Exercise 2-4

This change simply adds 2 to each service time in Table 2-1, so that they become 4.90, 3.76, 5.39, 6.52, 6.46, 6.36, 4.07, 5.36, 4.37, and 7.38. The hand-simulation table then looks like this (entries whose values or positions are changed due to the new service times are shaded):

Just-Finished Event: Entity No.	Time t	Event Type	Variables: $Q(t)$	$B(t)$	Attributes: Arrival Times: (In Queue)	In Service	P	N	ΣWQ	WQ^*	ΣTS	TS^*	$\int Q$	Q^*	$\int B$	Event Calendar [Entity No.,	Time,	Type]
–	0.00	Init	0	0	()	–	0	0	0.00	0.00	0.00	0.00	0.00	0	0.00	[1, [–,	0.00, 20.00,	Arr] End]
1	0.00	Arr	0	1	()	0.00	0	1	0.00	0.00	0.00	0.00	0.00	0	0.00	[2, [1, [–,	1.73, 4.90, 20.00,	Arr] Dep] End]
2	1.73	Arr	1	1	(1.73)	0.00	0	1	0.00	0.00	0.00	0.00	0.00	1	1.73	 [1, [–,	3.08, 4.90, 20.00,	Arr] Dep] End]
3	3.08	Arr	2	1	(3.09, 1.73)	0.00	0	1	0.00	0.00	0.00	0.00	1.35	2	3.08	 [1,	3.79, 4.90, 20.00,	Arr] Dep] End]
4	3.79	Arr	3	1	(3.79, 3.09, 1.73)	0.00	0	1	0.00	0.00	0.00	0.00	2.77	3	3.79	 [1, [–,	4.41, 4.90, 20.00,	Arr] Dep] End]
5	4.41	Arr	4	1	(4.41, 3.79, 3.09, 1.73)	0.00	0	1	0.00	0.00	0.00	0.00	4.63	4	4.41	 [6, [–,	4.90, 18.69, 20.00,	Dep] Arr] End]
1	4.90	Dep	3	1	(4.41, 3.79, 3.09)	1.73	1	2	3.17	3.17	4.90	4.90	6.59	4	4.90	 [6, [–,	8.66, 18.69, 20.00,	Dep] Arr] End]
2	8.66	Dep	2	1	(4.41, 3.79)	3.09	2	3	8.74	5.57	11.83	6.93	17.87	4	8.66	 [6, [–,	14.05, 18.69, 20.00,	Dep] Arr] End]
3	14.05	Dep	1	1	(4.41)	3.79	3	4	19.00	10.26	22.79	10.96	28.65	4	14.05	 [–,	18.69, 20.00, 20.57,	Arr] End] Dep]
6	18.69	Arr	2	1	(18.69, 4.41)	3.79	3	4	19.00	10.26	22.79	10.96	33.29	4	18.69	 [–,	19.39, 20.00, 20.57,	Arr] End] Dep]
7	19.39	Arr	3	1	(19.39, 18.69, 4.41)	3.79	3	4	19.00	10.26	22.79	10.96	34.69	4	19.39	 [4,	20.00, 20.57, 34.91,	End] Dep] Arr]
–	20.00	End	3	1	(19.39, 18.69, 4.41)	3.79	3	4	19.00	10.26	22.79	10.96	36.52	4	20.00	 [8,	20.57, 34.91,	Dep] Arr]

Here are the summary results:

Performance Measure	Value	Result from Table 2-3	Change
Total production	3 parts	5 parts	Decreased
Average waiting time in queue	4.75 minutes per part (4 parts)	2.53 minutes per part (6 parts)	Increased
Maximum waiting time in queue	10.26 minutes	8.16 minutes	Increased
Average total time in system	7.60 minutes per part (4 parts)	6.44 minutes per part (5 parts)	Increased
Maximum total time in system	10.96 minutes	12.62 minutes	Decreased
Time-average number of parts in queue	1.83 parts	0.79 part	Increased
Maximum number of parts in queue	4 parts	3 parts	Increased
Drill-press utilization	1.00 (dimensionless proportion)	0.92 (dimensionless proportion)	Increased

So, as expected, these longer "service" times make the system more congested by most measures (the one exception is the maximum total time in system, which we think would probably also have gotten larger in a longer run) and reduce production over this fixed 20-minute time span.