
10	0.01		0.10		0.29		0.06			
11	0.07			0.49	0.05					
12			0.03		0.10		0.04		0.01	
13	0.10		0.02		0.15		0.13		0.10	
14	0.01		0.05		0.18		0.09		0.06	
15					0.04		0.006			
16	0.24		0.04		0.40		0.21		0.11	
17	0.23		0.23		0.42		0.31		0.26	
18	0.44		0.35		0.27		0.63		0.57	
19	0.17			0.01	0.24		0.22		0.09	
20	0.35		0.21		0.45		0.40		0.36	
21	0.17		0.04		0.36		0.22		0.17	
22	0.04			0.12	0.24		0.09		0.02	
23	0.05		0.63		0.95		0.87		0.38	

Table A.37 Percent Deviations from Process Line Balance (SUMZ=1, Strategy III)

Time Period	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11
1	1,3,8,19	17,19	3,8,17	5,23	1,5,17	8,11,13,17	3,5	2,5,8,17	5,22	3,5,18	5,23
2	2,3,8,16	3,8,19	2	6,8,11,12	6,8,23	2,8	8,11	2	8,22	8,12,22	3,8
3	3	3,4,23	3	3,11,17	6,8,11	3,8	3	2	3	3	3
4	1,8,12	8,16,23	3,10,16	10,14	9,22,23	5,8,9,14	3,4,8,11	2,8,14	8,22	6,11,16 ,23	3,15,16
5	3,17,23	3,8,12,17	2,12,17	4,11,17	15,17,2 2	1,8,17	3,5,11,22	1,8,12	12,23	12,18	2,12,10,9
6	2,3,5	8,9,16,23	4,8,17	6	6	4,8,11,14	6,8,9,11	2,11,23	4,7,14,15	9,11,23	3,6,11
7	1,2,20	17,22	8,22,23	10,21	7,8,17,2 2	6,21,23	6,8	4,8	12,22	6,13	17,22
8	1,3,8	8	2,3,4,8	8,11,14	8	2,3,8	8	8	8	3,8,15, 17	3,8
9	1,8,20	8,17	7,8,17	6,7,8	8,11,15	2,8,13	5,13	2,14,22	7,11,14,16	6,7,8,1 5	3,9,10,11
10	1	4,17	3,14,17	1,7,11	7,17,22	3,22	1,11	6,8	8,22	9,11,18	5,13
11	1,3,8	15,17,19	2,3,8,1 7	3,11,15,23	8,11	2,8,17	11	2,8	3,7,11,14	2,3,11, 22	3,8,19,22
12	2,13,16,17	19,23	8,23	6,7,8,20	11,12,2 2,23	1,19,22,23	5,11,21	2,8,20	8,22,23	2,8,11, 12	3,10,22
13	8,19,22	3,19	3,8	2,8	2,19	8,11	2,22	8	8	8,19,22	11,22
14	9,16	8,11,17,22	8,11,22	8,11	6,8,17,2 1	8,11	11,20	2,8,11	7,11,14,22	11,15	3,11,17
15	1,3,17	3,4,9,23	4,8,17, 20	15	15	1,8,23	3,5,13,23	2,15,23	3,7,15,23	3,12,23	3,13,23
16	8,19	19,21	8,19	8	8,22	8	8,22	8	8,22	8,22	11,22
17	2,3	3,8,21,23	2,3,23	11,17	23	2,3,8,11	11,19,20	2,3	3,6,11,22	3,8,16, 22	3,11
18	2,5	4,8,21,23	8,21,23	5,8,11,18	8,17,20, 23	7,8,13,21	11,20,22	2	18	5,8,16, 22	3,11
19	19	19	19	8	14,22	8	8,22	8	8,22	22	11,22
20	8,11	8,15,21	2,8,13	2,3,8,11	8,22,23	7,8,13	2,8,11	2	3,18,22	10,11,2 2	3,11
21	12,19	8,9,21,23	8,19	6,8,11,19	4,22	8,21,22	8,16,19,23	2,8	3,18,22	3,14,22	8,11
22	8,19	19	8,19	8	5,17,19, 22	8	22	8	22	22	22
23	2,12	3,8,23	2	11	23	2,8,22	3,8	2	3,18	3,8	3,11

Table A.38 Reference Observations - Peers (SUMZ=1, Strategy III)

Time Period	Process 1			Process 2			Process 3			Process 4			Process 5			Process 6		
	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r
	0.05			0.09			0.13			0.12			0.09			0.10		
1																		
2					0.09			0.07			0.06			0.03				0.04
3									0.03									
4														0.10			0.04	
5					0.15			0.01			0.01			0.22			0.07	
6					0.35			0.08			0.07			0.14				
7					0.11			0.09			0.05			0.25			0.03	
8					0.19			0.02			0.06			0.06			0.03	
9					0.18									0.04				
10					0.08													
11					0.07			0.05			0.01			0.01				
12					0.12									0.08			0.01	
13					0.02													
14														0.07				
15					0.10			0.18			0.15			0.16			0.06	
16			0.05												0.01			
17												0.02			0.17			
18																		
19																		
20															0.06			
21					0.05			0.14			0.05						0.02	
22																	0.03	
23						0.11			0.12			0.07			0.13			
	Process 7			**Process 8**			**Process 9**			**Process 10**			**Process 11**					
	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r			
	0.08			0.04			0.000			0.06			0.06					
1		0.02												0.03				
2			0.01			0.07		0.07						0.08				
3			0.09			0.07			0.12			0.08			0.03			
4											0.002			0.04				
5											0.01			0.04				
6		0.03			0.02						0.004			0.07				
7											0.03			0.03				
8			0.02		0.002						0.03			0.06				
9																		
10														0.01				
11					0.08						0.05			0.06				
12		0.003									0.01							
13																		
14																		
15		0.12			0.05									0.05				
16									0.09									
17						0.01												
18						0.20			0.37									
19						0.01			0.12									
20						0.25			0.26									
21						0.04			0.08									
22									0.21						0.00			
23			0.06			0.28			0.32			0.03			0.10			

Table A.39 Percent Deviations from Output Targets for Plant and Process Levels (Z>0, Strategy III)

Time Period	Process 1			Process 2			Process 3			Process 4			Process 5			Process 6		
	N_I	p^t_i	n^t_i	N_I	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_I	p^t_i	n^t_i	N_i	p^t_i	n^t_i
	0.15			0.12			0.04			0.05			0.04			0.08		
1			0.28			0.39			0.24			0.27			0.10			
2			0.01			0.02												0.19
3			0.02			0.13						0.06						
4			0.15			0.30			0.16			0.01			0.16			
5			0.20						0.04						0.04			
6						0.11												0.05
7			0.32			0.26						0.28			0.14			0.43
8			0.17									0.00050						
9			0.32			0.03			0.01									
10			0.51			0.49			0.106			0.08			0.23			0.04
11			0.21			0.39						0.01						0.22
12			0.19			0.02						0.07						0.38
13			0.18						0.01			0.07						0.07
14			0.16															0.07
15			0.29			0.00			0.18									
16									0.05									0.14
17			0.01									0.19			0.20			0.07
18															0.04			
19			0.12									0.02						
20			0.01			0.10												
21			0.08															
22			0.07															0.04
23			0.01			0.19						0.07						
	Process 7			**Process 8**			**Process 9**			**Process 10**			**Process 11**					
	N_I	p^t_i	n^t_i	N_I	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_I	p^t_i	n^t_i			
	0.05			0.09			0.06			0.05			0.06					
1			0.09						0.17			0.347			0.15			
2									0.09						0.00			
3																		
4						0.08									0.03			
5			0.10						0.05			0.12						
6									0.01			0.005						
7			0.33			0.22			0.33			0.31			0.24			
8												0.01						
9			0.08			0.10						0.03						
10			0.11						0.05			0.00			0.28			
11			0.02			0.02			0.12									
12			0.25			0.15			0.16			0.25			0.21			
13						0.17									0.02			
14						0.08									0.09			
15						0.15			0.28						0.22			
16												0.01						
17												0.01						
18						0.23			0.23									
19						0.07												
20						0.24			0.09									
21						0.15												
22						0.14												
23						0.23												

Table A.40 Percent Deviations from Labor (Input) Targets for Plant and Process Levels (Z>0, Strategy III)

Time Period	Process 1			Process 2			Process 3			Process 4			Process 5			Process 6		
	N_I	p^t_i	n^t_i	N_I	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_I	p^t_i	n^t_i	N_i	p^t_i	n^t_i
	0.17			0.12			0.10			0.09			0.12			0.06		
1			0.23			0.40						0.03						0.04
2																		
3						0.01												0.06
4						0.04						0.06						
5			0.07			0.02			0.14			0.26						
6			0.10			0.08			0.19			0.29						
7			0.23			0.33						0.50			0.14			0.40
8			0.05			0.02									0.07			
9			0.32			0.47						0.258			0.43			
10			0.42			0.40						0.04			0.40			
11			0.29			0.07									0.38			
12			0.32			0.04			0.20			0.14			0.06			0.32
13			0.34									0.02						
14			0.28			0.06									0.26			
15			0.24						0.28			0.00						0.03
16			0.29			0.06			0.26			0.14			0.37			0.001
17			0.17						0.05									
18			0.03						0.29			0.04			0.03			0.02
19			0.22															0.17
20			0.11						0.01									
21						0.06												0.07
22						0.13			0.37									
23									0.24									0.07
	Process 7			**Process 8**			**Process 9**			**Process 10**			**Process 11**					
	N_I	p^t_i	n^t_i	N_I	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_I	p^t_i	n^t_i			
	0.10			0.04			0.09			0.25			0.13					
1			0.19			0.01			0.24						0.11			
2																		
3						0.10												
4												0.47						
5									0.13			0.30			0.17			
6						0.05						0.43			0.49			
7			0.44			0.21			0.49			0.71			0.37			
8						0.17												
9									0.09			0.28			0.12			
10									0.29						0.24			
11									0.05									
12			0.37									0.36			0.29			
13			0.14									0.34						
14									0.05									
15									0.24			0.12			0.07			
16			0.21			0.14						0.56			0.05			
17			0.26			0.03									0.07			
18															0.14			
19																		
20												0.20			0.135			
21			0.17									0.40						
22			0.27												0.28			
23												0.33			0.09			

Table A.41 Percent Deviations from RM (Input) Targets for Plant and Process Levels (Z>0, Strategy III)

Time Period	Process 2		Process 3		Process 4		Process 5		Process 6	
	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t
1	0.11		0.14		0.002		0.003		0.15	
2				0.03				0.03	0.05	
3	0.01		0.01		0.03		0.004		0.10	
4	0.10		0.22		0.06					
5										
6									0.04	
7										
8								0.04	0.02	
9			0.002		0.02				0.09	
10			0.12		0.15		0.09		0.18	
11								0.07	0.10	
12			0.05		0.03					
13			0.02		0.04		0.09		0.12	
14	0.02		0.04		0.07				0.08	
15										
16	0.19		0.15		0.16		0.20		0.32	
17	0.47		0.45		0.38		0.09		0.26	
18	0.25		0.21		0.26		0.25		0.29	
19	0.09		0.08		0.12		0.17		0.07	
20	0.21		0.22		0.23		0.15		0.21	
21							0.01			
22	0.45		0.31		0.19		0.15			
23	0.25		0.23		0.35		0.26		0.15	
	Process 7		**Process 8**		**Process 9**		**Process 10**		**Process 11**	
	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t
1			0.08		0.08		0.04			
2	0.12		0.03		0.15		0.08			
3	0.00		0.04		0.04		0.02		0.001	
4	0.03		0.04		0.07					
5	0.04		0.02		0.04					
6					0.06					
7	0.11		0.12		0.09					
8		0.02		0.07	0.03					
9	0.07		0.11		0.12		0.05		0.02	
10	0.01		0.10		0.06		0.02			
11	0.02				0.05					
12			0.03		0.10				0.01	
13	0.10		0.11		0.21		0.10		0.10	
14	0.10		0.05		0.18		0.09		0.06	
15					0.04		0.003			
16	0.38		0.30		0.54		0.37		0.31	
17	0.23		0.21		0.42		0.31		0.26	
18	0.44		0.19		0.30		0.63		0.61	
19	0.34		0.28		0.38		0.41		0.34	
20	0.35		0.01		0.49		0.40		0.43	
21	0.17		0.10		0.37		0.22		0.17	
22	0.19		0.15		0.24		0.26		0.15	
23	0.69		0.31		0.78		0.80		0.42	

Table A.42 Percent Deviations from Process Line Balance (Z>0, Strategy III)

Time Period	Process 1			Process 2			Process 3			Process 4			Process 5			Process 6		
	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r
	0.05			0.09			0.13			0.12			0.09			0.10		
1																		
2					0.09			0.07			0.06			0.03				0.04
3									0.03									
4														0.10			0.04	
5					0.15			0.01			0.01			0.22			0.07	
6		0.18			0.35			0.08			0.07			0.14				
7					0.11			0.09			0.05			0.25			0.03	
8					0.19			0.02			0.06			0.06			0.01	
9					0.18									0.04				
10					0.08													
11					0.07			0.05			0.01			0.01				
12					0.12									0.08			0.01	
13					0.02													
14														0.07				
15					0.10			0.18			0.15			0.16			0.06	
16			0.05												0.01			
17												0.02			0.17			
18																		
19																		
20															0.06			
21					0.05			0.14			0.05						0.02	
22																	0.03	
23						0.11			0.12			0.07			0.13			
	Process 7			**Process 8**			**Process 9**			**Process 10**			**Process 11**					
	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r			
	0.08			0.03			0.00			0.06			0.06					
1		0.02												0.03				
2			0.01			0.07		0.07						0.08				
3			0.09			0.07			0.12			0.08			0.03			
4											0.002			0.04				
5											0.01			0.04				
6		0.03			0.02						0.004			0.07				
7											0.03			0.03				
8			0.02			0.001					0.03			0.06				
9																		
10														0.01				
11					0.08						0.05			0.06				
12		0.003									0.01							
13																		
14																		
15		0.12			0.05									0.05				
16									0.09									
17						0.01												
18						0.20			0.37									
19						0.06			0.12									
20						0.25			0.26						0.01			
21						0.05			0.08									
22						0.01			0.21						0.03			
23			0.06			0.28			0.32			0.03			0.10			

Table A.43 Percent Deviations from Output Targets for Plant and Process Levels (Z<1, Strategy III)

Time Period	Process 1			Process 2			Process 3			Process 4			Process 5			Process 6		
	N_I	p^t_i	n^t_i	N_I	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_I	p^t_i	n^t_i	N_i	p^t_i	n^t_i
	0.12			0.13			0.03			0.06			0.04			0.09		
1			0.28			0.39			0.24			0.27			0.10			
2			0.01			0.02												0.19
3			0.03			0.13						0.06						
4			0.15			0.30			0.16			0.01			0.07			
5			0.20						0.04						0.04			0.02
6			0.01			0.11												0.05
7			0.32			0.27			0.18			0.28			0.23			0.43
8			0.17									0.00050						
9			0.18			0.03			0.01									
10			0.51			0.49			0.002			0.06			0.18			0.03
11			0.07			0.39						0.005						0.22
12			0.11			0.08						0.07			0.05			0.38
13			0.18									0.07						0.07
14			0.16															0.07
15			0.29			0.10						0.14			0.06			0.39
16																		0.07
17												0.19			0.20			
18						0.07												
19												0.02						
20						0.10												
21																		
22			0.11															0.01
23			0.01			0.19						0.07						
	Process 7			**Process 8**			**Process 9**			**Process 10**			**Process 11**					
	N_I	p^t_i	n^t_i	N_I	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_I	p^t_i	n^t_i			
	0.04			0.10			0.06			0.07			0.06					
1			0.09						0.17			0.347			0.15			
2									0.09						0.00			
3																		
4						0.08									0.03			
5			0.10						0.05			0.12						
6			0.06						0.04			0.005						
7			0.33			0.14			0.33			0.30			0.24			
8												0.01						
9			0.00			0.10			0.04			0.03						
10			0.09			0.02			0.05			0.00			0.25			
11			0.04			0.02			0.12									
12						0.15						0.25			0.21			
13						0.17									0.12			
14						0.10									0.04			
15			0.06			0.29						0.33			0.22			
16																		
17			0.06						0.14									
18						0.23			0.23									
19						0.10						0.06			0.02			
20			0.03			0.24			0.09									
21						0.15												
22						0.15												
23						0.23												

Table A.44 Percent Deviations from Labor (Input) Targets for Plant and Process Levels (Z<1, Strategy III)

Time Period	Process 1			Process 2			Process 3			Process 4			Process 5			Process 6		
	N_I	p^t_i	n^t_i	N_I	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_I	p^t_i	n^t_i	N_i	p^t_i	n^t_i
	0.12			0.12			0.09			0.10			0.12			0.09		
1			0.23			0.40						0.03						0.04
2												0.07						
3						0.01												0.06
4						0.04						0.06						
5			0.07			0.02			0.14			0.26						
6			0.11			0.08			0.19			0.29						
7			0.23			0.33						0.50			0.18			0.40
8			0.05			0.02									0.07			0.01
9			0.16			0.47						0.258			0.15			
10			0.42			0.40						0.03			0.40			
11						0.07									0.38			
12						0.05			0.20			0.14			0.15			0.32
13			0.33			0.01												
14			0.28			0.02									0.26			
15			0.24						0.10			0.19						0.32
16			0.30			0.01						0.11			0.37			
17			0.13			0.07												0.04
18			0.03						0.22			0.04						0.02
19			0.05			0.05			0.24									0.15
20																		0.20
21									0.01						0.13			0.31
22						0.06			0.37			0.02						
23									0.24									0.01
	Process 7			**Process 8**			**Process 9**			**Process 10**			**Process 11**					
	N_I	p^t_i	n^t_i	N_I	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_I	p^t_i	n^t_i			
	0.10			0.03			0.08			0.25			0.14					
1			0.19			0.01			0.24						0.11			
2																		
3						0.10												
4												0.25						
5									0.13			0.30			0.17			
6						0.05			0.04			0.43			0.49			
7			0.44			0.18			0.49			0.70			0.37			
8						0.15												
9									0.13			0.28			0.12			
10									0.29						0.21			
11			0.05						0.05						0.18			
12												0.36			0.29			
13			0.08									0.29						
14			0.05						0.05									
15												0.64			0.08			
16			0.32			0.03						0.51						
17			0.20			0.03						0.24			0.19			
18															0.15			
19																		
20			0.21												0.107			
21			0.20									0.38						
22			0.25												0.24			
23												0.33			0.07			

Table A.45 Percent Deviations from RM (Input) Targets for Plant and Process Levels (Z<1, Strategy III)

Time Period	Process 2		Process 3		Process 4		Process 5		Process 6	
	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t
1	0.11		0.14		0.002		0.003		0.15	
2				0.03				0.03	0.05	
3	0.01		0.01		0.03		0.004		0.10	
4	0.10		0.22		0.06					
5										
6									0.04	
7										
8								0.04		
9			0.002		0.02				0.09	
10			0.12		0.15		0.09		0.18	
11								0.07	0.10	
12			0.05		0.03					
13			0.02		0.04		0.09		0.12	
14	0.02		0.04		0.07				0.08	
15										
16	0.19		0.15		0.16		0.20		0.32	
17	0.47		0.45		0.38		0.09		0.26	
18	0.25		0.21		0.26		0.25		0.29	
19	0.09		0.08		0.12		0.17		0.07	
20	0.21		0.22		0.23		0.15		0.21	
21							0.01			
22	0.45		0.31		0.19		0.15			
23	0.25		0.23		0.35		0.26		0.15	
	Process 7		**Process 8**		**Process 9**		**Process 10**		**Process 11**	
	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t
1			0.08		0.08		0.04			
2	0.12		0.03		0.15		0.08			
3	0.00		0.04		0.04		0.02		0.001	
4	0.03		0.04		0.07					
5	0.04		0.02		0.04					
6					0.06					
7	0.11		0.12		0.09					
8		0.02		0.07	0.03					
9	0.07		0.11		0.12		0.05		0.02	
10	0.01		0.10		0.06		0.02			
11	0.02				0.05					
12			0.03		0.10				0.01	
13	0.10		0.11		0.21		0.10		0.10	
14	0.10		0.05		0.18		0.09		0.06	
15					0.04		0.003			
16	0.38		0.30		0.54		0.37		0.31	
17	0.23		0.21		0.42		0.31		0.26	
18	0.44		0.19		0.30		0.63		0.61	
19	0.34		0.21		0.38		0.41		0.34	
20	0.35		0.01		0.49		0.40		0.42	
21	0.17		0.08		0.37		0.22		0.17	
22	0.19		0.13		0.24		0.26		0.13	
23	0.69		0.31		0.78		0.80		0.41	

Table A.46 Percent Deviations from Process Line Balance (Z<1, Strategy III)

Time Period	Process 1			Process 2			Process 3			Process 4			Process 5			Process 6		
	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	N^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r
	0.001			0.04			0.06			0.05			0.05			0.01		
1														0.01				
2											0.04			0.07				
3														0.03				
4											0.00			0.12				
5								0.01			0.01			0.10			0.04	
6								0.04									0.00	
7								0.03						0.15			0.06	
8																		
9								0.05			0.05			0.04			0.06	
10											0.00							
11								0.05										
12					0.03									0.12			0.04	
13								0.04			0.05			0.02			0.00	
14								0.02						0.14			0.05	
15								0.04										
16								0.02			0.04			0.09			0.04	
17																	0.18	
18								0.04						0.03			0.12	
19											0.04						0.17	
20					0.01			0.01									0.11	
21								0.06			0.05						0.19	
22																	0.03	
23																	0.56	
	Process 7			**Process 8**			**Process 9**			**Process 10**			**Process 11**					
	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r			
	0.00			0.00			0.00			0.00			0.00					
1		0.10			0.32			0.42										
2		0.06						19.30						0.00				
3																		
4		0.00			0.16			0.20			0.001							
5					0.26			0.32			0.01							
6		0.03			0.25			0.29						0.03				
7					0.19									0.15				
8												0.00			0.00			
9		0.00			0.19						0.18			0.00				
10		0.06			0.25									0.38				
11					0.11													
12		0.029			0.21						0.24			0.02				
13		0.13			0.11						0.15							
14					0.20			0.17						0.05				
15		0.13			0.36			0.21										
16					0.36													
17					0.37			0.38						0.10				
18		0.41			0.27						0.62							
19					0.20			0.12			0.13							
20		0.36									0.02			0.26				
21					0.36									0.01				
22					0.20													
23		0.01			0.01						0.09			0.20				

Table A.47 Percent Deviations from Output Targets for Plant and Process Levels (SUMZ=1, Strategy I, Actual Process Targets)

Time Period	Process 1			Process 2			Process 3			Process 4			Process 5			Process 6		
	N_I	p^t_i	n^t_i	N_I	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_I	p^t_i	n^t_i	N_i	p^t_i	n^t_i
	0.06			0.09			0.08			0.05			0.03			0.08		
1						0.20			0.23			0.16			0.01			
2						0.08												
3																		
4			0.07			0.16						0.12			0.17			
5									0.12									0.06
6														0.00				
7			0.15			0.11			0.31			0.10			0.13			0.01
8																		
9			0.03															
10			0.15			0.39			0.23			0.05			0.03			0.33
11						0.15												0.16
12						0.13			0.15									0.05
13						0.13			0.31			0.17			0.10			0.27
14			0.01						0.18			0.08						0.14
15			0.07			0.11												
16			0.09			0.26									0.08			0.02
17															0.00			
18			0.01						0.01						0.05			
19												0.19			0.09			0.32
20			0.06									0.01			0.02			
21			0.01												0.03			
22			0.37									0.07						0.31
23			0.12											0.00				
	Process 7			**Process 8**			**Process 9**			**Process 10**			**Process 11**					
	N_I	p^t_i	n^t_i	N_I	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_I	p^t_i	n^t_i			
	0.01			0.14			0.04			0.00			0.01					
1			0.06			0.05			0.06									
2															0.08			
3					0.00													
4						0.13												
5						0.09												
6						0.04												
7						0.21			0.04									
8																		
9						0.15												
10			0.13			0.26			0.35						0.17			
11						0.06												
12						0.18						0.01						
13			0.03			0.24												
14						0.20												
15						0.14												
16						0.21			0.03									
17																		
18						0.07												
19			0.00			0.26			0.27			0.04			0.00			
20																		
21						0.18												
22						0.33												
23																		

Table A.48 Percent Deviations from Labor (Input) Targets for Plant and Process Levels (SUMZ=1, Strategy I, Actual Process Targets)

Time Period	Process 1			Process 2			Process 3			Process 4			Process 5			Process 6		
	N_I	p^t_i	n^t_i	N_I	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_I	p^t_i	n^t_i	N_i	p^t_i	n^t_i
	0.12			0.05			0.10			0.09			0.06			0.09		
1						0.23						0.24						0.00
2																	0.07	
3																	0.04	
4												0.14						
5			0.05									0.37						
6									0.30						0.00			
7												0.35			0.19			
8																		
9									0.17									
10			0.13			0.33									0.51			0.23
11			0.17															
12									0.24									0.07
13			0.19			0.07			0.30			0.14			0.21			0.30
14			0.22						0.12			0.12						
15			0.14						0.06									
16			0.34			0.09									0.49			0.00
17														0.00				
18			0.33			0.03			0.21						0.28			
19												0.18			0.14			0.39
20			0.27						0.10			0.11						0.17
21									0.24						0.10			0.21
22			0.37			0.15			0.22			0.10						0.25
23			0.23															
	Process 7			**Process 8**			**Process 9**			**Process 10**			**Process 11**					
	N_I	p^t_i	n^t_i	N_I	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_I	p^t_i	n^t_i			
				0.03			0.12			0.15			0.00					
1									0.35									
2									0.13									
3		0.00				0.00												
4									0.07									
5									0.06			0.53						
6												0.32			0.06			
7						0.12			0.55			0.42						
8																		
9																		
10						0.07			0.37									
11																		
12									0.21									
13						0.06			0.28			0.24						
14												0.05						
15					0.02													
16						0.22			0.05			0.43						
17			0.00			0.01												
18								0.00										
19						0.04												
20																		
21												0.36						
22			0.00			0.09												
23					0.00							0.00						

Table A.49 Percent Deviations from RM (Input) Targets for Plant and Process Levels (SUMZ=1, Strategy I, Actual Process Targets)

Time Period	Process 2		Process 3		Process 4		Process 5		Process 6	
	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t
1	0.04		0.12		0.013				0.09	
2	0.01			0.03				0.05	0.02	
3	0.03		0.01			0.01		0.01		0.01
4			0.16						0.02	
5	0.03									
6	0.05					0.01		0.04		
7	0.25				0.02					
8	0.03		0.03		0.00			0.04	0.02	
9	0.05									
10	0.05		0.02				0.01		0.04	
11	0.06				0.05			0.09	0.01	
12			0.03		0.00					
13	0.01									
14	0.06				0.06					
15	0.06				0.001			0.08	0.10	
16	0.04									
17	0.01		0.02		0.08		0.04		0.21	
18	0.03		0.21		0.01					
19	0.01			0.04		0.001	0.10			0.07
20					0.01		0.00			
21	0.09			0.03			0.02			
22	0.10		0.11		0.04		0.18			0.16
23	0.01			0.04	0.00		0.26			
	Process 7		**Process 8**		**Process 9**		**Process 10**		**Process 11**	
	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t
1			0.32		0.40		0.03		0.00	
2	0.05		0.03				0.01			0.01
3		0.02		0.06	0.04		0.02		0.001	
4			0.13		0.22				0.01	
5	0.02		0.23		0.34				0.01	
6			0.16		0.31		0.02			
7	0.02		0.23		0.05		0.02		0.18	
8		0.02		0.10	0.03		0.02			0.02
9			0.17		0.00		0.17			
10			0.29				0.02		0.35	
11	0.07			0.02	0.13		0.04		0.02	
12			0.12		0.06		0.27			
13	0.13		0.02		0.18		0.15		0.01	
14	0.04		0.07		0.27		0.02			
15			0.25		0.25		0.063		0.03	
16	0.06		0.04		2.44		0.04		0.05	
17	0.00		0.19		0.49		0.04			
18	0.36			0.08	0.27		0.64		0.10	
19	0.04			0.01	0.24		0.19		0.07	
20	0.37			0.33	0.43				0.32	
21	0.02		0.04		0.22		0.04			
22	0.04			0.12	0.24		0.09		0.02	
23			0.63	0.30	0.41		0.30		0.26	

Table A.50 Percent Deviations from Process Line Balance (SUMZ=1, Strategy I, Actual Process Targets)

Time Period	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11
1	1	13,17	3,8,17	5,23	1,10,17	8,13,17	11,22,23	2,8	22	1	9,10,17, 22
2	2	3,8,11	2,23	6,8,11 ,12	6,8,23	2	3,11,22	2	11,16,2 2	2	3,8
3	3	3	3	3	6,8,11	3	3	2,3	3	3	3
4	7,8,17	10,11,17	3,10,16 ,23	10,14	12,15,2 1	5,8,9,1 3	3,8,12,1 6	2,8	8,22	6,11,16, 23	3,13,22, 23
5	1,2,3	2,8,9,23	2,12,17	4,11,1 7	2,10,11 ,16	1,2,23	5,11	2,8	8,22	2,12,18	1,3,6,17
6	2,6,16	2,6,8,19	4,8,17	6	6	3,4,8,1 1	4,5,16,1 7	2,8	8,13,22	9,11,23	3,6,22
7	1,18,20	8,17,20	8,22,23	10,21	17,21	7,14,21	7	8	22,23	1,18,22	6,11,13, 22
8	8	8	8	8	8	8	8	8	8	8,11	8
9	1,8,20	9	7,8,17	5,6,8, 19	4,11,20 ,22	3,16,20 ,21	5,10,19, 23	2,8	1,7,14,2 3	6,8,16	7,9,11,2 1
10	1,4	5,17	3,14,17	1,11,1 7	4,17	3,23	1,11,16	8	3,23	1,5,18,2 2	8,22
11	1,3,8	3,18,19	2,3,8,1 7	11	11	2,8,17	11	2,8	11	11	11
12	2,3,13,16	8,9,10	8,23	6,7,8, 20	8,11,14 ,22	1,22	2,10,16, 19	2,8	11,22,2 3	11,22	2,9,10,2 2
13	8,19,22	3,21	3,8	2,8	2,19	8,11	11,22	8	3,12,22	8,22	13
14	9,16	3,8,18,21	11,22	11,22	17,21,2 2,23	8,22,23	8,16,19, 20	2,8	7,8,22	4,11,15	3,10,11, 12
15	1,3	5,17,23	4,22,23	6,15	15	3,5,8,1 0	5,8,16,1 9	2	3,7,11,2 2	15	15
16	2,19	15,21	3,8,13, 19	7,8,16 ,22	20,22	13,18	10,16,17	8	12,22	8,12,19	8,13,17, 22
17	8,17	17	17	17	17,23	2,3,21	3,17,23	2,3	3,8,22	1,3,9,18	3,6,17,2 2
18	4,5	8,14,20	16,20	8,11,1 8	17,20	3,7,21, 23	8,11,13, 23	2,20	18,23	8,16,22	10,11,17 ,19
19	19	19	19	8	15,22	8	11,19	8	8,22	16,22	11,19,22
20	1,9	7,8,9,17	8,15,23	2,17	2,1017	7,8,23	8,11,22	20	3,18,22, 23	7,18,20	3,19,22
21	8,12,19	21	8,19	5,8,11 ,19	3,11,22	8,21,22	8,16,19, 23	2,8	1,20,22, 23	2,18,19	3,13,20, 22
22	5,6	7,13,20	19,21,2 3	8,19	22,23	9	8,22	8	22	22	22
23	1,3	23	23	23	22,23	3,11,22 ,23	3,16,22, 23	2,20,23	18,23	3,15,23	3,6,10

Table A.51 Reference Observations - Peers (SUMZ=1, Strategy I, Actual Process Targets)

Time Period	Process 1			Process 2			Process 3			Process 4			Process 5			Process 6		
	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	N^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r
	0.001			0.04			0.06			0.05			0.05			0.01		
1														0.01				
2											0.04			0.07				
3														0.03				
4											0.00			0.12				
5								0.01			0.01			0.10			0.04	
6								0.04									0.00	
7								0.03						0.15			0.06	
8																		
9								0.05			0.05			0.04			0.06	
10											0.00							
11								0.05										
12					0.03									0.12			0.04	
13								0.04			0.05			0.02			0.00	
14								0.02						0.14			0.05	
15								0.04										
16								0.02			0.04			0.09			0.04	
17																		
18								0.04						0.03			0.12	
19											0.04						0.17	
20					0.01			0.01									0.11	
21								0.06			0.05						0.19	
22																	0.03	
23																	0.56	
	Process 7			**Process 8**			**Process 9**			**Process 10**			**Process 11**					
	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	N^t_r	P_r	p^t_r	n^t_r	P_r	p^t_r	n^t_r			
	0			0			0			0			0					
1		0.47			0.32			0.02										
2		0.00						0.03						0.00				
3																		
4		0.00			0.16			0.20			0.001							
5					0.26			0.32			0.01							
6		0.03			0.25			0.29						0.22				
7					0.19													
8															0.00			
9		0.08			0.19			0.23			0.01			0.00				
10		0.06			0.25									0.34				
11					0.11			0.00										
12		0.029			0.21						0.06			0.02				
13		0.00			0.11						0.00							
14					0.20			0.17						0.05				
15		0.13			0.28			0.35			0.40			0.18				
16					0.36													
17					0.37			0.38						0.10				
18		0.59			0.27						0.62							
19					0.20									0.02				
20								0.01			0.02							
21					0.36			0.11						0.01				
22					0.20													
23		0.01									0.48			0.29				

Table A.52 Percent Deviations from Output Targets for Plant and Process Levels (SUMZ=1, Strategy III, Actual Process Targets)

Time Period	Process 1			Process 2			Process 3			Process 4			Process 5			Process 6		
	N_I	p^t_i	n^t_i	N_I	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_I	p^t_i	n^t_i	N_i	p^t_i	n^t_i
	0.06			0.08			0.08			0.05			0.03			0.08		
1						0.20			0.23			0.16			0.01			
2						0.08												
3																		
4			0.07			0.16						0.12			0.15			
5									0.12									0.06
6														0.00				
7			0.15			0.11			0.31			0.10			0.13			0.01
8																		
9			0.03															
10			0.15			0.39			0.23			0.05			0.03			0.33
11						0.15												0.16
12									0.15									0.05
13						0.13			0.31			0.17			0.10			0.27
14			0.01						0.18			0.12						0.07
15			0.07			0.11												
16			0.09			0.26			0.08						0.08			0.02
17																		
18			0.01						0.01						0.05			
19												0.19			0.09			0.32
20			0.06									0.01			0.02			
21			0.05												0.03			
22			0.37									0.07						0.31
23			0.12											0.00				
	Process 7			**Process 8**			**Process 9**			**Process 10**			**Process 11**					
	N_I	p^t_i	n^t_i	N_I	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_I	p^t_i	n^t_i			
	0.05			0.14			0.03			0.058			0.04					
1			0.08			0.05			0.22			0.272			0.14			
2												0.04			0.08			
3																		
4						0.13												
5						0.09						0.04						
6						0.04												
7			0.20			0.21			0.04			0.02			0.03			
8																		
9			0.02			0.15						0.07						
10			0.17			0.26			0.21			0.27			0.07			
11						0.06												
12			0.04			0.18						0.03			0.08			
13			0.17			0.24												
14			0.11			0.20						0.09			0.15			
15						0.13									0.01			
16						0.21			0.03			0.04						
17																		
18			0.09			0.07									0.08			
19			0.04			0.26			0.17			0.18			0.17			
20			0.08									0.11			0.05			
21						0.18						0.03			0.04			
22						0.33												
23																		

Table A.53 Percent Deviations from Labor (Input) Targets for Plant and Process Levels (SUMZ=1, Strategy III, Actual Process Targets)

Time Period	Process 1			Process 2			Process 3			Process 4			Process 5			Process 6		
	N_I	p^t_i	n^t_i	N_I	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_I	p^t_i	n^t_i	N_i	p^t_i	n^t_i
	0.12			0.05			0.10			0.09			0.12			0.09		
1						0.23						0.24						0.05
2																		
3																		
4												0.14						
5			0.03									0.37						
6									0.30									
7												0.35			0.19			
8																		
9									0.17									
10			0.13			0.33									0.51			0.23
11			0.17															
12									0.24						0.12			0.07
13			0.19			0.07			0.30			0.14			0.21			0.30
14			0.22						0.12			0.17						
15			0.14						0.06									
16			0.34			0.09									0.49			0.00
17																		
18			0.33			0.03			0.21						0.28			
19												0.18			0.14			0.39
20			0.27						0.10			0.11						0.17
21									0.24						0.10			0.21
22			0.37			0.15			0.22			0.10						0.25
23			0.23															

	Process 7			Process 8			Process 9			Process 10			Process 11					
	N_I	p^t_i	n^t_i	N_I	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_i	p^t_i	n^t_i	N_I	p^t_i	n^t_i			
	0.0			0.04			0.11			0.21			0.05					
1									0.31						0.14			
2									0.13									
3																		
4									0.07									
5									0.06			0.57						
6												0.32			0.43			
7			0.24			0.12			0.55			0.43			0.13			
8																		
9																		
10			0.13			0.07			0.16									
11																		
12									0.21									
13			0.21			0.06			0.28			0.23						
14			0.25									0.22			0.00			
15					0.02							0.47						
16						0.22			0.05			0.48						
17			0.11			0.01									0.13			
18															0.03			
19						0.04												
20												0.32						
21												0.40						
22						0.09												
23												0.39						

Table A.54 Percent Deviations from RM (Input) Targets for Plant and Process Levels (SUMZ=1, Strategy III, Actual Process Targets)

Time Period	Process 2		Process 3		Process 4		Process 5		Process 6	
	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t
1	0.04		0.12		0.013				0.09	
2	0.01			0.03				0.05	0.02	
3	0.03		0.01			0.01		0.01		0.01
4			0.16						0.02	
5	0.03									
6	0.05					0.01		0.04		
7	0.25				0.02					
8	0.03		0.03		0.00			0.04	0.02	
9	0.05									
10	0.05		0.02				0.01		0.04	
11	0.06				0.05			0.09	0.01	
12			0.03		0.00					
13	0.01									
14	0.06				0.06					
15	0.06				0.001			0.08	0.10	
16	0.04									
17	0.01		0.02		0.08		0.04		0.03	
18	0.03				0.01					
19	0.01			0.04		0.001	0.10			0.07
20					0.01		0.00			
21	0.09			0.03			0.02			
22	0.10		0.11		0.04		0.18			0.16
23	0.01			0.04	0.00		0.26			
	Process 7		**Process 8**		**Process 9**		**Process 10**		**Process 11**	
	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t	ξ_r^t	μ_r^t
1	0.34		0.32		0.01		0.03		0.00	
2			0.03				0.01			0.01
3		0.02		0.06	0.04		0.02		0.001	
4			0.13		0.22				0.01	
5	0.02		0.23		0.34				0.01	
6			0.16		0.31		0.02		0.18	
7	0.02		0.23		0.05		0.02		0.02	
8		0.02		0.10	0.03		0.02			0.02
9	0.08		0.17		0.23					
10			0.29				0.02		0.31	
11	0.07			0.02	0.13		0.04		0.02	
12			0.12		0.06		0.08			
13	0.00		0.02		0.18				0.01	
14	0.04		0.07		0.27		0.02			
15			0.18		0.40		0.485		0.22	
16	0.06		0.04		0.24		0.04		0.05	
17	0.00		0.19		0.49		0.04			
18	0.53			0.08	0.27		0.64		0.10	
19	0.04			0.01	0.11		0.05		0.09	
20	0.00			0.33	0.45				0.05	
21	0.02		0.04		0.36		0.04			
22	0.04			0.12	0.24		0.09		0.02	
23				0.31	0.41		0.76		0.36	

Table A.55 Percent Deviations from Process Line Balance (SUMZ=1, Strategy III, Actual Process Targets)

APPENDIX B: GLOSSARY OF TERMS USED IN THE MANUFACTURING PROCESS

1. **Copper Clad Laminate:** The PWB base material, or “laminate” consists of a dielectric material sandwiched by copper foils.

2. **Etch:** Etching is the process whereby an etchant is sprayed on to the surfaces of the panel and removes the exposed copper, but cannot significantly dissolve the copper residing under the resist. In this way, a copper circuit is formed.
3. **Epoxy:** Most PWBs are manufactured on glass-woven epoxy-based materials with the most common resin being FR-4 (flame retardent)

4. **Black Oxide Chemistry:** Oxide treatment, common in the plating industry as a paint base, is used in PWB manufacture to promote copper-to-epoxy adhesion in multilayer manufacture.

5. **Desmear:** A process designed to remove epoxy-resin smear from inner layer copper interfaces. Smear occurs during drilling.

6. **Electroless Plating:** Plating that proceeds without an external electricity source. A reduction of metal ions is accomplished with a chemical reducing agent (such as formaldehyde in electroless copper).

7. **B-stage:** Also referred to as “prepeg”. Semi-cured stage of base printed wiring board substrate. B-stage material is used in lamination.

8. **Microplate Line:** This is an automatic line that cleans the copper in the areas that requires the gold. It then applies 100 micro inches of nickel to the copper and then applies 35 micro inches of gold over the nickel. This is a hardened coating that resists being scratched off the surface of the board making it ideal for edge connectors.

9. **Scoring:** The scoring machine delivers thickness capabilities from 0.020" to 0.126", jump scoring, adjustable cutting thickness within a panel, and a typical web thickness of 0.016"

APPENDIX C: SAS PROGRAMS

The *DEA* and *SMGP* models were developed in *SAS*. The version used was 'The SAS System for Windows v6.12'.

C.1 Generating Output from SAS Programs

Install all the *SAS* programs in any folder under the *SAS* directory. For example, we could create a folder in the *SAS* directory called 'Programs' (C:\SAS\Programs). Copy all the data sets in the *SASUSER* folder. This is because all the programs directly read the data sets in this folder (All the data sets have to be imported into the *SAS* system through either a flat file or a spreadsheet through the *SAS* import utility). Once all the programs and the data sets are in place, we can then run the programs and generate the output.

With the help of a sample program, the following section illustrates the procedure to run and generate outputs in *SAS*. All the *DEA* and *SMGP* programs are also attached for reference.

C.2 BCC Input Reducing Model Program

The following is the BCC input reducing model program. Programs are opened in the *SAS* program editor mode.

```
data dea;
set sasuser.layer;

run;

proc transpose data=dea out=model name=_id_ prefix=z;
run;


data model;
set model;
if _id_ = 'VAR1' then _type_='ge ';
else _type_='le ';
if _type_='le ' then _rhs_=0;
run;

data addobj;
input _id_ $ _type_ $;
cards;
OBJFN min
;
run;

data addsumz (drop=i);
array vbls(23) Z1-Z23;
do i=1 to 23;
vbls(i)=1;
end;
input _id_ $ _type_ $ _rhs_;
cards;
SUMZ eq 1
;
run;

data model;
set model addobj addsumz;
run;

data thetas;
input dmu _var_ $ _value_;
cards;
;
run;

%macro runlp;
%do n=1 %to 23;

data model;
set model;
```

```
if _id_='OBJFN' then theta=1;
else if _id_ = 'SUMZ' or _id_ = 'VAR1' then theta= .;
else theta=-z&n;
if _type_='ge' then _rhs_=z&n;
run;
*proc print data=model;run;

proc lp scale=both printlevel=-2 primalout=prim&n;
row _id_;
var theta z1-z23;
*proc print;
run;

data theta (keep=dmu _var_ _value_);
set prim&n;
dmu=&n;
if _value_ > 0 and _type_ = 'NON-NEG' then output;
run;

proc append base=thetas data=theta;
run;

%end;

%mend runlp;

%runlp;

proc print data=thetas;
run;
```

The second line of the program reads in the data set (set sasuser.layer). The following table shows the mapping needed to run each process. For example, to run proces 2 just substitute etch instead of layer.

Process	Representation
Layer	P1
Etch	P2
Drill	P3
Electro	P4
Plate	P5
Multi	P6
Laminate	P7
Solder	P8
Ha	P9
Gl	P10
Machine	P11

Table C.1 Process Mapping

This program has to be run for each process separately. The above program will run for the inner layer process. To run for a different process, just replace the name of the process in the second line. To run the program, go to the edit menu and select 'Select all' option. In the tool bar, click on the 'submit' icon. The status of the request can then be viewed in the 'Log' screen. Error messages are displayed in red and warning messages in green. After the program terminates successfully, the 'Output' screen automatically displays the results. The results can either be printed or can be saved to a file for future reference.

For a more detailed explanation on the syntax, refer to the *SAS* Language and *SAS OR* manuals.

C.3 Goal program with the First Strategy and convexity Assumption

The following section displays one of the goal programs developed for the research. In this section, all changes needed to be made to the programs to run different strategies and processes will be described. The following program shows the goal program for process 1, first strategy and satisfying the convexity assumption. At the end of the program for process 1, the procedure for running the the programs for process 2 through process 11 are described. Process 1 is different because of the absence of the balance constraint. The procedure for running process 1 is the same as explained for process 2 through process11.

```
/****Optimization for process 1.**********************/

data labor;
set sasuser.labor1;
proc print;
run;

proc transpose data=labor out=l_data name=_id_ prefix=l;
run;
proc print ;run;

data rm;
set sasuser.RM1;
proc print;
run;
proc transpose data=rm out=r_data name=_id_ prefix=r;
run;
proc print ;run;

data boards;
set sasuser.p1;
proc print;
run;

proc transpose data=boards out=b_data name=_id_ prefix=b;
run;
proc print ;run;


data prtarget;
set sasuser.p1tar;
proc print;
run;
proc transpose data=prtarget out=prt_data name=_id_ prefix=pt;
run;
proc print ;run;
```

```
data gltarget;
set sasuser.gltarget;
proc print;
run;

proc transpose data=gltarget out=gt_data name=_id_ prefix=gt;
run;
proc print ;run;

data recur_o;
set sasuser.recur_a1;
proc print; run;

proc transpose data = recur_o out=recurout name=_id_ prefix=ro;
run;
proc print;run;

data agg_data;
merge l_data r_data b_data prt_data gt_data;
run;
proc print; run;

/***define global objective function*******/


data gl_obj (drop=h);
array vbls(3) gl_neg_o gl_pos_l gl_pos_r;
do h=1 to 3;
vbls(1) = 1/400000;
vbls(2) = 1/112226;
vbls(3) = 1/17267183;
end;
_id_ = 'gl_obj';
_type_= 'min    ';
_rhs_= 1;
run;

proc print;
run;


/**********************define process objective function **************/

data pr_obj(keep = _id_ _type_ _rhs_ pd_l_1-pd_l_23  pd_r_1-pd_r_23 nd_o_1-nd_o_23 );
set agg_data;
array vbls(138) pd_l_1-pd_l_23  pd_r_1-pd_r_23 nd_o_1-nd_o_23 nd_l_1-nd_l_23 nd_r_1-nd_r_23
pd_o_1-pd_o_23;

do i=1 to 138;
vbls(1)=1/l1;
vbls(2)=1/l2;
vbls(3)=1/l3;
vbls(4)=1/l4;
```

```
vbls(5)=1/l5;
vbls(6)=1/l6;
vbls(7)=1/l7;
vbls(8)=1/l8;
vbls(9)=1/l9;
vbls(10)=1/l10;
vbls(11)=1/l11;
vbls(12)=1/l12;
vbls(13)=1/l13;
vbls(14)=1/l14;
vbls(15)=1/l15;
vbls(16)=1/l16;
vbls(17)=1/l17;
vbls(18)=1/l18;
vbls(19)=1/l19;
vbls(20)=1/l20;
vbls(21)=1/l21;
vbls(22)=1/l22;
vbls(23)=1/l23;
vbls(24)=1/r1;
vbls(25)=1/r2;
vbls(26)=1/r3;
vbls(27)=1/r4;
vbls(28)=1/r5;
vbls(29)=1/r6;
vbls(30)=1/r7;
vbls(31)=1/r8;
vbls(32)=1/r9;
vbls(33)=1/r10;
vbls(34)=1/r11;
vbls(35)=1/r12;
vbls(36)=1/r13;
vbls(37)=1/r14;
vbls(38)=1/r15;
vbls(39)=1/r16;
vbls(40)=1/r17;
vbls(41)=1/r18;
vbls(42)=1/r19;
vbls(43)=1/r20;
vbls(44)=1/r21;
vbls(45)=1/r22;
vbls(46)=1/r23;
vbls(47)=1/pt1;
vbls(48)=1/pt2;
vbls(49)=1/pt3;
vbls(50)=1/pt4;
vbls(51)=1/pt5;
vbls(52)=1/pt6;
vbls(53)=1/pt7;
vbls(54)=1/pt8;
vbls(55)=1/pt9;
vbls(56)=1/pt10;
vbls(57)=1/pt11;
vbls(58)=1/pt12;
vbls(59)=1/pt13;
```

```
vbls(60)=1/pt14;
vbls(61)=1/pt15;
vbls(62)=1/pt16;
vbls(63)=1/pt17;
vbls(64)=1/pt18;
vbls(65)=1/pt19;
vbls(66)=1/pt20;
vbls(67)=1/pt21;
vbls(68)=1/pt22;
vbls(69)=1/pt23;
vbls(70)=1/l1;
vbls(71)=1/l2;
vbls(72)=1/l3;
vbls(73)=1/l4;
vbls(74)=1/l5;
vbls(75)=1/l6;
vbls(76)=1/l7;
vbls(77)=1/l8;
vbls(78)=1/l9;
vbls(79)=1/l10;
vbls(80)=1/l11;
vbls(81)=1/l12;
vbls(82)=1/l13;
vbls(83)=1/l14;
vbls(84)=1/l15;
vbls(85)=1/l16;
vbls(86)=1/l17;
vbls(87)=1/l18;
vbls(88)=1/l19;
vbls(89)=1/l20;
vbls(90)=1/l21;
vbls(91)=1/l22;
vbls(92)=1/l23;
vbls(93)=1/r1;
vbls(94)=1/r2;
vbls(95)=1/r3;
vbls(96)=1/r4;
vbls(97)=1/r5;
vbls(98)=1/r6;
vbls(99)=1/r7;
vbls(100)=1/r8;
vbls(101)=1/r9;
vbls(102)=1/r10;
vbls(103)=1/r11;
vbls(104)=1/r12;
vbls(105)=1/r13;
vbls(106)=1/r14;
vbls(107)=1/r15;
vbls(108)=1/r16;
vbls(109)=1/r17;
vbls(110)=1/r18;
vbls(111)=1/r19;
vbls(112)=1/r20;
vbls(113)=1/r21;
vbls(114)=1/r22;
```

```
vbls(115)=1/r23;
vbls(116)=1/pt1;
vbls(117)=1/pt2;
vbls(118)=1/pt3;
vbls(119)=1/pt4;
vbls(120)=1/pt5;
vbls(121)=1/pt6;
vbls(122)=1/pt7;
vbls(123)=1/pt8;
vbls(124)=1/pt9;
vbls(125)=1/pt10;
vbls(126)=1/pt11;
vbls(127)=1/pt12;
vbls(128)=1/pt13;
vbls(129)=1/pt14;
vbls(130)=1/pt15;
vbls(131)=1/pt16;
vbls(132)=1/pt17;
vbls(133)=1/pt18;
vbls(134)=1/pt19;
vbls(135)=1/pt20;
vbls(136)=1/pt21;
vbls(137)=1/pt22;
vbls(138)=1/pt23;

end;
_id_ = 'pr_obj';
_type_ = 'min    ';
_rhs_ = 2;

run;
proc print;
run;


/****************define activity parameters***************/
%macro ac_param;
%do n=1 %to 23;
%let x1 = %eval((&n-1)*23+1);
%let x2 = %eval(&n*23);
data a&n (keep=_id_ _type_ _rhs_ z&x1-z&x2 drop=i);
array vbls(23) z&x1-z&x2;
do i=1 to 23;
vbls(i)=1;
end;
length _id_ $ 12;
_id_ = compress('ac_const'||&n);
_rhs_=1;
_type_ = 'eq     ';
run;
proc print;
run;
%end;
%mend ac_param;
%ac_param;
```

```
/*************************************************************************/

data model;
set gl_obj pr_obj a1 a2 a3 a4 a5 a6 a7 a8 a9 a10 a11 a12 a13 a14 a15 a16 a17 a18 a19 a20 a21 a22 a23;
run;
proc print;
run;

data pconst;
merge b_data prt_data;
run;
*proc print; run;


/**************setting process output target constrainsts**************/
%macro p_const1;
%do n=1 %to 23;
%let x1 = %eval((&n-1)*23+1);
%let x2 = %eval(&n*23);
data pr_o&n (keep=_id_ _type_ _rhs_ z&x1-z&x2 nd_o_&n pd_o_&n);
length _id_ $ 12;
set pconst;
array vbls(23) z&x1-z&x2;
do i=1 to 23;
vbls(1)=b1;
vbls(2)=b2;
vbls(3)=b3;
vbls(4)=b4;
vbls(5)=b5;
vbls(6)=b6;
vbls(7)=b7;
vbls(8)=b8;
vbls(9)=b9;
vbls(10)=b10;
vbls(11)=b11;
vbls(12)=b12;
vbls(13)=b13;
vbls(14)=b14;
vbls(15)=b15;
vbls(16)=b16;
vbls(17)=b17;
vbls(18)=b18;
vbls(19)=b19;
vbls(20)=b20;
vbls(21)=b21;
vbls(22)=b22;
vbls(23)=b23;

end;
_id_ = compress('pro_const'||&n);
_rhs_=pt&n;
_type_ = 'eq     ';
nd_o_&n = 1;
pd_o_&n = -1;
```

```
run;
proc print;
run;
%end;
%mend p_const1;
%p_const1;

/**************setting process labor target constrainsts*************/
%macro p_const2;
%do n=1 %to 23;
%let x1 = %eval((&n-1)*23+1);
%let x2 = %eval(&n*23);
data pr_l&n (keep=_id_ _type_ _rhs_ z&x1-z&x2 nd_l_&n pd_l_&n drop=i);
length _id_ $ 12;
set l_data;
array vbls(23) z&x1-z&x2;
do i=1 to 23;
vbls(1)=l1;
vbls(2)=l2;
vbls(3)=l3;
vbls(4)=l4;
vbls(5)=l5;
vbls(6)=l6;
vbls(7)=l7;
vbls(8)=l8;
vbls(9)=l9;
vbls(10)=l10;
vbls(11)=l11;
vbls(12)=l12;
vbls(13)=l13;
vbls(14)=l14;
vbls(15)=l15;
vbls(16)=l16;
vbls(17)=l17;
vbls(18)=l18;
vbls(19)=l19;
vbls(20)=l20;
vbls(21)=l21;
vbls(22)=l22;
vbls(23)=l23;
end;
_id_ = compress('prl_const'||&n);
_rhs_=l&n;
_type_ = 'eq     ';
nd_l_&n = 1;
pd_l_&n = -1;
run;
proc print;
run;
%end;
%mend p_const2;
%p_const2;


/**************setting process raw materials target constrainsts*************/
```

```
%macro p_const3;
%do n=1 %to 23;
%let x1 = %eval((&n-1)*23+1);
%let x2 = %eval(&n*23);
data pr_r&n (keep=_id_ _type_ _rhs_ z&x1-z&x2 nd_r_&n pd_r_&n);
length _id_ $ 12;
set r_data;
array vbls(23) z&x1-z&x2;
do i=1 to 23;
vbls(1)=r1;
vbls(2)=r2;
vbls(3)=r3;
vbls(4)=r4;
vbls(5)=r5;
vbls(6)=r6;
vbls(7)=r7;
vbls(8)=r8;
vbls(9)=r9;
vbls(10)=r10;
vbls(11)=r11;
vbls(12)=r12;
vbls(13)=r13;
vbls(14)=r14;
vbls(15)=r15;
vbls(16)=r16;
vbls(17)=r17;
vbls(18)=r18;
vbls(19)=r19;
vbls(20)=r20;
vbls(21)=r21;
vbls(22)=r22;
vbls(23)=r23;
end;
_id_ = compress('prr_const'||&n);
_rhs_=r&n;
_type_ = 'eq     ';
nd_r_&n = 1;
pd_r_&n = -1;
run;
proc print;
run;
%end;
%mend p_const3;
%p_const3;



/************Setting global output target constraints*********/

%macro g;
data g_const (keep= z1-z529);
set b_data;
%do m=1%to 23;
%do n=1%to 23;
%let mn = %eval((&m-1)*23+&n);
```

```
z&mn = b&n;
%end;
%end;
run;
%mend g;
%g;

proc print; run;

data g_const;
set g_const;
_rhs_=400000;

_id_ = 'glo_const';
_type_ = 'eq     ';
gl_neg_o = 1;
gl_pos_o = -1;
run;
proc print;
run;


/************Setting global input labor target constraints*********/
%macro l;
data l_const (keep= z1-z529);
set l_data;
%do m=1%to 23;
%do n=1%to 23;
%let mn = %eval((&m-1)*23+&n);
z&mn = l&n;
%end;
%end;
run;
%mend l;
%l;

proc print; run;

data l_const;
set l_const;
_rhs_=112226;

_id_ = 'prl_const';
_type_ = 'eq     ';
gl_neg_l = 1;
gl_pos_l = -1;
run;
proc print;
run;

/************Setting global input raw materials target constraints*********/

%macro r;
data r_const (keep= z1-z529);
set r_data;
```

```
%do m=1%to 23;
%do n=1%to 23;
%let mn = %eval((&m-1)*23+&n);
z&mn = r&n;
%end;
%end;
run;
%mend r;
%r;

proc print; run;

data r_const;
set r_const;
_rhs_=17267183;

_id_ = 'prr_const';
_type_ = 'eq     ';
gl_neg_r = 1;
gl_pos_r = -1;
run;
proc print;
run;


/***********set the model******************/

data model;
set model pr_o1 pr_o2 pr_o3 pr_o4 pr_o5 pr_o6 pr_o7 pr_o8 pr_o9 pr_o10 pr_o11 pr_o12 pr_o13 pr_o14
pr_o15 pr_o16 pr_o17 pr_o18 pr_o19
pr_o20 pr_o21 pr_o22 pr_o23 g_const;
run;
proc print; run;

data model;
set model pr_l1 pr_l2 pr_l3 pr_l4 pr_l5 pr_l6 pr_l7 pr_l8 pr_l9 pr_l10 pr_l11 pr_l12 pr_l13 pr_l14 pr_l15
pr_l16 pr_l17 pr_l18 pr_l19
pr_l20 pr_l21 pr_l22 pr_l23 l_const;
run;
proc print; run;


data model;
set model pr_r1 pr_r2 pr_r3 pr_r4 pr_r5 pr_r6 pr_r7 pr_r8 pr_r9 pr_r10 pr_r11 pr_r12 pr_r13 pr_r14 pr_r15
pr_r16 pr_r17 pr_r18 pr_r19
pr_r20 pr_r21 pr_r22 pr_r23 r_const;
run;
proc print; run;


proc lp goalprogram scale=both printlevel=-2 primalout=prim1  maxit1=200 maxit2=200;
var z1-z529 gl_neg_o gl_pos_o gl_neg_l gl_pos_l gl_neg_r gl_pos_r nd_o_1-nd_o_23 pd_o_1-pd_o_23
nd_l_1-nd_l_23 pd_l_1-pd_l_23 nd_r_1-nd_r_23 pd_r_1-pd_r_23;
run;
```

```
data dev(keep= _var_ _value_);
set prim1;
if _value_>0 then output;
run;
proc print;
run;
```

The following section displays the program needed to run processes 2 through11. (Process 1 is different because of the absence of the line-balance constraint).

```
/****Optimization for process 2, 3 ...11.**********************/

data labor;
1  set sasuser.labor9;
proc print;
run;

proc transpose data=labor out=l_data name=_id_ prefix=l;
run;
proc print ;run;

data rm;
2 set sasuser.RM9;
proc print;
run;
proc transpose data=rm out=r_data name=_id_ prefix=r;
run;
proc print ;run;

data boards;
3 set sasuser.p9;
proc print;
run;

proc transpose data=boards out=b_data name=_id_ prefix=b;
run;
proc print ;run;


data balance;
4 set sasuser.p8;
proc print;
run;

proc transpose data=balance out=bl_data name=_id_ prefix=bt;
run;
```

```
proc print ;run;


data prtarget;
5 set sasuser.p9tar;
proc print;
run;
proc transpose data=prtarget out=prt_data name=_id_ prefix=pt;
run;
proc print ;run;

/******************
data gltarget;
set sasuser.gltarget;
proc print;
run;

proc transpose data=gltarget out=gt_data name=_id_ prefix=gt;
run;
proc print ;run;
*************************/



data agg_data;
merge l_data r_data b_data prt_data bl_data;
run;
proc print; run;

/***define global objective function*******/


data gl_obj (drop=h);
array vbls(3) gl_neg_o gl_pos_l gl_pos_r;
do h=1 to 3;
vbls(1) = 1/400000;
6 vbls(2) = 1/60446;
7 vbls(3) = 1/841182;
end;
_id_ = 'gl_obj';
_type_= 'min    ';
8 _rhs_= 1;
run;

proc print;
run;


/**********************define process objective function *************/

data pr_obj(keep = _id_ _type_ _rhs_ pd_l_1-pd_l_23  pd_r_1-pd_r_23 nd_o_1-nd_o_23);
set agg_data;
array vbls(138) pd_l_1-pd_l_23  pd_r_1-pd_r_23 nd_o_1-nd_o_23 nd_l_1-nd_l_23 nd_r_1-nd_r_23
pd_o_1-pd_o_23;
```

```
do i=1 to 138;
vbls(1)=1/l1;
vbls(2)=1/l2;
vbls(3)=1/l3;
vbls(4)=1/l4;
vbls(5)=1/l5;
vbls(6)=1/l6;
vbls(7)=1/l7;
vbls(8)=1/l8;
vbls(9)=1/l9;
vbls(10)=1/l10;
vbls(11)=1/l11;
vbls(12)=1/l12;
vbls(13)=1/l13;
vbls(14)=1/l14;
vbls(15)=1/l15;
vbls(16)=1/l16;
vbls(17)=1/l17;
vbls(18)=1/l18;
vbls(19)=1/l19;
vbls(20)=1/l20;
vbls(21)=1/l21;
vbls(22)=1/l22;
vbls(23)=1/l23;
vbls(24)=1/r1;
vbls(25)=1/r2;
vbls(26)=1/r3;
vbls(27)=1/r4;
vbls(28)=1/r5;
vbls(29)=1/r6;
vbls(30)=1/r7;
vbls(31)=1/r8;
vbls(32)=1/r9;
vbls(33)=1/r10;
vbls(34)=1/r11;
vbls(35)=1/r12;
vbls(36)=1/r13;
vbls(37)=1/r14;
vbls(38)=1/r15;
vbls(39)=1/r16;
vbls(40)=1/r17;
vbls(41)=1/r18;
vbls(42)=1/r19;
vbls(43)=1/r20;
vbls(44)=1/r21;
vbls(45)=1/r22;
vbls(46)=1/r23;
vbls(47)=1/pt1;
vbls(48)=1/pt2;
vbls(49)=1/pt3;
vbls(50)=1/pt4;
vbls(51)=1/pt5;
vbls(52)=1/pt6;
vbls(53)=1/pt7;
vbls(54)=1/pt8;
```

```
vbls(55)=1/pt9;
vbls(56)=1/pt10;
vbls(57)=1/pt11;
vbls(58)=1/pt12;
vbls(59)=1/pt13;
vbls(60)=1/pt14;
vbls(61)=1/pt15;
vbls(62)=1/pt16;
vbls(63)=1/pt17;
vbls(64)=1/pt18;
vbls(65)=1/pt19;
vbls(66)=1/pt20;
vbls(67)=1/pt21;
vbls(68)=1/pt22;
vbls(69)=1/pt23;
vbls(70)=1/l1;
vbls(71)=1/l2;
vbls(72)=1/l3;
vbls(73)=1/l4;
vbls(74)=1/l5;
vbls(75)=1/l6;
vbls(76)=1/l7;
vbls(77)=1/l8;
vbls(78)=1/l9;
vbls(79)=1/l10;
vbls(80)=1/l11;
vbls(81)=1/l12;
vbls(82)=1/l13;
vbls(83)=1/l14;
vbls(84)=1/l15;
vbls(85)=1/l16;
vbls(86)=1/l17;
vbls(87)=1/l18;
vbls(88)=1/l19;
vbls(89)=1/l20;
vbls(90)=1/l21;
vbls(91)=1/l22;
vbls(92)=1/l23;
vbls(93)=1/r1;
vbls(94)=1/r2;
vbls(95)=1/r3;
vbls(96)=1/r4;
vbls(97)=1/r5;
vbls(98)=1/r6;
vbls(99)=1/r7;
vbls(100)=1/r8;
vbls(101)=1/r9;
vbls(102)=1/r10;
vbls(103)=1/r11;
vbls(104)=1/r12;
vbls(105)=1/r13;
vbls(106)=1/r14;
vbls(107)=1/r15;
vbls(108)=1/r16;
vbls(109)=1/r17;
```

```
vbls(110)=1/r18;
vbls(111)=1/r19;
vbls(112)=1/r20;
vbls(113)=1/r21;
vbls(114)=1/r22;
vbls(115)=1/r23;
vbls(116)=1/pt1;
vbls(117)=1/pt2;
vbls(118)=1/pt3;
vbls(119)=1/pt4;
vbls(120)=1/pt5;
vbls(121)=1/pt6;
vbls(122)=1/pt7;
vbls(123)=1/pt8;
vbls(124)=1/pt9;
vbls(125)=1/pt10;
vbls(126)=1/pt11;
vbls(127)=1/pt12;
vbls(128)=1/pt13;
vbls(129)=1/pt14;
vbls(130)=1/pt15;
vbls(131)=1/pt16;
vbls(132)=1/pt17;
vbls(133)=1/pt18;
vbls(134)=1/pt19;
vbls(135)=1/pt20;
vbls(136)=1/pt21;
vbls(137)=1/pt22;
vbls(138)=1/pt23;
end;
_id_ = 'pr_obj';
_type_ = 'min    ';
9 _rhs_ = 2;

run;
proc print;
run;

/**********************define balance objective function **************/

data bl_obj(keep = _id_ _type_ _rhs_ bl_neg1-bl_neg23);
set bl_data;
array vbls(23) bl_neg1-bl_neg23;

do i=1 to 23;
vbls(1)=1/bt1;
vbls(2)=1/bt2;
vbls(3)=1/bt3;
vbls(4)=1/bt4;
vbls(5)=1/bt5;
vbls(6)=1/bt6;
vbls(7)=1/bt7;
vbls(8)=1/bt8;
vbls(9)=1/bt9;
vbls(10)=1/bt10;
```

```
vbls(11)=1/bt11;
vbls(12)=1/bt12;
vbls(13)=1/bt13;
vbls(14)=1/bt14;
vbls(15)=1/bt15;
vbls(16)=1/bt16;
vbls(17)=1/bt17;
vbls(18)=1/bt18;
vbls(19)=1/bt19;
vbls(20)=1/bt20;
vbls(21)=1/bt21;
vbls(22)=1/bt22;
vbls(23)=1/bt23;

end;
_id_ = 'bl_obj';
_type_ = 'min    ';
10 _rhs_ = 3;

run;
proc print;
run;


/****************define activity parameters**************/
%macro ac_param;
%do n=1 %to 23;
%let x1 = %eval((&n-1)*23+1);
%let x2 = %eval(&n*23);
data a&n (keep=_id_ _type_ _rhs_ z&x1-z&x2 drop=i);
array vbls(23) z&x1-z&x2;
do i=1 to 23;
vbls(i)=1;
end;
length _id_ $ 12;
_id_ = compress('ac_const'||&n);
_rhs_=1;
_type_ = 'eq     ';
run;
proc print;
run;
%end;
%mend ac_param;
%ac_param;

/*********************************************************************/

data model;
set gl_obj pr_obj bl_obj a1 a2 a3 a4 a5 a6 a7 a8 a9 a10 a11 a12 a13 a14 a15 a16 a17 a18 a19 a20 a21 a22
a23;
run;
proc print;
run;

data pconst;
```

```
merge b_data prt_data;
run;
*proc print; run;


/**************setting process output target constrainsts**************/
%macro p_const1;
%do n=1 %to 23;
%let x1 = %eval((&n-1)*23+1);
%let x2 = %eval(&n*23);
data pr_o&n (keep=_id_ _type_ _rhs_ z&x1-z&x2 nd_o_&n pd_o_&n);
length _id_ $ 12;
set pconst;
array vbls(23) z&x1-z&x2;
do i=1 to 23;
vbls(1)=b1;
vbls(2)=b2;
vbls(3)=b3;
vbls(4)=b4;
vbls(5)=b5;
vbls(6)=b6;
vbls(7)=b7;
vbls(8)=b8;
vbls(9)=b9;
vbls(10)=b10;
vbls(11)=b11;
vbls(12)=b12;
vbls(13)=b13;
vbls(14)=b14;
vbls(15)=b15;
vbls(16)=b16;
vbls(17)=b17;
vbls(18)=b18;
vbls(19)=b19;
vbls(20)=b20;
vbls(21)=b21;
vbls(22)=b22;
vbls(23)=b23;

end;
_id_ = compress('pro_const'||&n);
_rhs_=pt&n;
_type_ = 'eq     ';
nd_o_&n = 1;
pd_o_&n = -1;
run;
proc print;
run;
%end;
%mend p_const1;
%p_const1;

data bconst;
merge b_data bl_data;
run;
```

```
/***************setting balance target constrainsts**************/
%macro b_const1;
%do n=1 %to 23;
%let x1 = %eval((&n-1)*23+1);
%let x2 = %eval(&n*23);
data bl_o&n (keep=_id_ _type_ _rhs_ z&x1-z&x2 bl_neg&n bl_pos&n);
length _id_ $ 12;
set bconst;
array vbls(23) z&x1-z&x2;
do i=1 to 23;
vbls(1)=b1;
vbls(2)=b2;
vbls(3)=b3;
vbls(4)=b4;
vbls(5)=b5;
vbls(6)=b6;
vbls(7)=b7;
vbls(8)=b8;
vbls(9)=b9;
vbls(10)=b10;
vbls(11)=b11;
vbls(12)=b12;
vbls(13)=b13;
vbls(14)=b14;
vbls(15)=b15;
vbls(16)=b16;
vbls(17)=b17;
vbls(18)=b18;
vbls(19)=b19;
vbls(20)=b20;
vbls(21)=b21;
vbls(22)=b22;
vbls(23)=b23;

end;
_id_ = compress('blo_const'||&n);
_rhs_=bt&n;
_type_ = 'eq     ';
bl_neg&n = 1;
bl_pos&n = -1;
run;
proc print;
run;
%end;
%mend b_const1;
%b_const1;

/***************setting process labor target constrainsts**************/
%macro p_const2;
%do n=1 %to 23;
%let x1 = %eval((&n-1)*23+1);
%let x2 = %eval(&n*23);
data pr_l&n (keep=_id_ _type_ _rhs_ z&x1-z&x2 nd_l_&n pd_l_&n drop=i);
length _id_ $ 12;
```

```
set l_data;
array vbls(23) z&x1-z&x2;
do i=1 to 23;
vbls(1)=l1;
vbls(2)=l2;
vbls(3)=l3;
vbls(4)=l4;
vbls(5)=l5;
vbls(6)=l6;
vbls(7)=l7;
vbls(8)=l8;
vbls(9)=l9;
vbls(10)=l10;
vbls(11)=l11;
vbls(12)=l12;
vbls(13)=l13;
vbls(14)=l14;
vbls(15)=l15;
vbls(16)=l16;
vbls(17)=l17;
vbls(18)=l18;
vbls(19)=l19;
vbls(20)=l20;
vbls(21)=l21;
vbls(22)=l22;
vbls(23)=l23;
end;
_id_ = compress('prl_const'||&n);
_rhs_=l&n;
_type_ = 'eq     ';
nd_l_&n = 1;
pd_l_&n = -1;
run;
proc print;
run;
%end;
%mend p_const2;
%p_const2;


/***************setting process raw materials target constrainsts**************/
%macro p_const3;
%do n=1 %to 23;
%let x1 = %eval((&n-1)*23+1);
%let x2 = %eval(&n*23);
data pr_r&n (keep=_id_ _type_ _rhs_ z&x1-z&x2 nd_r_&n pd_r_&n);
length _id_ $ 12;
set r_data;
array vbls(23) z&x1-z&x2;
do i=1 to 23;
vbls(1)=r1;
vbls(2)=r2;
vbls(3)=r3;
vbls(4)=r4;
vbls(5)=r5;
```

```
vbls(6)=r6;
vbls(7)=r7;
vbls(8)=r8;
vbls(9)=r9;
vbls(10)=r10;
vbls(11)=r11;
vbls(12)=r12;
vbls(13)=r13;
vbls(14)=r14;
vbls(15)=r15;
vbls(16)=r16;
vbls(17)=r17;
vbls(18)=r18;
vbls(19)=r19;
vbls(20)=r20;
vbls(21)=r21;
vbls(22)=r22;
vbls(23)=r23;
end;
_id_ = compress('prr_const'||&n);
_rhs_=r&n;
_type_ = 'eq     ';
nd_r_&n = 1;
pd_r_&n = -1;
run;
proc print;
run;
%end;
%mend p_const3;
%p_const3;



/*************Setting global output target constraints*********/

%macro g;
data g_const (keep= z1-z529);
set b_data;
%do m=1%to 23;
%do n=1%to 23;
%let mn = %eval((&m-1)*23+&n);
z&mn = b&n;
%end;
%end;
run;
%mend g;
%g;

proc print; run;

data g_const;
set g_const;
_rhs_=400000;

_id_ = 'glo_const';
```

```
_type_ = 'eq     ';
gl_neg_o = 1;
gl_pos_o = -1;
run;
proc print;
run;


/************Setting global input labor target constraints*********/
%macro l;
data l_const (keep= z1-z529);
set l_data;
%do m=1%to 23;
%do n=1%to 23;
%let mn = %eval((&m-1)*23+&n);
z&mn = l&n;
%end;
%end;
run;
%mend l;
%l;

proc print; run;

data l_const;
set l_const;
11_rhs_=60446;

_id_ = 'prl_const';
_type_ = 'eq     ';
gl_neg_l = 1;
gl_pos_l = -1;
run;
proc print;
run;

/************Setting global input raw materials target constraints*********/

%macro r;
data r_const (keep= z1-z529);
set r_data;
%do m=1%to 23;
%do n=1%to 23;
%let mn = %eval((&m-1)*23+&n);
z&mn = r&n;
%end;
%end;
run;
%mend r;
%r;

proc print; run;

data r_const;
set r_const;
```

```
12 _rhs_=841182;

_id_ = 'prr_const';
_type_ = 'eq     ';
gl_neg_r = 1;
gl_pos_r = -1;
run;
proc print;
run;


/***********set the model******************/

data model;
set model pr_o1 pr_o2 pr_o3 pr_o4 pr_o5 pr_o6 pr_o7 pr_o8 pr_o9 pr_o10 pr_o11 pr_o12 pr_o13 pr_o14
pr_o15 pr_o16 pr_o17 pr_o18 pr_o19
pr_o20 pr_o21 pr_o22 pr_o23 g_const;
run;
proc print; run;

data model;
set model pr_l1 pr_l2 pr_l3 pr_l4 pr_l5 pr_l6 pr_l7 pr_l8 pr_l9 pr_l10 pr_l11 pr_l12 pr_l13 pr_l14 pr_l15
pr_l16 pr_l17 pr_l18 pr_l19
pr_l20 pr_l21 pr_l22 pr_l23 l_const;
run;
proc print; run;


data model;
set model pr_r1 pr_r2 pr_r3 pr_r4 pr_r5 pr_r6 pr_r7 pr_r8 pr_r9 pr_r10 pr_r11 pr_r12 pr_r13 pr_r14 pr_r15
pr_r16 pr_r17 pr_r18 pr_r19
pr_r20 pr_r21 pr_r22 pr_r23 r_const;
run;
proc print; run;

data model;
set model bl_o1 bl_o2 bl_o3 bl_o4 bl_o5 bl_o6 bl_o7 bl_o8 bl_o9 bl_o10 bl_o11 bl_o12 bl_o13
bl_o14 bl_o15 bl_o16 bl_o17 bl_o18 bl_o19 bl_o20 bl_o21 bl_o22 bl_o23;
run;


proc lp goalprogram scale=both printlevel=-2 primalout=prim1  maxit1=200 maxit2=200;
var z1-z529 gl_neg_o gl_pos_o gl_neg_l gl_pos_l gl_neg_r gl_pos_r nd_o_1-nd_o_23 pd_o_1-pd_o_23
nd_l_1-nd_l_23 pd_l_1-pd_l_23 nd_r_1-nd_r_23 pd_r_1-pd_r_23 bl_neg1-bl_neg23 bl_pos1-bl_pos23;
run;




data dev(keep= _var_ _value_);
set prim1;
if _value_>0 then output;
run;
proc print;
run;
```

There are no changes to be made to run the program for the first process. It is a stand-alone program. The program for running all the other processes is generic. All the changes needed are highlighted in the preceding program. In the example, the program is run for process 9. All the highlighted portions in the program begin with a number, which is only for reference in this document and is not part of the actual program. The highlighted line with starting with number '1' inputs the labor information for process 9. To input a different process, just change the number in that line after labor. For example, to input labor information for process 6, the line would read

set sasuser.labor6;

The same approach has to be adopted for the highlighted lines beginning with 2, 3, 4 and 5. Note that in line 4, the number for the process is one less than the current process being evaluated. This is because at this line, the actual output of the previous process is being read.

After all the data is read, the next change occurs on highlighted lines 6 and 7. The objective function coefficients are normalized with respect to the aggregate labor and raw material consumption for the process. The denominator has to be changed to the appropriate value. These values are obtained by aggregating the actual labor and raw material consumption over the two-year period for the process.

The highlighted lines 8, 9 and 10 indicate the priorities attached to the plant-level, process and line-balance objective functions. Changing the numbers would alter the priorities to the objective functions.

Finally, the highlighted lines 11 and 12 indicate the right hand side value for the plant-level constraints. These values are also obtained by aggregating the actual labor and raw material consumption over the two-year period for the process. In fact, these values will be the same as the values of the denominators in lines 6 and 7.

Once all the above changes are made, the program is ready for execution for a particular process. This has to be repeated ten times for all the ten processes. There are no changes needed for process 1 as all the values are hard-coded.

C.4 BCC Output Increasing Model

The following sections display all the *DEA* and goal programs developed for the research. The current section presents the *SAS* code for the *BCC* output-increasing model.

```
data dea;
set sasuser.layer;
proc print;
run;

proc transpose data=dea out=model name=_id_ prefix=z;
run;


data model;
set model;
if _id_ = 'VAR1' then _type_='ge ';
else _type_='le ';
if _type_='ge ' then _rhs_=0;
run;

data addobj;
input _id_ $ _type_ $;
cards;
OBJFN max
;
run;

data addsumz (drop=i);
array vbls(23) Z1-Z23;
do i=1 to 23;
vbls(i)=1;
end;
input _id_ $ _type_ $ _rhs_;
cards;
SUMZ eq 1
;
run;


data model;
set model addobj addsumz;
run;
proc print;run;

data thetas;
input dmu _var_ $ _value_;
cards;
;
run;
```

```
%macro runlp;
%do n=1 %to 23;


data model;
set model;
if _id_='OBJFN' then theta=1;
else if _id_ = 'SUMZ' or _type_ = 'le' then theta= .;
else theta=-z&n;
if _type_='le' then _rhs_=z&n;
run;
proc print data=model;run;

proc lp scale=both printlevel=-2 primalout=prim&n;
row _id_;
var theta z1-z23;
*proc print;
run;

data theta (keep=dmu _var_ _value_);
set prim&n;
dmu=&n;
if _value_ > 0 and _type_ = 'NON-NEG' then output;
run;

proc append base=thetas data=theta;
run;

%end;

%mend runlp;

%runlp;

proc print data=thetas;
run;
```

_____

C.5 Input-Reducing Two-Stage Radial Model

The following is the code for the input-reducing two stage radial model.

```
/******** input reducing two stage radial model******************/

data dea;
set sasuser.machine;
proc print;
run;

proc transpose data=dea out=model name=_id_ prefix=z;
run;
proc print;


data model;
set model;
if _id_ = 'VAR1' then _type_='ge ';
else _type_='le ';
if _type_='le ' then _rhs_=0;
run;
proc print;

data addobj;
input _id_ $ _type_ $;
cards;
OBJFN min
;
run;
proc print;

data addsumz (drop=i);
array vbls(23) Z1-Z23;
do i=1 to 23;
vbls(i)=1;
end;
input _id_ $ _type_ $ _rhs_;
cards;
SUMZ eq 1
;
run;
proc print;


data model;
set model addobj addsumz;
run;

proc print;


data thetas;
input DMU _VAR_ $ _VALUE_ STAGE2;
```

```
cards;
;
run;
proc print;

*stage 2 objective function;

data addobj2 (drop=j);
array slack(2) e1-e2;
 do j=1 to 2;
slack(j)=1;
end;
s1=1;
*data addobj1;
input _id_ $ _type_ $;
cards;
OBJFN min
;
run;

proc print;
run;


%macro runlp;
%do n=1 %to 23;


data model;
set model;
if _id_='OBJFN' then theta=1;
else if _id_ = 'SUMZ' or _id_ = 'VAR1' then theta= .;
else theta=-z&n;
if _type_='ge' then _rhs_=z&n;
run;
proc print;


proc lp scale=both printlevel=-2 primalout=prim&n;
row _id_;
var theta z1-z23;
*proc print;
run;

data theta (keep=DMU _VAR_ _VALUE_);
set prim&n;
dmu=&n;
if _VALUE_ > 0.000000001 and _type_ = 'NON-NEG' then output;
run;
*proc print;


*second stage;

data _null_;
```

```
set prim&n;
if _VAR_ ='THETA' then CALL SYMPUT('thet', _VALUE_);
run;

%if &thet=1 %then %do;

data model2(drop=theta);
set model;
if _id_ = 'OBJFN' then delete;
if _type_='le' then _rhs_=z&n*&thet;
run;
*proc print;

data model2;
set model2 addobj2;
run;

data model2 (drop=j);
set model2;
array slack(2) e1-e2;
do j=1 to 2;
if _type_='le' then slack(j)=1;
end;
if _type_='ge' then s1=-1;
if _id_ ne 'OBJFN' then _type_='eq';
run;
proc print;
run;


proc lp scale=both printlevel=-2 primalout=prims&n;
row _id_;
run;

data _null_;
set prims&n;
if _VAR_='OBJFN' then CALL SYMPUT('obj', _VALUE_);
run;

data theta;
set theta;
if _VAR_='THETA' then stage2=&obj;
run;

%end;
proc append base=thetas data=theta;
run;


%end;

%mend runlp;

%runlp;
```

```
proc print data=thetas;
run;
```

C.6 Output-Increasing Two-Stage Radial Model

The following is the code for the output-increasing two stage radial model.

```
/******** Output increasing two stage radial model******************/

data dea;
set sasuser.machine;
proc print;
run;

proc transpose data=dea out=model name=_id_ prefix=z;
run;
proc print;


data model;
set model;
if _id_ = 'VAR1' then _type_='ge ';
else _type_='le ';
if _type_='ge ' then _rhs_=0;
run;
proc print;

data addobj;
input _id_ $ _type_ $;
cards;
OBJFN max
;
run;
proc print;

data addsumz (drop=i);
array vbls(23) Z1-Z23;
do i=1 to 23;
vbls(i)=1;
end;
input _id_ $ _type_ $ _rhs_;
cards;
SUMZ eq 1
;
run;
proc print;


data model;
set model addobj addsumz;
run;
proc print;


data thetas;
input DMU _VAR_ $ _VALUE_ STAGE2;
cards;
```

```
;
run;
proc print;

*stage 2 objective function;

data addobj2 (drop=j);
array slack(2) e1-e2;
 do j=1 to 2;
slack(j)=1;
end;
s1=1;
input _id_ $ _type_ $;
cards;
OBJFN max
;
run;

proc print;
run;


%macro runlp;
%do n=1 %to 23;


data model;
set model;
if _id_='OBJFN' then theta=1;
else if _id_ = 'SUMZ' or _type_ = 'le' then theta= .;
else theta=-z&n;
if _type_='le' then _rhs_=z&n;
run;
proc print;


proc lp scale=both printlevel=-2 primalout=prim&n;
row _id_;
var theta z1-z23;
*proc print;
run;

data theta (keep=DMU _VAR_ _VALUE_);
set prim&n;
dmu=&n;
if _VALUE_ > 0.000000001 and _type_ = 'NON-NEG' then output;
run;
*proc print;


*second stage;

data _null_;
set prim&n;
if _VAR_ ='THETA' then CALL SYMPUT('thet', _VALUE_);
```

```
run;

%if &thet=1 %then %do;

data model2(drop=theta);
set model;
if _id_ = 'OBJFN' then delete;
if _type_='ge' then _rhs_=z&n*&thet;
run;
*proc print;

data model2;
set model2 addobj2;
run;

data model2 (drop=j);
set model2;
array slack(2) e1-e2;
do j=1 to 2;
if _type_='le' then slack(j)=1;
end;
if _type_='ge' then s1=-1;
if _id_ ne 'OBJFN' then _type_='eq';
run;
proc print;
run;


proc lp scale=both printlevel=-2 primalout=prims&n;
row _id_;
run;

data _null_;
set prims&n;
if _VAR_='OBJFN' then CALL SYMPUT('obj', _VALUE_);
run;

data theta;
set theta;
if _VAR_='THETA' then stage2=&obj;
run;

%end;
proc append base=thetas data=theta;
run;


%end;

%mend runlp;

%runlp;

proc print data=thetas;
run;
```

C.7 Input-Reducing Non-Radial Model

The following is the code for input-reducing non-radial model.

```
/********** input reducing non-radial model*******************/

data dea ;
set sasuser.layer;
run;

proc transpose data=dea out=model name=_id_ prefix=z;
run;
data addobj (drop=j);
array vbls(2) lam1-lam2;
do j=1 to 2;
vbls(j)=1/2;
end;
input _id_ $ _type_ $char7.;
cards;
OBJFN min
;
run;


data model;
*length _type_ $;
set model;
if _id_='VAR1' then _type_='ge     ';
else _type_='le     ';
if _type_='le     ' then _rhs_=0;
run;

data addsumz (drop=i);
array vbls(23) z1-z23;
do i=1 to 23;
vbls(i)=1;
end;
input _id_ $ _type_ $char7. _rhs_;
cards;
SUMZ eq      1
;
run;


data addupr (drop=j);
array vbls(2) lam1-lam2;
do j=1 to 2;
vbls(j)=1;
end;
input _id_ $ _type_ $char7. _rhs_;
cards;
LAMUPR upperbd 1
;
run;
```

```
data model;
set model addobj addsumz addupr;
run;
proc print data=model;run;

data thetas;
input DMU _VAR_ $ _VALUE_;
cards;
;
run;

%macro runlp;
%do n=1 %to 23;

data model (drop=k);
set model;
array vbls(2) lam1-lam2;
do k=1 to 2;
if _type_='le     ' then vbls(k)=-z&n;
end;
if _type_='ge     ' then _rhs_=z&n;
run;

proc print;
run;

proc lp scale=row printlevel=-2 primalout=prim&n;
var z1-z23 lam1-lam2;
row _id_;
run;

data theta (keep=DMU _VAR_ _VALUE_);
set prim&n;
DMU=&n;
if _VALUE_ > 0.00001 then output;
run;

proc append base=thetas data=theta;
run;

%end;

%mend runlp;
%runlp;
proc print data=thetas;
run;
```

C.8 Output-Increasing Non-Radial Model

The following is the code for output-increasing non-radial model.

```
data dea ;
set sasuser.ag_in_ou;
run;

proc transpose data=dea out=model name=_id_ prefix=z;
run;

data addobj (drop=j);
array vbls(1) lam1;
do j=1;
vbls(j)=1;
end;
input _id_ $ _type_ $char7.;
cards;
OBJFN max
;
run;

data model;
*length _type_ $;
set model;
if _id_='VAR1' then _type_='ge     ';
else _type_='le     ';
if _type_='ge     ' then _rhs_=0;
run;

data addsumz (drop=i);
array vbls(23) z1-z23;
do i=1 to 23;
vbls(i)=1;
end;
input _id_ $ _type_ $char7. _rhs_;
cards;
SUMZ eq      1
;
run;


data model;
set model addobj addsumz;
run;
*proc print data=model;run;

data thetas;
input DMU _VAR_ $ _VALUE_;
cards;
;
run;

%macro runlp;
```

```
%do n=1 %to 23;

data model (drop=k);
set model;
array vbls(1) lam1;
do k=1;
if _type_='ge     ' then vbls(k)=-z&n;
end;
if _type_='le     ' then _rhs_=z&n;
run;

*proc print;
*run;

proc lp scale=row printlevel=-2 primalout=prim&n;
var z1-z23 lam1;
row _id_;
run;

data theta (keep=DMU _VAR_ _VALUE_);
set prim&n;
DMU=&n;
if _VALUE_ > 0.00001 then output;
run;

proc append base=thetas data=theta;
run;

%end;

%mend runlp;

%runlp;

proc print data=thetas;
run;
```

C.9 Goal Program with Activity Parameters Constrained between Zero and One

The following program is very similar to the preceding program except that the activity parameters are now restricted between zero and one. The following is the program for process 1.

```
/****Optimization for process 1.**********************/

data labor;
set sasuser.labor1;
proc print;
run;

proc transpose data=labor out=l_data name=_id_ prefix=l;
run;
proc print ;run;

data rm;
set sasuser.RM1;
proc print;
run;
proc transpose data=rm out=r_data name=_id_ prefix=r;
run;
proc print ;run;

data boards;
set sasuser.p1;
proc print;
run;

proc transpose data=boards out=b_data name=_id_ prefix=b;
run;
proc print ;run;


data prtarget;
set sasuser.p1tar;
proc print;
run;
proc transpose data=prtarget out=prt_data name=_id_ prefix=pt;
run;
proc print ;run;


data gltarget;
set sasuser.gltarget;
proc print;
run;

proc transpose data=gltarget out=gt_data name=_id_ prefix=gt;
run;
```

```
proc print ;run;

data recur_o;
set sasuser.recur_a1;
proc print; run;

proc transpose data = recur_o out=recurout name=_id_ prefix=ro;
run;
proc print;run;

data agg_data;
merge l_data r_data b_data prt_data gt_data;
run;
proc print; run;

/***define global objective function*******/


data gl_obj (drop=h);
array vbls(3) gl_neg_o gl_pos_l gl_pos_r;
do h=1 to 3;
vbls(1) = 1/400000;
vbls(2) = 1/112226;
vbls(3) = 1/17267183;
end;
_id_ = 'gl_obj';
_type_= 'min    ';
_rhs_= 2;
run;

proc print;
run;


/**********************define process objective function **************/

data pr_obj(keep = _id_ _type_ _rhs_ pd_l_1-pd_l_23  pd_r_1-pd_r_23 nd_o_1-nd_o_23 );
set agg_data;
array vbls(69) pd_l_1-pd_l_23  pd_r_1-pd_r_23 nd_o_1-nd_o_23;

do i=1 to 69;
vbls(1)=1/l1;
vbls(2)=1/l2;
vbls(3)=1/l3;
vbls(4)=1/l4;
vbls(5)=1/l5;
vbls(6)=1/l6;
vbls(7)=1/l7;
vbls(8)=1/l8;
vbls(9)=1/l9;
vbls(10)=1/l10;
vbls(11)=1/l11;
vbls(12)=1/l12;
vbls(13)=1/l13;
vbls(14)=1/l14;
```

```
vbls(15)=1/l15;
vbls(16)=1/l16;
vbls(17)=1/l17;
vbls(18)=1/l18;
vbls(19)=1/l19;
vbls(20)=1/l20;
vbls(21)=1/l21;
vbls(22)=1/l22;
vbls(23)=1/l23;
vbls(24)=1/r1;
vbls(25)=1/r2;
vbls(26)=1/r3;
vbls(27)=1/r4;
vbls(28)=1/r5;
vbls(29)=1/r6;
vbls(30)=1/r7;
vbls(31)=1/r8;
vbls(32)=1/r9;
vbls(33)=1/r10;
vbls(34)=1/r11;
vbls(35)=1/r12;
vbls(36)=1/r13;
vbls(37)=1/r14;
vbls(38)=1/r15;
vbls(39)=1/r16;
vbls(40)=1/r17;
vbls(41)=1/r18;
vbls(42)=1/r19;
vbls(43)=1/r20;
vbls(44)=1/r21;
vbls(45)=1/r22;
vbls(46)=1/r23;
vbls(47)=1/pt1;
vbls(48)=1/pt2;
vbls(49)=1/pt3;
vbls(50)=1/pt4;
vbls(51)=1/pt5;
vbls(52)=1/pt6;
vbls(53)=1/pt7;
vbls(54)=1/pt8;
vbls(55)=1/pt9;
vbls(56)=1/pt10;
vbls(57)=1/pt11;
vbls(58)=1/pt12;
vbls(59)=1/pt13;
vbls(60)=1/pt14;
vbls(61)=1/pt15;
vbls(62)=1/pt16;
vbls(63)=1/pt17;
vbls(64)=1/pt18;
vbls(65)=1/pt19;
vbls(66)=1/pt20;
vbls(67)=1/pt21;
vbls(68)=1/pt22;
vbls(69)=1/pt23;
```

```
end;
_id_ = 'pr_obj';
_type_ = 'min    ';
_rhs_ = 1;

run;
proc print;
run;


/***************define activity parameters**************/
data ac_param(keep = _id_ _rhs_ _type_ z1-z529);

array vbls(529) z1-z529;
do i=1 to 529;
vbls(i)=1;
end;

_id_ = 'ac_const';
_rhs_=1;
_type_ = 'upperbd';
run;
proc print;
run;

/*************************************************************************/

data model;
set gl_obj pr_obj ac_param;
run;
proc print;
run;

data pconst;
merge b_data prt_data;
run;
*proc print; run;


/***************setting process output target constrainsts**************/
%macro p_const1;
%do n=1 %to 23;
%let x1 = %eval((&n-1)*23+1);
%let x2 = %eval(&n*23);
data pr_o&n (keep=_id_ _type_ _rhs_ z&x1-z&x2 nd_o_&n pd_o_&n);
length _id_ $ 12;
set pconst;
array vbls(23) z&x1-z&x2;
do i=1 to 23;
vbls(1)=b1;
vbls(2)=b2;
vbls(3)=b3;
vbls(4)=b4;
vbls(5)=b5;
```

```
vbls(6)=b6;
vbls(7)=b7;
vbls(8)=b8;
vbls(9)=b9;
vbls(10)=b10;
vbls(11)=b11;
vbls(12)=b12;
vbls(13)=b13;
vbls(14)=b14;
vbls(15)=b15;
vbls(16)=b16;
vbls(17)=b17;
vbls(18)=b18;
vbls(19)=b19;
vbls(20)=b20;
vbls(21)=b21;
vbls(22)=b22;
vbls(23)=b23;

end;
_id_ = compress('pro_const'||&n);
_rhs_=pt&n;
_type_ = 'eq     ';
nd_o_&n = 1;
pd_o_&n = -1;
run;
proc print;
run;
%end;
%mend p_const1;
%p_const1;

/***************setting process labor target constrainsts**************/
%macro p_const2;
%do n=1 %to 23;
%let x1 = %eval((&n-1)*23+1);
%let x2 = %eval(&n*23);
data pr_l&n (keep=_id_ _type_ _rhs_ z&x1-z&x2 nd_l_&n pd_l_&n drop=i);
length _id_ $ 12;
set l_data;
array vbls(23) z&x1-z&x2;
do i=1 to 23;
vbls(1)=l1;
vbls(2)=l2;
vbls(3)=l3;
vbls(4)=l4;
vbls(5)=l5;
vbls(6)=l6;
vbls(7)=l7;
vbls(8)=l8;
vbls(9)=l9;
vbls(10)=l10;
vbls(11)=l11;
vbls(12)=l12;
vbls(13)=l13;
```

```
vbls(14)=l14;
vbls(15)=l15;
vbls(16)=l16;
vbls(17)=l17;
vbls(18)=l18;
vbls(19)=l19;
vbls(20)=l20;
vbls(21)=l21;
vbls(22)=l22;
vbls(23)=l23;
end;
_id_ = compress('prl_const'||&n);
_rhs_=l&n;
_type_ = 'eq     ';
nd_l_&n = 1;
pd_l_&n = -1;
run;
proc print;
run;
%end;
%mend p_const2;
%p_const2;


/***************setting process raw materials target constrainsts**************/
%macro p_const3;
%do n=1 %to 23;
%let x1 = %eval((&n-1)*23+1);
%let x2 = %eval(&n*23);
data pr_r&n (keep=_id_ _type_ _rhs_ z&x1-z&x2 nd_r_&n pd_r_&n);
length _id_ $ 12;
set r_data;
array vbls(23) z&x1-z&x2;
do i=1 to 23;
vbls(1)=r1;
vbls(2)=r2;
vbls(3)=r3;
vbls(4)=r4;
vbls(5)=r5;
vbls(6)=r6;
vbls(7)=r7;
vbls(8)=r8;
vbls(9)=r9;
vbls(10)=r10;
vbls(11)=r11;
vbls(12)=r12;
vbls(13)=r13;
vbls(14)=r14;
vbls(15)=r15;
vbls(16)=r16;
vbls(17)=r17;
vbls(18)=r18;
vbls(19)=r19;
vbls(20)=r20;
vbls(21)=r21;
```

```
vbls(22)=r22;
vbls(23)=r23;
end;
_id_ = compress('prr_const'||&n);
_rhs_=r&n;
_type_ = 'eq     ';
nd_r_&n = 1;
pd_r_&n = -1;
run;
proc print;
run;
%end;
%mend p_const3;
%p_const3;



/************Setting global output target constraints*********/

%macro g;
data g_const (keep= z1-z529);
set b_data;
%do m=1%to 23;
%do n=1%to 23;
%let mn = %eval((&m-1)*23+&n);
z&mn = b&n;
%end;
%end;
run;
%mend g;
%g;

proc print; run;

data g_const;
set g_const;
_rhs_=400000;

_id_ = 'glo_const';
_type_ = 'eq     ';
gl_neg_o = 1;
gl_pos_o = -1;
run;
proc print;
run;


/************Setting global input labor target constraints*********/
%macro l;
data l_const (keep= z1-z529);
set l_data;
%do m=1%to 23;
%do n=1%to 23;
%let mn = %eval((&m-1)*23+&n);
z&mn = l&n;
```

```
%end;
%end;
run;
%mend l;
%l;

proc print; run;

data l_const;
set l_const;
_rhs_=112226;

_id_ = 'prl_const';
_type_ = 'eq     ';
gl_neg_l = 1;
gl_pos_l = -1;
run;
proc print;
run;

/************Setting global input raw materials target constraints*********/

%macro r;
data r_const (keep= z1-z529);
set r_data;
%do m=1%to 23;
%do n=1%to 23;
%let mn = %eval((&m-1)*23+&n);
z&mn = r&n;
%end;
%end;
run;
%mend r;
%r;

proc print; run;

data r_const;
set r_const;
_rhs_=17267183;

_id_ = 'prr_const';
_type_ = 'eq     ';
gl_neg_r = 1;
gl_pos_r = -1;
run;
proc print;
run;


/***********set the model******************/

data model;
set model pr_o1 pr_o2 pr_o3 pr_o4 pr_o5 pr_o6 pr_o7 pr_o8 pr_o9 pr_o10 pr_o11 pr_o12 pr_o13 pr_o14
pr_o15 pr_o16 pr_o17 pr_o18 pr_o19
```

```
pr_o20 pr_o21 pr_o22 pr_o23 g_const;
run;
proc print; run;

data model;
set model pr_l1 pr_l2 pr_l3 pr_l4 pr_l5 pr_l6 pr_l7 pr_l8 pr_l9 pr_l10 pr_l11 pr_l12 pr_l13 pr_l14 pr_l15
pr_l16 pr_l17 pr_l18 pr_l19
pr_l20 pr_l21 pr_l22 pr_l23 l_const;
run;
proc print; run;


data model;
set model pr_r1 pr_r2 pr_r3 pr_r4 pr_r5 pr_r6 pr_r7 pr_r8 pr_r9 pr_r10 pr_r11 pr_r12 pr_r13 pr_r14 pr_r15
pr_r16 pr_r17 pr_r18 pr_r19
pr_r20 pr_r21 pr_r22 pr_r23 r_const;
run;
proc print; run;


proc lp goalprogram scale=both printlevel=-2 primalout=prim1  maxit1=200 maxit2=200;
var z1-z529 gl_neg_o gl_pos_o gl_neg_l gl_pos_l gl_neg_r gl_pos_r nd_o_1-nd_o_23 pd_o_1-pd_o_23
nd_l_1-nd_l_23 pd_l_1-pd_l_23 nd_r_1-nd_r_23 pd_r_1-pd_r_23;
run;




data dev(keep= _var_ _value_);
set prim1;
if _value_>0 then output;
run;
proc print;
run;
```

The following is the code for process 2 through 11.

```
/****Optimization for process 2, 3 ...11.**********************/

data labor;
set sasuser.labor11;
proc print;
run;

proc transpose data=labor out=l_data name=_id_ prefix=l;
run;
proc print ;run;

data rm;
set sasuser.RM11;
```

```
proc print;
run;
proc transpose data=rm out=r_data name=_id_ prefix=r;
run;
proc print ;run;

data boards;
set sasuser.p11;
proc print;
run;

proc transpose data=boards out=b_data name=_id_ prefix=b;
run;
proc print ;run;


data balance;
set sasuser.p10;
proc print;
run;

proc transpose data=balance out=bl_data name=_id_ prefix=bt;
run;
proc print ;run;


data prtarget;
set sasuser.p11tar;
proc print;
run;
proc transpose data=prtarget out=prt_data name=_id_ prefix=pt;
run;
proc print ;run;

/******************
data gltarget;
set sasuser.gltarget;
proc print;
run;

proc transpose data=gltarget out=gt_data name=_id_ prefix=gt;
run;
proc print ;run;
**************************/



data agg_data;
merge l_data r_data b_data prt_data bl_data;
run;
proc print; run;

/***define global objective function*******/
```

```
data gl_obj (drop=h);
array vbls(3) gl_neg_o gl_pos_l gl_pos_r;
do h=1 to 3;
vbls(1) = 1/400000;
vbls(2) = 1/40366;
vbls(3) = 1/579286;
end;
_id_ = 'gl_obj';
_type_= 'min    ';
_rhs_= 3;
run;

proc print;
run;


/**********************define process objective function *************/

data pr_obj(keep = _id_ _type_ _rhs_ pd_l_1-pd_l_23  pd_r_1-pd_r_23 nd_o_1-nd_o_23);
set agg_data;
array vbls(69) pd_l_1-pd_l_23  pd_r_1-pd_r_23 nd_o_1-nd_o_23;

do i=1 to 69;
vbls(1)=1/l1;
vbls(2)=1/l2;
vbls(3)=1/l3;
vbls(4)=1/l4;
vbls(5)=1/l5;
vbls(6)=1/l6;
vbls(7)=1/l7;
vbls(8)=1/l8;
vbls(9)=1/l9;
vbls(10)=1/l10;
vbls(11)=1/l11;
vbls(12)=1/l12;
vbls(13)=1/l13;
vbls(14)=1/l14;
vbls(15)=1/l15;
vbls(16)=1/l16;
vbls(17)=1/l17;
vbls(18)=1/l18;
vbls(19)=1/l19;
vbls(20)=1/l20;
vbls(21)=1/l21;
vbls(22)=1/l22;
vbls(23)=1/l23;
vbls(24)=1/r1;
vbls(25)=1/r2;
vbls(26)=1/r3;
vbls(27)=1/r4;
vbls(28)=1/r5;
vbls(29)=1/r6;
vbls(30)=1/r7;
vbls(31)=1/r8;
vbls(32)=1/r9;
```

```
vbls(33)=1/r10;
vbls(34)=1/r11;
vbls(35)=1/r12;
vbls(36)=1/r13;
vbls(37)=1/r14;
vbls(38)=1/r15;
vbls(39)=1/r16;
vbls(40)=1/r17;
vbls(41)=1/r18;
vbls(42)=1/r19;
vbls(43)=1/r20;
vbls(44)=1/r21;
vbls(45)=1/r22;
vbls(46)=1/r23;
vbls(47)=1/pt1;
vbls(48)=1/pt2;
vbls(49)=1/pt3;
vbls(50)=1/pt4;
vbls(51)=1/pt5;
vbls(52)=1/pt6;
vbls(53)=1/pt7;
vbls(54)=1/pt8;
vbls(55)=1/pt9;
vbls(56)=1/pt10;
vbls(57)=1/pt11;
vbls(58)=1/pt12;
vbls(59)=1/pt13;
vbls(60)=1/pt14;
vbls(61)=1/pt15;
vbls(62)=1/pt16;
vbls(63)=1/pt17;
vbls(64)=1/pt18;
vbls(65)=1/pt19;
vbls(66)=1/pt20;
vbls(67)=1/pt21;
vbls(68)=1/pt22;
vbls(69)=1/pt23;
end;
_id_ = 'pr_obj';
_type_ = 'min    ';
_rhs_ = 1;

run;
proc print;
run;

/**********************define balance objective function *************/

data bl_obj(keep = _id_ _type_ _rhs_ bl_neg1-bl_neg23);
set bl_data;
array vbls(23) bl_neg1-bl_neg23;

do i=1 to 23;
vbls(1)=1/bt1;
vbls(2)=1/bt2;
```

```
vbls(3)=1/bt3;
vbls(4)=1/bt4;
vbls(5)=1/bt5;
vbls(6)=1/bt6;
vbls(7)=1/bt7;
vbls(8)=1/bt8;
vbls(9)=1/bt9;
vbls(10)=1/bt10;
vbls(11)=1/bt11;
vbls(12)=1/bt12;
vbls(13)=1/bt13;
vbls(14)=1/bt14;
vbls(15)=1/bt15;
vbls(16)=1/bt16;
vbls(17)=1/bt17;
vbls(18)=1/bt18;
vbls(19)=1/bt19;
vbls(20)=1/bt20;
vbls(21)=1/bt21;
vbls(22)=1/bt22;
vbls(23)=1/bt23;

end;
_id_ = 'bl_obj';
_type_ = 'min    ';
_rhs_ = 2;

run;
proc print;
run;


/***************define activity parameters**************/
data ac_param(keep = _id_ _rhs_ _type_ z1-z529);

array vbls(529) z1-z529;
do i=1 to 529;
vbls(i)=1;
end;

_id_ = 'ac_const';
_rhs_=1;
_type_ = 'upperbd';
run;
proc print;
run;
/*************************************************************************/

data model;
set gl_obj pr_obj bl_obj ac_param;
run;
proc print;
run;

data pconst;
```

```
merge b_data prt_data;
run;
*proc print; run;


/**************setting process output target constrainsts**************/
%macro p_const1;
%do n=1 %to 23;
%let x1 = %eval((&n-1)*23+1);
%let x2 = %eval(&n*23);
data pr_o&n (keep=_id_ _type_ _rhs_ z&x1-z&x2 nd_o_&n pd_o_&n);
length _id_ $ 12;
set pconst;
array vbls(23) z&x1-z&x2;
do i=1 to 23;
vbls(1)=b1;
vbls(2)=b2;
vbls(3)=b3;
vbls(4)=b4;
vbls(5)=b5;
vbls(6)=b6;
vbls(7)=b7;
vbls(8)=b8;
vbls(9)=b9;
vbls(10)=b10;
vbls(11)=b11;
vbls(12)=b12;
vbls(13)=b13;
vbls(14)=b14;
vbls(15)=b15;
vbls(16)=b16;
vbls(17)=b17;
vbls(18)=b18;
vbls(19)=b19;
vbls(20)=b20;
vbls(21)=b21;
vbls(22)=b22;
vbls(23)=b23;

end;
_id_ = compress('pro_const'||&n);
_rhs_=pt&n;
_type_ = 'eq     ';
nd_o_&n = 1;
pd_o_&n = -1;
run;
proc print;
run;
%end;
%mend p_const1;
%p_const1;

data bconst;
merge b_data bl_data;
run;
```

```
/***************setting balance target constrainsts**************/
%macro b_const1;
%do n=1 %to 23;
%let x1 = %eval((&n-1)*23+1);
%let x2 = %eval(&n*23);
data bl_o&n (keep=_id_ _type_ _rhs_ z&x1-z&x2 bl_neg&n bl_pos&n);
length _id_ $ 12;
set bconst;
array vbls(23) z&x1-z&x2;
do i=1 to 23;
vbls(1)=b1;
vbls(2)=b2;
vbls(3)=b3;
vbls(4)=b4;
vbls(5)=b5;
vbls(6)=b6;
vbls(7)=b7;
vbls(8)=b8;
vbls(9)=b9;
vbls(10)=b10;
vbls(11)=b11;
vbls(12)=b12;
vbls(13)=b13;
vbls(14)=b14;
vbls(15)=b15;
vbls(16)=b16;
vbls(17)=b17;
vbls(18)=b18;
vbls(19)=b19;
vbls(20)=b20;
vbls(21)=b21;
vbls(22)=b22;
vbls(23)=b23;

end;
_id_ = compress('blo_const'||&n);
_rhs_=bt&n;
_type_ = 'eq     ';
bl_neg&n = 1;
bl_pos&n = -1;
run;
proc print;
run;
%end;
%mend b_const1;
%b_const1;

/***************setting process labor target constrainsts**************/
%macro p_const2;
%do n=1 %to 23;
%let x1 = %eval((&n-1)*23+1);
%let x2 = %eval(&n*23);
data pr_l&n (keep=_id_ _type_ _rhs_ z&x1-z&x2 nd_l_&n pd_l_&n drop=i);
length _id_ $ 12;
```

```
set l_data;
array vbls(23) z&x1-z&x2;
do i=1 to 23;
vbls(1)=l1;
vbls(2)=l2;
vbls(3)=l3;
vbls(4)=l4;
vbls(5)=l5;
vbls(6)=l6;
vbls(7)=l7;
vbls(8)=l8;
vbls(9)=l9;
vbls(10)=l10;
vbls(11)=l11;
vbls(12)=l12;
vbls(13)=l13;
vbls(14)=l14;
vbls(15)=l15;
vbls(16)=l16;
vbls(17)=l17;
vbls(18)=l18;
vbls(19)=l19;
vbls(20)=l20;
vbls(21)=l21;
vbls(22)=l22;
vbls(23)=l23;
end;
_id_ = compress('prl_const'||&n);
_rhs_=l&n;
_type_ = 'eq     ';
nd_l_&n = 1;
pd_l_&n = -1;
run;
proc print;
run;
%end;
%mend p_const2;
%p_const2;


/***************setting process raw materials target constrainsts**************/
%macro p_const3;
%do n=1 %to 23;
%let x1 = %eval((&n-1)*23+1);
%let x2 = %eval(&n*23);
data pr_r&n (keep=_id_ _type_ _rhs_ z&x1-z&x2 nd_r_&n pd_r_&n);
length _id_ $ 12;
set r_data;
array vbls(23) z&x1-z&x2;
do i=1 to 23;
vbls(1)=r1;
vbls(2)=r2;
vbls(3)=r3;
vbls(4)=r4;
vbls(5)=r5;
```

```
vbls(6)=r6;
vbls(7)=r7;
vbls(8)=r8;
vbls(9)=r9;
vbls(10)=r10;
vbls(11)=r11;
vbls(12)=r12;
vbls(13)=r13;
vbls(14)=r14;
vbls(15)=r15;
vbls(16)=r16;
vbls(17)=r17;
vbls(18)=r18;
vbls(19)=r19;
vbls(20)=r20;
vbls(21)=r21;
vbls(22)=r22;
vbls(23)=r23;
end;
_id_ = compress('prr_const'||&n);
_rhs_=r&n;
_type_ = 'eq     ';
nd_r_&n = 1;
pd_r_&n = -1;
run;
proc print;
run;
%end;
%mend p_const3;
%p_const3;



/*************Setting global output target constraints*********/

%macro g;
data g_const (keep= z1-z529);
set b_data;
%do m=1%to 23;
%do n=1%to 23;
%let mn = %eval((&m-1)*23+&n);
z&mn = b&n;
%end;
%end;
run;
%mend g;
%g;

proc print; run;

data g_const;
set g_const;
_rhs_=400000;

_id_ = 'glo_const';
```

```
_type_ = 'eq     ';
gl_neg_o = 1;
gl_pos_o = -1;
run;
proc print;
run;


/************Setting global input labor target constraints*********/
%macro l;
data l_const (keep= z1-z529);
set l_data;
%do m=1%to 23;
%do n=1%to 23;
%let mn = %eval((&m-1)*23+&n);
z&mn = l&n;
%end;
%end;
run;
%mend l;
%l;

proc print; run;

data l_const;
set l_const;
_rhs_=40366;

_id_ = 'prl_const';
_type_ = 'eq     ';
gl_neg_l = 1;
gl_pos_l = -1;
run;
proc print;
run;

/************Setting global input raw materials target constraints*********/

%macro r;
data r_const (keep= z1-z529);
set r_data;
%do m=1%to 23;
%do n=1%to 23;
%let mn = %eval((&m-1)*23+&n);
z&mn = r&n;
%end;
%end;
run;
%mend r;
%r;

proc print; run;

data r_const;
set r_const;
```

```
_rhs_=579286;

_id_ = 'prr_const';
_type_ = 'eq     ';
gl_neg_r = 1;
gl_pos_r = -1;
run;
proc print;
run;


/***********set the model******************/

data model;
set model pr_o1 pr_o2 pr_o3 pr_o4 pr_o5 pr_o6 pr_o7 pr_o8 pr_o9 pr_o10 pr_o11 pr_o12 pr_o13 pr_o14
pr_o15 pr_o16 pr_o17 pr_o18 pr_o19
pr_o20 pr_o21 pr_o22 pr_o23 g_const;
run;
proc print; run;

data model;
set model pr_l1 pr_l2 pr_l3 pr_l4 pr_l5 pr_l6 pr_l7 pr_l8 pr_l9 pr_l10 pr_l11 pr_l12 pr_l13 pr_l14 pr_l15
pr_l16 pr_l17 pr_l18 pr_l19
pr_l20 pr_l21 pr_l22 pr_l23 l_const;
run;
proc print; run;


data model;
set model pr_r1 pr_r2 pr_r3 pr_r4 pr_r5 pr_r6 pr_r7 pr_r8 pr_r9 pr_r10 pr_r11 pr_r12 pr_r13 pr_r14 pr_r15
pr_r16 pr_r17 pr_r18 pr_r19
pr_r20 pr_r21 pr_r22 pr_r23 r_const;
run;
proc print; run;

data model;
set model bl_o1 bl_o2 bl_o3 bl_o4 bl_o5 bl_o6 bl_o7 bl_o8 bl_o9 bl_o10 bl_o11 bl_o12 bl_o13
bl_o14 bl_o15 bl_o16 bl_o17 bl_o18 bl_o19 bl_o20 bl_o21 bl_o22 bl_o23;
run;


proc lp goalprogram scale=both printlevel=-2 primalout=prim1  maxit1=200 maxit2=200;
var z1-z529 gl_neg_o gl_pos_o gl_neg_l gl_pos_l gl_neg_r gl_pos_r nd_o_1-nd_o_23 pd_o_1-pd_o_23
nd_l_1-nd_l_23 pd_l_1-pd_l_23 nd_r_1-nd_r_23 pd_r_1-pd_r_23 bl_neg1-bl_neg23 bl_pos1-bl_pos23;
run;




data dev(keep= _var_ _value_);
set prim1;
if _value_>0 then output;
run;
proc print;
run;
```

C.10 Goal Program with Activity Parameters Unrestricted

The following sectiosn illustrates the goal programs with the activity parameter constraint unrestricted. As in the previous cases, there are two separate programs for process 1 and processes 2 through11.

The following is the program for process 1.

```
/****Optimization for process 1.**********************/

data labor;
set sasuser.labor1;
proc print;
run;

proc transpose data=labor out=l_data name=_id_ prefix=l;
run;
proc print ;run;

data rm;
set sasuser.RM1;
proc print;
run;
proc transpose data=rm out=r_data name=_id_ prefix=r;
run;
proc print ;run;

data boards;
set sasuser.p1;
proc print;
run;

proc transpose data=boards out=b_data name=_id_ prefix=b;
run;
proc print ;run;


data prtarget;
set sasuser.p1tar;
proc print;
run;
proc transpose data=prtarget out=prt_data name=_id_ prefix=pt;
run;
proc print ;run;


data gltarget;
set sasuser.gltarget;
proc print;
run;
```

```
proc transpose data=gltarget out=gt_data name=_id_ prefix=gt;
run;
proc print ;run;

data recur_o;
set sasuser.recur_a1;
proc print; run;

proc transpose data = recur_o out=recurout name=_id_ prefix=ro;
run;
proc print;run;

data agg_data;
merge l_data r_data b_data prt_data gt_data;
run;
proc print; run;

/***define global objective function*******/


data gl_obj (drop=h);
array vbls(3) gl_neg_o gl_pos_l gl_pos_r;
do h=1 to 3;
vbls(1) = 1/400000;
vbls(2) = 1/112226;
vbls(3) = 1/17267183;
end;
_id_ = 'gl_obj';
_type_= 'min    ';
_rhs_= 2;
run;

proc print;
run;


/**********************define process objective function *************/

data pr_obj(keep = _id_ _type_ _rhs_ pd_l_1-pd_l_23  pd_r_1-pd_r_23 nd_o_1-nd_o_23 );
set agg_data;
array vbls(69) pd_l_1-pd_l_23  pd_r_1-pd_r_23 nd_o_1-nd_o_23;

do i=1 to 69;
vbls(1)=1/l1;
vbls(2)=1/l2;
vbls(3)=1/l3;
vbls(4)=1/l4;
vbls(5)=1/l5;
vbls(6)=1/l6;
vbls(7)=1/l7;
vbls(8)=1/l8;
vbls(9)=1/l9;
vbls(10)=1/l10;
vbls(11)=1/l11;
vbls(12)=1/l12;
```

```
vbls(13)=1/l13;
vbls(14)=1/l14;
vbls(15)=1/l15;
vbls(16)=1/l16;
vbls(17)=1/l17;
vbls(18)=1/l18;
vbls(19)=1/l19;
vbls(20)=1/l20;
vbls(21)=1/l21;
vbls(22)=1/l22;
vbls(23)=1/l23;
vbls(24)=1/r1;
vbls(25)=1/r2;
vbls(26)=1/r3;
vbls(27)=1/r4;
vbls(28)=1/r5;
vbls(29)=1/r6;
vbls(30)=1/r7;
vbls(31)=1/r8;
vbls(32)=1/r9;
vbls(33)=1/r10;
vbls(34)=1/r11;
vbls(35)=1/r12;
vbls(36)=1/r13;
vbls(37)=1/r14;
vbls(38)=1/r15;
vbls(39)=1/r16;
vbls(40)=1/r17;
vbls(41)=1/r18;
vbls(42)=1/r19;
vbls(43)=1/r20;
vbls(44)=1/r21;
vbls(45)=1/r22;
vbls(46)=1/r23;
vbls(47)=1/pt1;
vbls(48)=1/pt2;
vbls(49)=1/pt3;
vbls(50)=1/pt4;
vbls(51)=1/pt5;
vbls(52)=1/pt6;
vbls(53)=1/pt7;
vbls(54)=1/pt8;
vbls(55)=1/pt9;
vbls(56)=1/pt10;
vbls(57)=1/pt11;
vbls(58)=1/pt12;
vbls(59)=1/pt13;
vbls(60)=1/pt14;
vbls(61)=1/pt15;
vbls(62)=1/pt16;
vbls(63)=1/pt17;
vbls(64)=1/pt18;
vbls(65)=1/pt19;
vbls(66)=1/pt20;
vbls(67)=1/pt21;
```

```
vbls(68)=1/pt22;
vbls(69)=1/pt23;

end;
_id_ = 'pr_obj';
_type_ = 'min    ';
_rhs_ = 1;

run;
proc print;
run;


/***************define activity parameters**************
data ac_param(keep = _id_ _rhs_ _type_ z1-z529);

array vbls(529) z1-z529;
do i=1 to 529;
vbls(i)=1;
end;

_id_ = 'ac_const';
_rhs_=0;
_type_ = 'lowerbd';
run;
proc print;
run;

*************************************************************************/

data model;
set gl_obj pr_obj;
run;
proc print;
run;

data pconst;
merge b_data prt_data;
run;
*proc print; run;


/***************setting process output target constrainsts**************/
%macro p_const1;
%do n=1 %to 23;
%let x1 = %eval((&n-1)*23+1);
%let x2 = %eval(&n*23);
data pr_o&n (keep=_id_ _type_ _rhs_ z&x1-z&x2 nd_o_&n pd_o_&n);
length _id_ $ 12;
set pconst;
array vbls(23) z&x1-z&x2;
do i=1 to 23;
vbls(1)=b1;
vbls(2)=b2;
vbls(3)=b3;
```

```
vbls(4)=b4;
vbls(5)=b5;
vbls(6)=b6;
vbls(7)=b7;
vbls(8)=b8;
vbls(9)=b9;
vbls(10)=b10;
vbls(11)=b11;
vbls(12)=b12;
vbls(13)=b13;
vbls(14)=b14;
vbls(15)=b15;
vbls(16)=b16;
vbls(17)=b17;
vbls(18)=b18;
vbls(19)=b19;
vbls(20)=b20;
vbls(21)=b21;
vbls(22)=b22;
vbls(23)=b23;

end;
_id_ = compress('pro_const'||&n);
_rhs_=pt&n;
_type_ = 'eq     ';
nd_o_&n = 1;
pd_o_&n = -1;
run;
proc print;
run;
%end;
%mend p_const1;
%p_const1;

/***************setting process labor target constrainsts**************/
%macro p_const2;
%do n=1 %to 23;
%let x1 = %eval((&n-1)*23+1);
%let x2 = %eval(&n*23);
data pr_l&n (keep=_id_ _type_ _rhs_ z&x1-z&x2 nd_l_&n pd_l_&n drop=i);
length _id_ $ 12;
set l_data;
array vbls(23) z&x1-z&x2;
do i=1 to 23;
vbls(1)=l1;
vbls(2)=l2;
vbls(3)=l3;
vbls(4)=l4;
vbls(5)=l5;
vbls(6)=l6;
vbls(7)=l7;
vbls(8)=l8;
vbls(9)=l9;
vbls(10)=l10;
vbls(11)=l11;
```

```
vbls(12)=l12;
vbls(13)=l13;
vbls(14)=l14;
vbls(15)=l15;
vbls(16)=l16;
vbls(17)=l17;
vbls(18)=l18;
vbls(19)=l19;
vbls(20)=l20;
vbls(21)=l21;
vbls(22)=l22;
vbls(23)=l23;
end;
_id_ = compress('prl_const'||&n);
_rhs_=l&n;
_type_ = 'eq     ';
nd_l_&n = 1;
pd_l_&n = -1;
run;
proc print;
run;
%end;
%mend p_const2;
%p_const2;


/***************setting process raw materials target constrainsts*************/
%macro p_const3;
%do n=1 %to 23;
%let x1 = %eval((&n-1)*23+1);
%let x2 = %eval(&n*23);
data pr_r&n (keep=_id_ _type_ _rhs_ z&x1-z&x2 nd_r_&n pd_r_&n);
length _id_ $ 12;
set r_data;
array vbls(23) z&x1-z&x2;
do i=1 to 23;
vbls(1)=r1;
vbls(2)=r2;
vbls(3)=r3;
vbls(4)=r4;
vbls(5)=r5;
vbls(6)=r6;
vbls(7)=r7;
vbls(8)=r8;
vbls(9)=r9;
vbls(10)=r10;
vbls(11)=r11;
vbls(12)=r12;
vbls(13)=r13;
vbls(14)=r14;
vbls(15)=r15;
vbls(16)=r16;
vbls(17)=r17;
vbls(18)=r18;
vbls(19)=r19;
```

```
vbls(20)=r20;
vbls(21)=r21;
vbls(22)=r22;
vbls(23)=r23;
end;
_id_ = compress('prr_const'||&n);
_rhs_=r&n;
_type_ = 'eq     ';
nd_r_&n = 1;
pd_r_&n = -1;
run;
proc print;
run;
%end;
%mend p_const3;
%p_const3;



/**********Setting global output target constraints*********/

%macro g;
data g_const (keep= z1-z529);
set b_data;
%do m=1%to 23;
%do n=1%to 23;
%let mn = %eval((&m-1)*23+&n);
z&mn = b&n;
%end;
%end;
run;
%mend g;
%g;

proc print; run;

data g_const;
set g_const;
_rhs_=400000;

_id_ = 'glo_const';
_type_ = 'eq     ';
gl_neg_o = 1;
gl_pos_o = -1;
run;
proc print;
run;


/**********Setting global input labor target constraints*********/
%macro l;
data l_const (keep= z1-z529);
set l_data;
%do m=1%to 23;
%do n=1%to 23;
```

```
%let mn = %eval((&m-1)*23+&n);
z&mn = l&n;
%end;
%end;
run;
%mend l;
%l;

proc print; run;

data l_const;
set l_const;
_rhs_=112226;

_id_ = 'prl_const';
_type_ = 'eq     ';
gl_neg_l = 1;
gl_pos_l = -1;
run;
proc print;
run;

/************Setting global input raw materials target constraints*********/

%macro r;
data r_const (keep= z1-z529);
set r_data;
%do m=1%to 23;
%do n=1%to 23;
%let mn = %eval((&m-1)*23+&n);
z&mn = r&n;
%end;
%end;
run;
%mend r;
%r;

proc print; run;

data r_const;
set r_const;
_rhs_=17267183;

_id_ = 'prr_const';
_type_ = 'eq     ';
gl_neg_r = 1;
gl_pos_r = -1;
run;
proc print;
run;


/***********set the model*****************/

data model;
```

```
set model pr_o1 pr_o2 pr_o3 pr_o4 pr_o5 pr_o6 pr_o7 pr_o8 pr_o9 pr_o10 pr_o11 pr_o12 pr_o13 pr_o14
pr_o15 pr_o16 pr_o17 pr_o18 pr_o19
pr_o20 pr_o21 pr_o22 pr_o23 g_const;
run;
proc print; run;

data model;
set model pr_l1 pr_l2 pr_l3 pr_l4 pr_l5 pr_l6 pr_l7 pr_l8 pr_l9 pr_l10 pr_l11 pr_l12 pr_l13 pr_l14 pr_l15
pr_l16 pr_l17 pr_l18 pr_l19
pr_l20 pr_l21 pr_l22 pr_l23 l_const;
run;
proc print; run;


data model;
set model pr_r1 pr_r2 pr_r3 pr_r4 pr_r5 pr_r6 pr_r7 pr_r8 pr_r9 pr_r10 pr_r11 pr_r12 pr_r13 pr_r14 pr_r15
pr_r16 pr_r17 pr_r18 pr_r19
pr_r20 pr_r21 pr_r22 pr_r23 r_const;
run;
proc print; run;


proc lp goalprogram scale=both printlevel=-2 primalout=prim1  maxit1=200 maxit2=200;
var z1-z529 gl_neg_o gl_pos_o gl_neg_l gl_pos_l gl_neg_r gl_pos_r nd_o_1-nd_o_23 pd_o_1-pd_o_23
nd_l_1-nd_l_23 pd_l_1-pd_l_23 nd_r_1-nd_r_23 pd_r_1-pd_r_23;
run;




data dev(keep= _var_ _value_);
set prim1;
if _value_>0 then output;
run;
proc print;
run;
```

The following is the program for processes 2 through 11.

```
/****Optimization for process 2, 3 ...11.**********************/

data labor;
set sasuser.labor11;
proc print;
run;

proc transpose data=labor out=l_data name=_id_ prefix=l;
run;
proc print ;run;

data rm;
set sasuser.RM11;
proc print;
```

```
run;
proc transpose data=rm out=r_data name=_id_ prefix=r;
run;
proc print ;run;

data boards;
set sasuser.p11;
proc print;
run;

proc transpose data=boards out=b_data name=_id_ prefix=b;
run;
proc print ;run;


data balance;
set sasuser.p10;
proc print;
run;

proc transpose data=balance out=bl_data name=_id_ prefix=bt;
run;
proc print ;run;


data prtarget;
set sasuser.p11tar;
proc print;
run;
proc transpose data=prtarget out=prt_data name=_id_ prefix=pt;
run;
proc print ;run;

/******************
data gltarget;
set sasuser.gltarget;
proc print;
run;

proc transpose data=gltarget out=gt_data name=_id_ prefix=gt;
run;
proc print ;run;
**************************/



data agg_data;
merge l_data r_data b_data prt_data bl_data;
run;
proc print; run;

/***define global objective function*******/


data gl_obj (drop=h);
```

```
array vbls(3) gl_neg_o gl_pos_l gl_pos_r;
do h=1 to 3;
vbls(1) = 1/400000;
vbls(2) = 1/40366;
vbls(3) = 1/579286;
end;
_id_ = 'gl_obj';
_type_= 'min    ';
_rhs_= 3;
run;

proc print;
run;


/**********************define process objective function *************/

data pr_obj(keep = _id_ _type_ _rhs_ pd_l_1-pd_l_23  pd_r_1-pd_r_23 nd_o_1-nd_o_23);
set agg_data;
array vbls(138) pd_l_1-pd_l_23  pd_r_1-pd_r_23 nd_o_1-nd_o_23 nd_l_1-nd_l_23 nd_r_1-nd_r_23
pd_o_1-pd_o_23;

do i=1 to 138;
vbls(1)=1/l1;
vbls(2)=1/l2;
vbls(3)=1/l3;
vbls(4)=1/l4;
vbls(5)=1/l5;
vbls(6)=1/l6;
vbls(7)=1/l7;
vbls(8)=1/l8;
vbls(9)=1/l9;
vbls(10)=1/l10;
vbls(11)=1/l11;
vbls(12)=1/l12;
vbls(13)=1/l13;
vbls(14)=1/l14;
vbls(15)=1/l15;
vbls(16)=1/l16;
vbls(17)=1/l17;
vbls(18)=1/l18;
vbls(19)=1/l19;
vbls(20)=1/l20;
vbls(21)=1/l21;
vbls(22)=1/l22;
vbls(23)=1/l23;
vbls(24)=1/r1;
vbls(25)=1/r2;
vbls(26)=1/r3;
vbls(27)=1/r4;
vbls(28)=1/r5;
vbls(29)=1/r6;
vbls(30)=1/r7;
vbls(31)=1/r8;
vbls(32)=1/r9;
```

```
vbls(33)=1/r10;
vbls(34)=1/r11;
vbls(35)=1/r12;
vbls(36)=1/r13;
vbls(37)=1/r14;
vbls(38)=1/r15;
vbls(39)=1/r16;
vbls(40)=1/r17;
vbls(41)=1/r18;
vbls(42)=1/r19;
vbls(43)=1/r20;
vbls(44)=1/r21;
vbls(45)=1/r22;
vbls(46)=1/r23;
vbls(47)=1/pt1;
vbls(48)=1/pt2;
vbls(49)=1/pt3;
vbls(50)=1/pt4;
vbls(51)=1/pt5;
vbls(52)=1/pt6;
vbls(53)=1/pt7;
vbls(54)=1/pt8;
vbls(55)=1/pt9;
vbls(56)=1/pt10;
vbls(57)=1/pt11;
vbls(58)=1/pt12;
vbls(59)=1/pt13;
vbls(60)=1/pt14;
vbls(61)=1/pt15;
vbls(62)=1/pt16;
vbls(63)=1/pt17;
vbls(64)=1/pt18;
vbls(65)=1/pt19;
vbls(66)=1/pt20;
vbls(67)=1/pt21;
vbls(68)=1/pt22;
vbls(69)=1/pt23;
vbls(70)=1/l1;
vbls(71)=1/l2;
vbls(72)=1/l3;
vbls(73)=1/l4;
vbls(74)=1/l5;
vbls(75)=1/l6;
vbls(76)=1/l7;
vbls(77)=1/l8;
vbls(78)=1/l9;
vbls(79)=1/l10;
vbls(80)=1/l11;
vbls(81)=1/l12;
vbls(82)=1/l13;
vbls(83)=1/l14;
vbls(84)=1/l15;
vbls(85)=1/l16;
vbls(86)=1/l17;
vbls(87)=1/l18;
```

```
vbls(88)=1/l19;
vbls(89)=1/l20;
vbls(90)=1/l21;
vbls(91)=1/l22;
vbls(92)=1/l23;
vbls(93)=1/r1;
vbls(94)=1/r2;
vbls(95)=1/r3;
vbls(96)=1/r4;
vbls(97)=1/r5;
vbls(98)=1/r6;
vbls(99)=1/r7;
vbls(100)=1/r8;
vbls(101)=1/r9;
vbls(102)=1/r10;
vbls(103)=1/r11;
vbls(104)=1/r12;
vbls(105)=1/r13;
vbls(106)=1/r14;
vbls(107)=1/r15;
vbls(108)=1/r16;
vbls(109)=1/r17;
vbls(110)=1/r18;
vbls(111)=1/r19;
vbls(112)=1/r20;
vbls(113)=1/r21;
vbls(114)=1/r22;
vbls(115)=1/r23;
vbls(116)=1/pt1;
vbls(117)=1/pt2;
vbls(118)=1/pt3;
vbls(119)=1/pt4;
vbls(120)=1/pt5;
vbls(121)=1/pt6;
vbls(122)=1/pt7;
vbls(123)=1/pt8;
vbls(124)=1/pt9;
vbls(125)=1/pt10;
vbls(126)=1/pt11;
vbls(127)=1/pt12;
vbls(128)=1/pt13;
vbls(129)=1/pt14;
vbls(130)=1/pt15;
vbls(131)=1/pt16;
vbls(132)=1/pt17;
vbls(133)=1/pt18;
vbls(134)=1/pt19;
vbls(135)=1/pt20;
vbls(136)=1/pt21;
vbls(137)=1/pt22;
vbls(138)=1/pt23;
end;
_id_ = 'pr_obj';
_type_ = 'min    ';
_rhs_ = 1;
```

```
run;
proc print;
run;

/**********************define balance objective function *************/

data bl_obj(keep = _id_ _type_ _rhs_ bl_neg1-bl_neg23);
set bl_data;
array vbls(23) bl_neg1-bl_neg23;

do i=1 to 23;
vbls(1)=1/bt1;
vbls(2)=1/bt2;
vbls(3)=1/bt3;
vbls(4)=1/bt4;
vbls(5)=1/bt5;
vbls(6)=1/bt6;
vbls(7)=1/bt7;
vbls(8)=1/bt8;
vbls(9)=1/bt9;
vbls(10)=1/bt10;
vbls(11)=1/bt11;
vbls(12)=1/bt12;
vbls(13)=1/bt13;
vbls(14)=1/bt14;
vbls(15)=1/bt15;
vbls(16)=1/bt16;
vbls(17)=1/bt17;
vbls(18)=1/bt18;
vbls(19)=1/bt19;
vbls(20)=1/bt20;
vbls(21)=1/bt21;
vbls(22)=1/bt22;
vbls(23)=1/bt23;

end;
_id_ = 'bl_obj';
_type_ = 'min    ';
_rhs_ = 2;

run;
proc print;
run;


/****************define activity parameters**************
data ac_param(keep = _id_ _rhs_ _type_ z1-z529);

array vbls(529) z1-z529;
do i=1 to 529;
vbls(i)=1;
end;

_id_ = 'ac_const';
```

```
_rhs_=0;
_type_ = 'lowerbd';
run;
proc print;
run;
**************************************************************************/

data model;
set gl_obj pr_obj bl_obj;
run;
proc print;
run;

data pconst;
merge b_data prt_data;
run;
*proc print; run;


/***************setting process output target constrainsts**************/
%macro p_const1;
%do n=1 %to 23;
%let x1 = %eval((&n-1)*23+1);
%let x2 = %eval(&n*23);
data pr_o&n (keep=_id_ _type_ _rhs_ z&x1-z&x2 nd_o_&n pd_o_&n);
length _id_ $ 12;
set pconst;
array vbls(23) z&x1-z&x2;
do i=1 to 23;
vbls(1)=b1;
vbls(2)=b2;
vbls(3)=b3;
vbls(4)=b4;
vbls(5)=b5;
vbls(6)=b6;
vbls(7)=b7;
vbls(8)=b8;
vbls(9)=b9;
vbls(10)=b10;
vbls(11)=b11;
vbls(12)=b12;
vbls(13)=b13;
vbls(14)=b14;
vbls(15)=b15;
vbls(16)=b16;
vbls(17)=b17;
vbls(18)=b18;
vbls(19)=b19;
vbls(20)=b20;
vbls(21)=b21;
vbls(22)=b22;
vbls(23)=b23;

end;
_id_ = compress('pro_const'||&n);
```

```
_rhs_=pt&n;
_type_ = 'eq     ';
nd_o_&n = 1;
pd_o_&n = -1;
run;
proc print;
run;
%end;
%mend p_const1;
%p_const1;

data bconst;
merge b_data bl_data;
run;

/**************setting balance target constrainsts**************/
%macro b_const1;
%do n=1 %to 23;
%let x1 = %eval((&n-1)*23+1);
%let x2 = %eval(&n*23);
data bl_o&n (keep=_id_ _type_ _rhs_ z&x1-z&x2 bl_neg&n bl_pos&n);
length _id_ $ 12;
set bconst;
array vbls(23) z&x1-z&x2;
do i=1 to 23;
vbls(1)=b1;
vbls(2)=b2;
vbls(3)=b3;
vbls(4)=b4;
vbls(5)=b5;
vbls(6)=b6;
vbls(7)=b7;
vbls(8)=b8;
vbls(9)=b9;
vbls(10)=b10;
vbls(11)=b11;
vbls(12)=b12;
vbls(13)=b13;
vbls(14)=b14;
vbls(15)=b15;
vbls(16)=b16;
vbls(17)=b17;
vbls(18)=b18;
vbls(19)=b19;
vbls(20)=b20;
vbls(21)=b21;
vbls(22)=b22;
vbls(23)=b23;

end;
_id_ = compress('blo_const'||&n);
_rhs_=bt&n;
_type_ = 'eq     ';
bl_neg&n = 1;
bl_pos&n = -1;
```

```
run;
proc print;
run;
%end;
%mend b_const1;
%b_const1;

/**************setting process labor target constrainsts*************/
%macro p_const2;
%do n=1 %to 23;
%let x1 = %eval((&n-1)*23+1);
%let x2 = %eval(&n*23);
data pr_l&n (keep=_id_ _type_ _rhs_ z&x1-z&x2 nd_l_&n pd_l_&n drop=i);
length _id_ $ 12;
set l_data;
array vbls(23) z&x1-z&x2;
do i=1 to 23;
vbls(1)=l1;
vbls(2)=l2;
vbls(3)=l3;
vbls(4)=l4;
vbls(5)=l5;
vbls(6)=l6;
vbls(7)=l7;
vbls(8)=l8;
vbls(9)=l9;
vbls(10)=l10;
vbls(11)=l11;
vbls(12)=l12;
vbls(13)=l13;
vbls(14)=l14;
vbls(15)=l15;
vbls(16)=l16;
vbls(17)=l17;
vbls(18)=l18;
vbls(19)=l19;
vbls(20)=l20;
vbls(21)=l21;
vbls(22)=l22;
vbls(23)=l23;
end;
_id_ = compress('prl_const'||&n);
_rhs_=l&n;
_type_ = 'eq     ';
nd_l_&n = 1;
pd_l_&n = -1;
run;
proc print;
run;
%end;
%mend p_const2;
%p_const2;


/**************setting process raw materials target constrainsts*************/
```

```
%macro p_const3;
%do n=1 %to 23;
%let x1 = %eval((&n-1)*23+1);
%let x2 = %eval(&n*23);
data pr_r&n (keep=_id_ _type_ _rhs_ z&x1-z&x2 nd_r_&n pd_r_&n);
length _id_ $ 12;
set r_data;
array vbls(23) z&x1-z&x2;
do i=1 to 23;
vbls(1)=r1;
vbls(2)=r2;
vbls(3)=r3;
vbls(4)=r4;
vbls(5)=r5;
vbls(6)=r6;
vbls(7)=r7;
vbls(8)=r8;
vbls(9)=r9;
vbls(10)=r10;
vbls(11)=r11;
vbls(12)=r12;
vbls(13)=r13;
vbls(14)=r14;
vbls(15)=r15;
vbls(16)=r16;
vbls(17)=r17;
vbls(18)=r18;
vbls(19)=r19;
vbls(20)=r20;
vbls(21)=r21;
vbls(22)=r22;
vbls(23)=r23;
end;
_id_ = compress('prr_const'||&n);
_rhs_=r&n;
_type_ = 'eq     ';
nd_r_&n = 1;
pd_r_&n = -1;
run;
proc print;
run;
%end;
%mend p_const3;
%p_const3;



/**********Setting global output target constraints*********/

%macro g;
data g_const (keep= z1-z529);
set b_data;
%do m=1%to 23;
%do n=1%to 23;
%let mn = %eval((&m-1)*23+&n);
```

```
z&mn = b&n;
%end;
%end;
run;
%mend g;
%g;

proc print; run;

data g_const;
set g_const;
_rhs_=400000;

_id_ = 'glo_const';
_type_ = 'eq     ';
gl_neg_o = 1;
gl_pos_o = -1;
run;
proc print;
run;


/************Setting global input labor target constraints*********/
%macro l;
data l_const (keep= z1-z529);
set l_data;
%do m=1%to 23;
%do n=1%to 23;
%let mn = %eval((&m-1)*23+&n);
z&mn = l&n;
%end;
%end;
run;
%mend l;
%l;

proc print; run;

data l_const;
set l_const;
_rhs_=40366;

_id_ = 'prl_const';
_type_ = 'eq     ';
gl_neg_l = 1;
gl_pos_l = -1;
run;
proc print;
run;

/************Setting global input raw materials target constraints*********/

%macro r;
data r_const (keep= z1-z529);
set r_data;
```

```
%do m=1%to 23;
%do n=1%to 23;
%let mn = %eval((&m-1)*23+&n);
z&mn = r&n;
%end;
%end;
run;
%mend r;
%r;

proc print; run;

data r_const;
set r_const;
_rhs_=579286;

_id_ = 'prr_const';
_type_ = 'eq     ';
gl_neg_r = 1;
gl_pos_r = -1;
run;
proc print;
run;


/***********set the model******************/

data model;
set model pr_o1 pr_o2 pr_o3 pr_o4 pr_o5 pr_o6 pr_o7 pr_o8 pr_o9 pr_o10 pr_o11 pr_o12 pr_o13 pr_o14
pr_o15 pr_o16 pr_o17 pr_o18 pr_o19
pr_o20 pr_o21 pr_o22 pr_o23 g_const;
run;
proc print; run;

data model;
set model pr_l1 pr_l2 pr_l3 pr_l4 pr_l5 pr_l6 pr_l7 pr_l8 pr_l9 pr_l10 pr_l11 pr_l12 pr_l13 pr_l14 pr_l15
pr_l16 pr_l17 pr_l18 pr_l19
pr_l20 pr_l21 pr_l22 pr_l23 l_const;
run;
proc print; run;


data model;
set model pr_r1 pr_r2 pr_r3 pr_r4 pr_r5 pr_r6 pr_r7 pr_r8 pr_r9 pr_r10 pr_r11 pr_r12 pr_r13 pr_r14 pr_r15
pr_r16 pr_r17 pr_r18 pr_r19
pr_r20 pr_r21 pr_r22 pr_r23 r_const;
run;
proc print; run;

data model;
set model bl_o1 bl_o2 bl_o3 bl_o4 bl_o5 bl_o6 bl_o7 bl_o8 bl_o9 bl_o10 bl_o11 bl_o12 bl_o13
bl_o14 bl_o15 bl_o16 bl_o17 bl_o18 bl_o19 bl_o20 bl_o21 bl_o22 bl_o23;
run;
```

```
proc lp goalprogram scale=both printlevel=-2 primalout=prim1  maxit1=200 maxit2=200;
var z1-z529 gl_neg_o gl_pos_o gl_neg_l gl_pos_l gl_neg_r gl_pos_r nd_o_1-nd_o_23 pd_o_1-pd_o_23
nd_l_1-nd_l_23 pd_l_1-pd_l_23 nd_r_1-nd_r_23 pd_r_1-pd_r_23 bl_neg1-bl_neg23 bl_pos1-bl_pos23;
run;



data dev(keep= _var_ _value_);
set prim1;
if _value_>0 then output;
run;
proc print;
run;
```

_____

C.11 Goal Program with Actual Outputs as Process Targets

The following are the goal programs where the process targets are the actual outputs themselves. The following is the program for process 1.

```
/****Optimization for process 1.**********************/

data labor;
set sasuser.labor1;
proc print;
run;

proc transpose data=labor out=l_data name=_id_ prefix=l;
run;
proc print ;run;

data rm;
set sasuser.RM1;
proc print;
run;
proc transpose data=rm out=r_data name=_id_ prefix=r;
run;
proc print ;run;

data boards;
set sasuser.p1;
proc print;
run;

proc transpose data=boards out=b_data name=_id_ prefix=b;
run;
proc print ;run;


data prtarget;
set sasuser.p1;
proc print;
run;
proc transpose data=prtarget out=prt_data name=_id_ prefix=pt;
run;
proc print ;run;


data gltarget;
set sasuser.gltarget;
proc print;
run;

proc transpose data=gltarget out=gt_data name=_id_ prefix=gt;
run;
proc print ;run;
```

```
data recur_o;
set sasuser.recur_a1;
proc print; run;

proc transpose data = recur_o out=recurout name=_id_ prefix=ro;
run;
proc print;run;

data agg_data;
merge l_data r_data b_data prt_data gt_data;
run;
proc print; run;

/***define global objective function*******/


data gl_obj (drop=h);
array vbls(3) gl_neg_o gl_pos_l gl_pos_r;
do h=1 to 3;
vbls(1) = 1/400000;
vbls(2) = 1/112226;
vbls(3) = 1/17267183;
end;
_id_ = 'gl_obj';
_type_= 'min    ';
_rhs_= 2;
run;

proc print;
run;


/**********************define process objective function *************/

data pr_obj(keep = _id_ _type_ _rhs_ pd_l_1-pd_l_23  pd_r_1-pd_r_23 nd_o_1-nd_o_23 );
set agg_data;
array vbls(138) pd_l_1-pd_l_23  pd_r_1-pd_r_23 nd_o_1-nd_o_23 nd_l_1-nd_l_23 nd_r_1-nd_r_23
pd_o_1-pd_o_23;

do i=1 to 138;
vbls(1)=1/l1;
vbls(2)=1/l2;
vbls(3)=1/l3;
vbls(4)=1/l4;
vbls(5)=1/l5;
vbls(6)=1/l6;
vbls(7)=1/l7;
vbls(8)=1/l8;
vbls(9)=1/l9;
vbls(10)=1/l10;
vbls(11)=1/l11;
vbls(12)=1/l12;
vbls(13)=1/l13;
vbls(14)=1/l14;
vbls(15)=1/l15;
```

```
vbls(16)=1/l16;
vbls(17)=1/l17;
vbls(18)=1/l18;
vbls(19)=1/l19;
vbls(20)=1/l20;
vbls(21)=1/l21;
vbls(22)=1/l22;
vbls(23)=1/l23;
vbls(24)=1/r1;
vbls(25)=1/r2;
vbls(26)=1/r3;
vbls(27)=1/r4;
vbls(28)=1/r5;
vbls(29)=1/r6;
vbls(30)=1/r7;
vbls(31)=1/r8;
vbls(32)=1/r9;
vbls(33)=1/r10;
vbls(34)=1/r11;
vbls(35)=1/r12;
vbls(36)=1/r13;
vbls(37)=1/r14;
vbls(38)=1/r15;
vbls(39)=1/r16;
vbls(40)=1/r17;
vbls(41)=1/r18;
vbls(42)=1/r19;
vbls(43)=1/r20;
vbls(44)=1/r21;
vbls(45)=1/r22;
vbls(46)=1/r23;
vbls(47)=1/pt1;
vbls(48)=1/pt2;
vbls(49)=1/pt3;
vbls(50)=1/pt4;
vbls(51)=1/pt5;
vbls(52)=1/pt6;
vbls(53)=1/pt7;
vbls(54)=1/pt8;
vbls(55)=1/pt9;
vbls(56)=1/pt10;
vbls(57)=1/pt11;
vbls(58)=1/pt12;
vbls(59)=1/pt13;
vbls(60)=1/pt14;
vbls(61)=1/pt15;
vbls(62)=1/pt16;
vbls(63)=1/pt17;
vbls(64)=1/pt18;
vbls(65)=1/pt19;
vbls(66)=1/pt20;
vbls(67)=1/pt21;
vbls(68)=1/pt22;
vbls(69)=1/pt23;
vbls(70)=1/l1;
```

```
vbls(71)=1/l2;
vbls(72)=1/l3;
vbls(73)=1/l4;
vbls(74)=1/l5;
vbls(75)=1/l6;
vbls(76)=1/l7;
vbls(77)=1/l8;
vbls(78)=1/l9;
vbls(79)=1/l10;
vbls(80)=1/l11;
vbls(81)=1/l12;
vbls(82)=1/l13;
vbls(83)=1/l14;
vbls(84)=1/l15;
vbls(85)=1/l16;
vbls(86)=1/l17;
vbls(87)=1/l18;
vbls(88)=1/l19;
vbls(89)=1/l20;
vbls(90)=1/l21;
vbls(91)=1/l22;
vbls(92)=1/l23;
vbls(93)=1/r1;
vbls(94)=1/r2;
vbls(95)=1/r3;
vbls(96)=1/r4;
vbls(97)=1/r5;
vbls(98)=1/r6;
vbls(99)=1/r7;
vbls(100)=1/r8;
vbls(101)=1/r9;
vbls(102)=1/r10;
vbls(103)=1/r11;
vbls(104)=1/r12;
vbls(105)=1/r13;
vbls(106)=1/r14;
vbls(107)=1/r15;
vbls(108)=1/r16;
vbls(109)=1/r17;
vbls(110)=1/r18;
vbls(111)=1/r19;
vbls(112)=1/r20;
vbls(113)=1/r21;
vbls(114)=1/r22;
vbls(115)=1/r23;
vbls(116)=1/pt1;
vbls(117)=1/pt2;
vbls(118)=1/pt3;
vbls(119)=1/pt4;
vbls(120)=1/pt5;
vbls(121)=1/pt6;
vbls(122)=1/pt7;
vbls(123)=1/pt8;
vbls(124)=1/pt9;
vbls(125)=1/pt10;
```

```
vbls(126)=1/pt11;
vbls(127)=1/pt12;
vbls(128)=1/pt13;
vbls(129)=1/pt14;
vbls(130)=1/pt15;
vbls(131)=1/pt16;
vbls(132)=1/pt17;
vbls(133)=1/pt18;
vbls(134)=1/pt19;
vbls(135)=1/pt20;
vbls(136)=1/pt21;
vbls(137)=1/pt22;
vbls(138)=1/pt23;

end;
_id_ = 'pr_obj';
_type_ = 'min    ';
_rhs_ = 1;

run;
proc print;
run;


/****************define activity parameters**************/
%macro ac_param;
%do n=1 %to 23;
%let x1 = %eval((&n-1)*23+1);
%let x2 = %eval(&n*23);
data a&n (keep=_id_ _type_ _rhs_ z&x1-z&x2 drop=i);
array vbls(23) z&x1-z&x2;
do i=1 to 23;
vbls(i)=1;
end;
length _id_ $ 12;
_id_ = compress('ac_const'||&n);
_rhs_=1;
_type_ = 'eq     ';
run;
proc print;
run;
%end;
%mend ac_param;
%ac_param;

/*********************************************************************/

data model;
set gl_obj pr_obj a1 a2 a3 a4 a5 a6 a7 a8 a9 a10 a11 a12 a13 a14 a15 a16 a17 a18 a19 a20 a21 a22 a23;
run;
proc print;
run;

data pconst;
merge b_data prt_data;
```

```
run;
*proc print; run;


/**************setting process output target constrainsts**************/
%macro p_const1;
%do n=1 %to 23;
%let x1 = %eval((&n-1)*23+1);
%let x2 = %eval(&n*23);
data pr_o&n (keep=_id_ _type_ _rhs_ z&x1-z&x2 nd_o_&n pd_o_&n);
length _id_ $ 12;
set pconst;
array vbls(23) z&x1-z&x2;
do i=1 to 23;
vbls(1)=b1;
vbls(2)=b2;
vbls(3)=b3;
vbls(4)=b4;
vbls(5)=b5;
vbls(6)=b6;
vbls(7)=b7;
vbls(8)=b8;
vbls(9)=b9;
vbls(10)=b10;
vbls(11)=b11;
vbls(12)=b12;
vbls(13)=b13;
vbls(14)=b14;
vbls(15)=b15;
vbls(16)=b16;
vbls(17)=b17;
vbls(18)=b18;
vbls(19)=b19;
vbls(20)=b20;
vbls(21)=b21;
vbls(22)=b22;
vbls(23)=b23;

end;
_id_ = compress('pro_const'||&n);
_rhs_=pt&n;
_type_ = 'eq     ';
nd_o_&n = 1;
pd_o_&n = -1;
run;
proc print;
run;
%end;
%mend p_const1;
%p_const1;

/**************setting process labor target constrainsts**************/
%macro p_const2;
%do n=1 %to 23;
%let x1 = %eval((&n-1)*23+1);
```

```
%let x2 = %eval(&n*23);
data pr_l&n (keep=_id_ _type_ _rhs_ z&x1-z&x2 nd_l_&n pd_l_&n drop=i);
length _id_ $ 12;
set l_data;
array vbls(23) z&x1-z&x2;
do i=1 to 23;
vbls(1)=l1;
vbls(2)=l2;
vbls(3)=l3;
vbls(4)=l4;
vbls(5)=l5;
vbls(6)=l6;
vbls(7)=l7;
vbls(8)=l8;
vbls(9)=l9;
vbls(10)=l10;
vbls(11)=l11;
vbls(12)=l12;
vbls(13)=l13;
vbls(14)=l14;
vbls(15)=l15;
vbls(16)=l16;
vbls(17)=l17;
vbls(18)=l18;
vbls(19)=l19;
vbls(20)=l20;
vbls(21)=l21;
vbls(22)=l22;
vbls(23)=l23;
end;
_id_ = compress('prl_const'||&n);
_rhs_=l&n;
_type_ = 'eq     ';
nd_l_&n = 1;
pd_l_&n = -1;
run;
proc print;
run;
%end;
%mend p_const2;
%p_const2;


/**************setting process raw materials target constrainsts*************/
%macro p_const3;
%do n=1 %to 23;
%let x1 = %eval((&n-1)*23+1);
%let x2 = %eval(&n*23);
data pr_r&n (keep=_id_ _type_ _rhs_ z&x1-z&x2 nd_r_&n pd_r_&n);
length _id_ $ 12;
set r_data;
array vbls(23) z&x1-z&x2;
do i=1 to 23;
vbls(1)=r1;
vbls(2)=r2;
```

```
vbls(3)=r3;
vbls(4)=r4;
vbls(5)=r5;
vbls(6)=r6;
vbls(7)=r7;
vbls(8)=r8;
vbls(9)=r9;
vbls(10)=r10;
vbls(11)=r11;
vbls(12)=r12;
vbls(13)=r13;
vbls(14)=r14;
vbls(15)=r15;
vbls(16)=r16;
vbls(17)=r17;
vbls(18)=r18;
vbls(19)=r19;
vbls(20)=r20;
vbls(21)=r21;
vbls(22)=r22;
vbls(23)=r23;
end;
_id_ = compress('prr_const'||&n);
_rhs_=r&n;
_type_ = 'eq     ';
nd_r_&n = 1;
pd_r_&n = -1;
run;
proc print;
run;
%end;
%mend p_const3;
%p_const3;



/************Setting global output target constraints*********/

%macro g;
data g_const (keep= z1-z529);
set b_data;
%do m=1%to 23;
%do n=1%to 23;
%let mn = %eval((&m-1)*23+&n);
z&mn = b&n;
%end;
%end;
run;
%mend g;
%g;

proc print; run;

data g_const;
set g_const;
```

```
_rhs_=400000;

_id_ = 'glo_const';
_type_ = 'eq     ';
gl_neg_o = 1;
gl_pos_o = -1;
run;
proc print;
run;


/************Setting global input labor target constraints*********/
%macro l;
data l_const (keep= z1-z529);
set l_data;
%do m=1%to 23;
%do n=1%to 23;
%let mn = %eval((&m-1)*23+&n);
z&mn = l&n;
%end;
%end;
run;
%mend l;
%l;

proc print; run;

data l_const;
set l_const;
_rhs_=112226;

_id_ = 'prl_const';
_type_ = 'eq     ';
gl_neg_l = 1;
gl_pos_l = -1;
run;
proc print;
run;

/************Setting global input raw materials target constraints*********/

%macro r;
data r_const (keep= z1-z529);
set r_data;
%do m=1%to 23;
%do n=1%to 23;
%let mn = %eval((&m-1)*23+&n);
z&mn = r&n;
%end;
%end;
run;
%mend r;
%r;

proc print; run;
```

```
data r_const;
set r_const;
_rhs_=17267183;

_id_ = 'prr_const';
_type_ = 'eq     ';
gl_neg_r = 1;
gl_pos_r = -1;
run;
proc print;
run;


/***********set the model******************/

data model;
set model pr_o1 pr_o2 pr_o3 pr_o4 pr_o5 pr_o6 pr_o7 pr_o8 pr_o9 pr_o10 pr_o11 pr_o12 pr_o13 pr_o14
pr_o15 pr_o16 pr_o17 pr_o18 pr_o19
pr_o20 pr_o21 pr_o22 pr_o23 g_const;
run;
proc print; run;

data model;
set model pr_l1 pr_l2 pr_l3 pr_l4 pr_l5 pr_l6 pr_l7 pr_l8 pr_l9 pr_l10 pr_l11 pr_l12 pr_l13 pr_l14 pr_l15
pr_l16 pr_l17 pr_l18 pr_l19
pr_l20 pr_l21 pr_l22 pr_l23 l_const;
run;
proc print; run;


data model;
set model pr_r1 pr_r2 pr_r3 pr_r4 pr_r5 pr_r6 pr_r7 pr_r8 pr_r9 pr_r10 pr_r11 pr_r12 pr_r13 pr_r14 pr_r15
pr_r16 pr_r17 pr_r18 pr_r19
pr_r20 pr_r21 pr_r22 pr_r23 r_const;
run;
proc print; run;


proc lp goalprogram scale=both printlevel=-2 primalout=prim1  maxit1=200 maxit2=200;
var z1-z529 gl_neg_o gl_pos_o gl_neg_l gl_pos_l gl_neg_r gl_pos_r nd_o_1-nd_o_23 pd_o_1-pd_o_23
nd_l_1-nd_l_23 pd_l_1-pd_l_23 nd_r_1-nd_r_23 pd_r_1-pd_r_23;
run;




data dev(keep= _var_ _value_);
set prim1;
if _value_>0 then output;
run;
proc print;
run;
```

The following is the program for process 2 through 11.

```
/****Optimization for process 2, 3 ...11.**********************/

data labor;
set sasuser.labor10;
proc print;
run;

proc transpose data=labor out=l_data name=_id_ prefix=l;
run;
proc print ;run;

data rm;
set sasuser.RM10;
proc print;
run;
proc transpose data=rm out=r_data name=_id_ prefix=r;
run;
proc print ;run;

data boards;
set sasuser.p10;
proc print;
run;

proc transpose data=boards out=b_data name=_id_ prefix=b;
run;
proc print ;run;


data balance;
set sasuser.p9;
proc print;
run;

proc transpose data=balance out=bl_data name=_id_ prefix=bt;
run;
proc print ;run;


data prtarget;
set sasuser.p10;
proc print;
run;
proc transpose data=prtarget out=prt_data name=_id_ prefix=pt;
run;
proc print ;run;

/******************
data gltarget;
set sasuser.gltarget;
```

```
proc print;
run;

proc transpose data=gltarget out=gt_data name=_id_ prefix=gt;
run;
proc print ;run;
*************************/



data agg_data;
merge l_data r_data b_data prt_data bl_data;
run;
proc print; run;

/***define global objective function*******/


data gl_obj (drop=h);
array vbls(3) gl_neg_o gl_pos_l gl_pos_r;
do h=1 to 3;
vbls(1) = 1/400000;
vbls(2) = 1/60446;
vbls(3) = 1/499948;
end;
_id_ = 'gl_obj';
_type_= 'min    ';
_rhs_= 3;
run;

proc print;
run;


/***********************define process objective function **************/

data pr_obj(keep = _id_ _type_ _rhs_ pd_l_1-pd_l_23  pd_r_1-pd_r_23 nd_o_1-nd_o_23);
set agg_data;
array vbls(138) pd_l_1-pd_l_23  pd_r_1-pd_r_23 nd_o_1-nd_o_23 nd_l_1-nd_l_23 nd_r_1-nd_r_23
pd_o_1-pd_o_23;

do i=1 to 138;
vbls(1)=1/l1;
vbls(2)=1/l2;
vbls(3)=1/l3;
vbls(4)=1/l4;
vbls(5)=1/l5;
vbls(6)=1/l6;
vbls(7)=1/l7;
vbls(8)=1/l8;
vbls(9)=1/l9;
vbls(10)=1/l10;
vbls(11)=1/l11;
vbls(12)=1/l12;
vbls(13)=1/l13;
```

```
vbls(14)=1/l14;
vbls(15)=1/l15;
vbls(16)=1/l16;
vbls(17)=1/l17;
vbls(18)=1/l18;
vbls(19)=1/l19;
vbls(20)=1/l20;
vbls(21)=1/l21;
vbls(22)=1/l22;
vbls(23)=1/l23;
vbls(24)=1/r1;
vbls(25)=1/r2;
vbls(26)=1/r3;
vbls(27)=1/r4;
vbls(28)=1/r5;
vbls(29)=1/r6;
vbls(30)=1/r7;
vbls(31)=1/r8;
vbls(32)=1/r9;
vbls(33)=1/r10;
vbls(34)=1/r11;
vbls(35)=1/r12;
vbls(36)=1/r13;
vbls(37)=1/r14;
vbls(38)=1/r15;
vbls(39)=1/r16;
vbls(40)=1/r17;
vbls(41)=1/r18;
vbls(42)=1/r19;
vbls(43)=1/r20;
vbls(44)=1/r21;
vbls(45)=1/r22;
vbls(46)=1/r23;
vbls(47)=1/pt1;
vbls(48)=1/pt2;
vbls(49)=1/pt3;
vbls(50)=1/pt4;
vbls(51)=1/pt5;
vbls(52)=1/pt6;
vbls(53)=1/pt7;
vbls(54)=1/pt8;
vbls(55)=1/pt9;
vbls(56)=1/pt10;
vbls(57)=1/pt11;
vbls(58)=1/pt12;
vbls(59)=1/pt13;
vbls(60)=1/pt14;
vbls(61)=1/pt15;
vbls(62)=1/pt16;
vbls(63)=1/pt17;
vbls(64)=1/pt18;
vbls(65)=1/pt19;
vbls(66)=1/pt20;
vbls(67)=1/pt21;
vbls(68)=1/pt22;
```

```
vbls(69)=1/pt23;
vbls(70)=1/l1;
vbls(71)=1/l2;
vbls(72)=1/l3;
vbls(73)=1/l4;
vbls(74)=1/l5;
vbls(75)=1/l6;
vbls(76)=1/l7;
vbls(77)=1/l8;
vbls(78)=1/l9;
vbls(79)=1/l10;
vbls(80)=1/l11;
vbls(81)=1/l12;
vbls(82)=1/l13;
vbls(83)=1/l14;
vbls(84)=1/l15;
vbls(85)=1/l16;
vbls(86)=1/l17;
vbls(87)=1/l18;
vbls(88)=1/l19;
vbls(89)=1/l20;
vbls(90)=1/l21;
vbls(91)=1/l22;
vbls(92)=1/l23;
vbls(93)=1/r1;
vbls(94)=1/r2;
vbls(95)=1/r3;
vbls(96)=1/r4;
vbls(97)=1/r5;
vbls(98)=1/r6;
vbls(99)=1/r7;
vbls(100)=1/r8;
vbls(101)=1/r9;
vbls(102)=1/r10;
vbls(103)=1/r11;
vbls(104)=1/r12;
vbls(105)=1/r13;
vbls(106)=1/r14;
vbls(107)=1/r15;
vbls(108)=1/r16;
vbls(109)=1/r17;
vbls(110)=1/r18;
vbls(111)=1/r19;
vbls(112)=1/r20;
vbls(113)=1/r21;
vbls(114)=1/r22;
vbls(115)=1/r23;
vbls(116)=1/pt1;
vbls(117)=1/pt2;
vbls(118)=1/pt3;
vbls(119)=1/pt4;
vbls(120)=1/pt5;
vbls(121)=1/pt6;
vbls(122)=1/pt7;
vbls(123)=1/pt8;
```

```
vbls(124)=1/pt9;
vbls(125)=1/pt10;
vbls(126)=1/pt11;
vbls(127)=1/pt12;
vbls(128)=1/pt13;
vbls(129)=1/pt14;
vbls(130)=1/pt15;
vbls(131)=1/pt16;
vbls(132)=1/pt17;
vbls(133)=1/pt18;
vbls(134)=1/pt19;
vbls(135)=1/pt20;
vbls(136)=1/pt21;
vbls(137)=1/pt22;
vbls(138)=1/pt23;
end;
_id_ = 'pr_obj';
_type_ = 'min    ';
_rhs_ = 1;

run;
proc print;
run;

/**********************define balance objective function *************/

data bl_obj(keep = _id_ _type_ _rhs_ bl_neg1-bl_neg23);
set bl_data;
array vbls(23) bl_neg1-bl_neg23;

do i=1 to 23;
vbls(1)=1/bt1;
vbls(2)=1/bt2;
vbls(3)=1/bt3;
vbls(4)=1/bt4;
vbls(5)=1/bt5;
vbls(6)=1/bt6;
vbls(7)=1/bt7;
vbls(8)=1/bt8;
vbls(9)=1/bt9;
vbls(10)=1/bt10;
vbls(11)=1/bt11;
vbls(12)=1/bt12;
vbls(13)=1/bt13;
vbls(14)=1/bt14;
vbls(15)=1/bt15;
vbls(16)=1/bt16;
vbls(17)=1/bt17;
vbls(18)=1/bt18;
vbls(19)=1/bt19;
vbls(20)=1/bt20;
vbls(21)=1/bt21;
vbls(22)=1/bt22;
vbls(23)=1/bt23;
```

```
end;
_id_ = 'bl_obj';
_type_ = 'min    ';
_rhs_ = 2;

run;
proc print;
run;


/***************define activity parameters**************/
%macro ac_param;
%do n=1 %to 23;
%let x1 = %eval((&n-1)*23+1);
%let x2 = %eval(&n*23);
data a&n (keep=_id_ _type_ _rhs_ z&x1-z&x2 drop=i);
array vbls(23) z&x1-z&x2;
do i=1 to 23;
vbls(i)=1;
end;
length _id_ $ 12;
_id_ = compress('ac_const'||&n);
_rhs_=1;
_type_ = 'eq     ';
run;
proc print;
run;
%end;
%mend ac_param;
%ac_param;

/*************************************************************************/

data model;
set gl_obj pr_obj bl_obj a1 a2 a3 a4 a5 a6 a7 a8 a9 a10 a11 a12 a13 a14 a15 a16 a17 a18 a19 a20 a21 a22
a23;
run;
proc print;
run;

data pconst;
merge b_data prt_data;
run;
*proc print; run;


/***************setting process output target constrainsts**************/
%macro p_const1;
%do n=1 %to 23;
%let x1 = %eval((&n-1)*23+1);
%let x2 = %eval(&n*23);
data pr_o&n (keep=_id_ _type_ _rhs_ z&x1-z&x2 nd_o_&n pd_o_&n);
length _id_ $ 12;
set pconst;
array vbls(23) z&x1-z&x2;
```

```
do i=1 to 23;
vbls(1)=b1;
vbls(2)=b2;
vbls(3)=b3;
vbls(4)=b4;
vbls(5)=b5;
vbls(6)=b6;
vbls(7)=b7;
vbls(8)=b8;
vbls(9)=b9;
vbls(10)=b10;
vbls(11)=b11;
vbls(12)=b12;
vbls(13)=b13;
vbls(14)=b14;
vbls(15)=b15;
vbls(16)=b16;
vbls(17)=b17;
vbls(18)=b18;
vbls(19)=b19;
vbls(20)=b20;
vbls(21)=b21;
vbls(22)=b22;
vbls(23)=b23;

end;
_id_ = compress('pro_const'||&n);
_rhs_=pt&n;
_type_ = 'eq     ';
nd_o_&n = 1;
pd_o_&n = -1;
run;
proc print;
run;
%end;
%mend p_const1;
%p_const1;

data bconst;
merge b_data bl_data;
run;

/***************setting balance target constrainsts**************/
%macro b_const1;
%do n=1 %to 23;
%let x1 = %eval((&n-1)*23+1);
%let x2 = %eval(&n*23);
data bl_o&n (keep=_id_ _type_ _rhs_ z&x1-z&x2 bl_neg&n bl_pos&n);
length _id_ $ 12;
set bconst;
array vbls(23) z&x1-z&x2;
do i=1 to 23;
vbls(1)=b1;
vbls(2)=b2;
vbls(3)=b3;
```

```
vbls(4)=b4;
vbls(5)=b5;
vbls(6)=b6;
vbls(7)=b7;
vbls(8)=b8;
vbls(9)=b9;
vbls(10)=b10;
vbls(11)=b11;
vbls(12)=b12;
vbls(13)=b13;
vbls(14)=b14;
vbls(15)=b15;
vbls(16)=b16;
vbls(17)=b17;
vbls(18)=b18;
vbls(19)=b19;
vbls(20)=b20;
vbls(21)=b21;
vbls(22)=b22;
vbls(23)=b23;

end;
_id_ = compress('blo_const'||&n);
_rhs_=bt&n;
_type_ = 'eq     ';
bl_neg&n = 1;
bl_pos&n = -1;
run;
proc print;
run;
%end;
%mend b_const1;
%b_const1;

/***************setting process labor target constrainsts**************/
%macro p_const2;
%do n=1 %to 23;
%let x1 = %eval((&n-1)*23+1);
%let x2 = %eval(&n*23);
data pr_l&n (keep=_id_ _type_ _rhs_ z&x1-z&x2 nd_l_&n pd_l_&n drop=i);
length _id_ $ 12;
set l_data;
array vbls(23) z&x1-z&x2;
do i=1 to 23;
vbls(1)=l1;
vbls(2)=l2;
vbls(3)=l3;
vbls(4)=l4;
vbls(5)=l5;
vbls(6)=l6;
vbls(7)=l7;
vbls(8)=l8;
vbls(9)=l9;
vbls(10)=l10;
vbls(11)=l11;
```

```
vbls(12)=l12;
vbls(13)=l13;
vbls(14)=l14;
vbls(15)=l15;
vbls(16)=l16;
vbls(17)=l17;
vbls(18)=l18;
vbls(19)=l19;
vbls(20)=l20;
vbls(21)=l21;
vbls(22)=l22;
vbls(23)=l23;
end;
_id_ = compress('prl_const'||&n);
_rhs_=l&n;
_type_ = 'eq     ';
nd_l_&n = 1;
pd_l_&n = -1;
run;
proc print;
run;
%end;
%mend p_const2;
%p_const2;


/***************setting process raw materials target constrainsts*************/
%macro p_const3;
%do n=1 %to 23;
%let x1 = %eval((&n-1)*23+1);
%let x2 = %eval(&n*23);
data pr_r&n (keep=_id_ _type_ _rhs_ z&x1-z&x2 nd_r_&n pd_r_&n);
length _id_ $ 12;
set r_data;
array vbls(23) z&x1-z&x2;
do i=1 to 23;
vbls(1)=r1;
vbls(2)=r2;
vbls(3)=r3;
vbls(4)=r4;
vbls(5)=r5;
vbls(6)=r6;
vbls(7)=r7;
vbls(8)=r8;
vbls(9)=r9;
vbls(10)=r10;
vbls(11)=r11;
vbls(12)=r12;
vbls(13)=r13;
vbls(14)=r14;
vbls(15)=r15;
vbls(16)=r16;
vbls(17)=r17;
vbls(18)=r18;
vbls(19)=r19;
```

```
vbls(20)=r20;
vbls(21)=r21;
vbls(22)=r22;
vbls(23)=r23;
end;
_id_ = compress('prr_const'||&n);
_rhs_=r&n;
_type_ = 'eq     ';
nd_r_&n = 1;
pd_r_&n = -1;
run;
proc print;
run;
%end;
%mend p_const3;
%p_const3;



/*************Setting global output target constraints*********/

%macro g;
data g_const (keep= z1-z529);
set b_data;
%do m=1%to 23;
%do n=1%to 23;
%let mn = %eval((&m-1)*23+&n);
z&mn = b&n;
%end;
%end;
run;
%mend g;
%g;

proc print; run;

data g_const;
set g_const;
_rhs_=400000;

_id_ = 'glo_const';
_type_ = 'eq     ';
gl_neg_o = 1;
gl_pos_o = -1;
run;
proc print;
run;


/*************Setting global input labor target constraints*********/
%macro l;
data l_const (keep= z1-z529);
set l_data;
%do m=1%to 23;
%do n=1%to 23;
```

```
%let mn = %eval((&m-1)*23+&n);
z&mn = l&n;
%end;
%end;
run;
%mend l;
%l;

proc print; run;

data l_const;
set l_const;
_rhs_=60446;

_id_ = 'prl_const';
_type_ = 'eq     ';
gl_neg_l = 1;
gl_pos_l = -1;
run;
proc print;
run;

/************Setting global input raw materials target constraints*********/

%macro r;
data r_const (keep= z1-z529);
set r_data;
%do m=1%to 23;
%do n=1%to 23;
%let mn = %eval((&m-1)*23+&n);
z&mn = r&n;
%end;
%end;
run;
%mend r;
%r;

proc print; run;

data r_const;
set r_const;
_rhs_=499948;

_id_ = 'prr_const';
_type_ = 'eq     ';
gl_neg_r = 1;
gl_pos_r = -1;
run;
proc print;
run;


/***********set the model*****************/

data model;
```

```
set model pr_o1 pr_o2 pr_o3 pr_o4 pr_o5 pr_o6 pr_o7 pr_o8 pr_o9 pr_o10 pr_o11 pr_o12 pr_o13 pr_o14
pr_o15 pr_o16 pr_o17 pr_o18 pr_o19
pr_o20 pr_o21 pr_o22 pr_o23 g_const;
run;
proc print; run;

data model;
set model pr_l1 pr_l2 pr_l3 pr_l4 pr_l5 pr_l6 pr_l7 pr_l8 pr_l9 pr_l10 pr_l11 pr_l12 pr_l13 pr_l14 pr_l15
pr_l16 pr_l17 pr_l18 pr_l19
pr_l20 pr_l21 pr_l22 pr_l23 l_const;
run;
proc print; run;


data model;
set model pr_r1 pr_r2 pr_r3 pr_r4 pr_r5 pr_r6 pr_r7 pr_r8 pr_r9 pr_r10 pr_r11 pr_r12 pr_r13 pr_r14 pr_r15
pr_r16 pr_r17 pr_r18 pr_r19
pr_r20 pr_r21 pr_r22 pr_r23 r_const;
run;
proc print; run;

data model;
set model bl_o1 bl_o2 bl_o3 bl_o4 bl_o5 bl_o6 bl_o7 bl_o8 bl_o9 bl_o10 bl_o11 bl_o12 bl_o13
bl_o14 bl_o15 bl_o16 bl_o17 bl_o18 bl_o19 bl_o20 bl_o21 bl_o22 bl_o23;
run;


proc lp goalprogram scale=both printlevel=-2 primalout=prim1  maxit1=200 maxit2=200;
var z1-z529 gl_neg_o gl_pos_o gl_neg_l gl_pos_l gl_neg_r gl_pos_r nd_o_1-nd_o_23 pd_o_1-pd_o_23
nd_l_1-nd_l_23 pd_l_1-pd_l_23 nd_r_1-nd_r_23 pd_r_1-pd_r_23 bl_neg1-bl_neg23 bl_pos1-bl_pos23;
run;




data dev(keep= _var_ _value_);
set prim1;
if _value_>0 then output;
run;
proc print;
run;
```

_____

C.12 Disposability Programs

Two sets of programs were run for the disposability assumptions. Two on the input side and two on the output side. The following are the two programs which evaluate the output-based tests for the input disposability.

```
data dea;
set sasuser.layer;

run;

proc transpose data=dea out=model name=_id_ prefix=z;
run;


data model;
set model;
if _id_ = 'VAR1' then _type_='ge ';
else _type_='eq ';
if _type_='eq ' then _rhs_=0;
run;

data addobj;
input _id_ $ _type_ $;
cards;
OBJFN min
;

run;

data addsumz (drop=i);
array vbls(23) Z1-Z23;
do i=1 to 23;
vbls(i)=1;
end;
input _id_ $ _type_ $ _rhs_;
cards;
SUMZ eq 1
;

run;


data model;
set model addobj addsumz;

run;
*proc print;run;

data thetas;
input dmu _var_ $ _value_;
cards;
```

```
;
run;

%macro runlp;
%do n=1 %to 23;


data model;
set model;
if _id_='OBJFN' then theta=1;
else if _id_ = 'SUMZ' or _id_ = 'VAR1' then theta= .;
else theta=-z&n;
if _type_='ge' then _rhs_=z&n;
run;
*proc print data=model;run;

proc lp scale=both printlevel=-2 primalout=prim&n;
row _id_;
var theta z1-z23;
*proc print;
run;

data theta (keep=dmu _var_ _value_);
set prim&n;
dmu=&n;
if _value_ > 0 and _type_ = 'NON-NEG' then output;
run;

proc append base=thetas data=theta;
run;

%end;

%mend runlp;

%runlp;

proc print data=thetas;
run;
```

```
data dea;
set sasuser.layer;

run;

proc transpose data=dea out=model name=_id_ prefix=z;
run;


data model;
set model;
```

```
if _id_ = 'VAR1' then _type_='eq ';
else _type_='le ';
if _type_='le ' then _rhs_=0;
run;

data addobj;
input _id_ $ _type_ $;
cards;
OBJFN min
;

run;

data addsumz (drop=i);
array vbls(23) Z1-Z23;
do i=1 to 23;
vbls(i)=1;
end;
input _id_ $ _type_ $ _rhs_;
cards;
SUMZ eq 1
;

run;


data model;
set model addobj addsumz;

run;
*proc print;run;

data thetas;
input dmu _var_ $ _value_;
cards;
;
run;

%macro runlp;
%do n=1 %to 23;


data model;
set model;
if _id_='OBJFN' then theta=1;
else if _id_ = 'SUMZ' or _id_ = 'VAR1' then theta= .;
else theta=-z&n;
if _type_='eq' then _rhs_=z&n;
run;
*proc print data=model;run;

proc lp scale=both printlevel=-2 primalout=prim&n;
row _id_;
var theta z1-z23;
*proc print;
```

```
run;

data theta (keep=dmu _var_ _value_);
set prim&n;
dmu=&n;
if _value_ > 0 and _type_ = 'NON-NEG' then output;
run;

proc append base=thetas data=theta;
run;

%end;

%mend runlp;

%runlp;

proc print data=thetas;
run;
```

The following are the two programs which evaluate the input-based tests for output disposability.

```
data dea;
set sasuser.layer;
*proc print;
run;

proc transpose data=dea out=model name=_id_ prefix=z;
run;


data model;
set model;
if _id_ = 'VAR1' then _type_='ge ';
else _type_='eq';
if _type_='ge ' then _rhs_=0;
run;

data addobj;
input _id_ $ _type_ $;
cards;
OBJFN max
;

run;

data addsumz (drop=i);
array vbls(23) Z1-Z23;
```

```
do i=1 to 23;
vbls(i)=1;
end;
input _id_ $ _type_ $ _rhs_;
cards;
SUMZ eq 1
;

run;



data model;
set model addobj addsumz ;

run;
*proc print;run;

data thetas;
input dmu _var_ $ _value_;
cards;
;
run;


%macro runlp;
%do n=1 %to 23;


data model;
set model;
if _id_='OBJFN' then theta=1;
else if _id_ = 'SUMZ' or _type_ = 'eq' then theta= .;
else theta=-z&n;
if _type_='eq' then _rhs_= z&n;


run;
*proc print data=model;run;

proc lp scale=both printlevel=-2 primalout=prim&n;
row _id_;
var theta z1-z23 ;
*proc print;
run;

data theta (keep=dmu _var_ _value_);
set prim&n;
dmu=&n;
if _value_ > 0 and _type_ = 'NON-NEG' then output;
run;

proc append base=thetas data=theta;
run;
```

```
%end;

%mend runlp;

%runlp;

proc print data=thetas;
run;
```

```
data dea (drop=var2 var4);
set sasuser.layer;
proc print;
run;

proc transpose data=dea out=model name=_id_ prefix=z;
run;


data model;
set model;
if _id_ = 'VAR1' then _type_='eq ';
else _type_='le ';
if _type_='eq ' then _rhs_=0;
run;

data addobj;
input _id_ $ _type_ $;
cards;
OBJFN max
;

run;

data addsumz (drop=i);
array vbls(23) Z1-Z23;
do i=1 to 23;
vbls(i)=1;
end;
input _id_ $ _type_ $ _rhs_;
cards;
SUMZ eq 1
;

run;


data model;
set model addobj addsumz;

run;
proc print;run;
```

```
data thetas;
input dmu _var_ $ _value_;
cards;
;
run;

%macro runlp;
%do n=1 %to 23;


data model;
set model;
if _id_='OBJFN' then theta=1;
else if _id_ = 'SUMZ' or _type_ = 'le' then theta= .;
else theta=-z&n;
if _type_='le' then _rhs_=z&n;
run;
proc print data=model;run;

proc lp scale=both printlevel=-2 primalout=prim&n;
row _id_;
var theta z1-z23;
*proc print;
run;

data theta (keep=dmu _var_ _value_);
set prim&n;
dmu=&n;
if _value_ > 0 and _type_ = 'NON-NEG' then output;
run;

proc append base=thetas data=theta;
run;

%end;

%mend runlp;

%runlp;

proc print data=thetas;
run;
```

As explained in the DEA section, all the programs are for a particular process. To run for a different process, change the name of the process in line 2.

APPENDIX D: ALTERNATIVE ASSUMPTIONS

Before the model in Chapter 4 was finalized, models with different assumptions and formulations were explored. Those models did not materialize because the basic assumptions were later found to be flawed. This section presents those assumptions and the basic idea in those models.

There were three kinds of models which were being considered. The basic assumption in those models were that the processes would act as peers and that they could be compared. The first model was called the monthly model where the objective function of the model has three parts. The first part, of the objective function (global objective function) minimizes the positive deviation from the global input targets and the negative deviation of the global output targets. The second part of the objective function (process objective function) minimizes the positive and negative deviations from the individual input and output targets for *k* processes. The third part of the objective function (balance objective function) of the objective function minimizes the negative deviation from the actual output of the previous process.

There were three sets of constraints for the objective function. The first set of constraints, represents the process target constraints. The first constraint for the individual targets represents the achievement of output targets for each process. A virtual output is computed based on the target specified for each process. The second constraint is similar to the above one, except that it is on the input side. The deviations are computed with respect to the input targets specified for each period and for each process.

The second constraint represents the dependency constraint. As the firm under consideration is a serial manufacturing process, the outputs at the end of each process have to be related. The target level for this constraint is the actual output of the previous process. In this case, only the negative deviations are minimized, as we do not want to go below the existing level of outputs at the end of each process.

The third set of constraints is the global target constraints. A weighted combination of outputs for each period across all processes is compared with the global output target.

The second model was called the yearly model which was almost identical to the monthy model except that it was on a yearly basis.

The third model was similar to the yearly model. The only difference being that, at the end of the first optimization (process optimization), the results are passed into the global optimization constraint.

The basic assumption in all these models was that the processes could be compared (used as peers) when the fact was they used different technologies. So this kind of a comparison was not meaningful. The third model also flirted with the idea of establishing a new frontier above and beyond the traditional *DEA* frontier.

The purpose of this section is to alert a potential researcher of the perils involved in adopting this kind of an approach if he/she were to conduct research in this area.