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APPENDIX A

Statistical Tests to Determine Whether there is a Significant Difference between the **Service Level** resulting from using the POS System and the ECR system

Service level is one of the criteria for measuring the customers' satisfaction level by determining the proportion of time the item is available in the store. Data are collected for four months, two before the installation of the new system, and two after. Table A.1, A.2, and A.3 show the summarized data of the frequency the items not available at their shelves. The product codes and names are not shown due to the company's confidentiality. The data in columns fq. are the frequency the items not available at their shelves during daily checking. In order to know the service level of each item, the frequency of absent items is divided by the number of observation days and this percentage is subtracted from 100%. So the service level of each item is calculated and summarized as shown in table A.4, A.5, and A.6.

Table A.1 Summarized Data of the Frequency of Absent Item at Pilot Store#1 The percent (%) of absent is the proportion of absent day over the observation day.

Service Level (Pilot Store#1)									
Product		Before				After			
Code	Name	August, 1997		September, 1997		March, 1998		April, 1998	
		fq.	%	fq.	%	fq.	%	fq.	%
	Medium Moving								
M01	*Not Shown*	0	0.00	0	0.00	0	0.00	0	0.00
M02	*Not Shown*	0	0.00	0	0.00	0	0.00	0	0.00
M03	*Not Shown*	0	0.00	0	0.00	0	0.00	2	0.07
M04	*Not Shown*	2	0.06	0	0.00	0	0.00	3	0.10
M05	*Not Shown*	4	0.13	1	0.03	2	0.06	4	0.13
M06	*Not Shown*	1	0.03	1	0.03	0	0.00	0	0.00
M07	*Not Shown*	2	0.06	1	0.03	0	0.00	0	0.00
M08	*Not Shown*	0	0.00	1	0.03	0	0.00	0	0.00
M09	*Not Shown*	0	0.00	0	0.00	0	0.00	0	0.00
M10	*Not Shown*	0	0.00	0	0.00	0	0.00	0	0.00
M11	*Not Shown*	0	0.00	0	0.00	0	0.00	0	0.00
M12	*Not Shown*	1	0.03	0	0.00	0	0.00	2	0.07
M13	*Not Shown*	0	0.00	0	0.00	0	0.00	4	0.13
M14	*Not Shown*	0	0.00	0	0.00	0	0.00	3	0.10
M15	*Not Shown*	0	0.00	0	0.00	0	0.00	0	0.00
	Slow Moving								
S01	*Not Shown*	0	0.00	1	0.03	0	0.00	0	0.00
S02	*Not Shown*	0	0.00	1	0.03	0	0.00	0	0.00
S03	*Not Shown*	0	0.00	3	0.10	0	0.00	0	0.00
S04	*Not Shown*	0	0.00	4	0.13	0	0.00	0	0.00
S05	*Not Shown*	0	0.00	0	0.00	1	0.03	0	0.00
S06	*Not Shown*	0	0.00	2	0.07	0	0.00	0	0.00
S07	*Not Shown*	0	0.00	2	0.07	1	0.03	0	0.00
S08	*Not Shown*	0	0.00	4	0.13	0	0.00	0	0.00
S09	*Not Shown*	0	0.00	3	0.10	0	0.00	0	0.00
S10	*Not Shown*	1	0.03	2	0.07	0	0.00	0	0.00
S11	*Not Shown*	0	0.00	1	0.03	0	0.00	0	0.00
S12	*Not Shown*	0	0.00	1	0.03	0	0.00	0	0.00
S13	*Not Shown*	0	0.00	2	0.07	0	0.00	0	0.00
S14	*Not Shown*	0	0.00	3	0.10	0	0.00	0	0.00
S15	*Not Shown*	0	0.00	3	0.10	0	0.00	0	0.00
	Fast Moving								
F01	*Not Shown*	2	0.06	1	0.03	0	0.00	0	0.00
F02	*Not Shown*	4	0.13	0	0.00	2	0.06	0	0.00
F03	*Not Shown*	3	0.10	0	0.00	0	0.00	1	0.03
F04	*Not Shown*	5	0.16	1	0.03	1	0.03	0	0.00
F05	*Not Shown*	3	0.10	2	0.07	0	0.00	1	0.03
F06	*Not Shown*	5	0.16	3	0.10	1	0.03	2	0.07
F07	*Not Shown*	4	0.13	2	0.07	2	0.06	1	0.03
F08	*Not Shown*	5	0.16	4	0.13	4	0.13	2	0.07
F09	*Not Shown*	3	0.10	1	0.03	0	0.00	1	0.03
F10	*Not Shown*	4	0.13	2	0.07	2	0.06	2	0.07
F11	*Not Shown*	1	0.03	0	0.00	0	0.00	1	0.03
F12	*Not Shown*	4	0.13	2	0.07	1	0.03	2	0.07
F13	*Not Shown*	2	0.06	1	0.03	2	0.06	3	0.10
F14	*Not Shown*	3	0.10	1	0.03	1	0.03	3	0.10
F15	*Not Shown*	4	0.13	3	0.10	1	0.03	2	0.07

Table A.2 Summarized Data of the Frequency of Absent Item at Pilot Store#2 The percent (%) of absent is the proportion of absent day over the observation day.

Service Level (Pilot Store#2)									
Product		Before				After			
Code	Name	August, 1997		September, 1997		March, 1998		April, 1998	
		fq.	%	fq.	%	fq.	%	fq.	%
	Medium Moving								
M01	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M02	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M03	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M04	*Not Shown*	0.00	0.00	0.00	0.00	1.00	0.03	0.00	0.00
M05	*Not Shown*	2.00	0.06	1.00	0.03	0.00	0.00	2.00	0.07
M06	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M07	*Not Shown*	1.00	0.03	2.00	0.07	0.00	0.00	1.00	0.03
M08	*Not Shown*	0.00	0.00	5.00	0.17	0.00	0.00	1.00	0.03
M09	*Not Shown*	1.00	0.03	1.00	0.03	0.00	0.00	2.00	0.07
M10	*Not Shown*	3.00	0.10	4.00	0.13	7.00	0.23	17.00	0.57
M11	*Not Shown*	4.00	0.13	4.00	0.13	9.00	0.29	10.00	0.33
M12	*Not Shown*	2.00	0.06	2.00	0.07	0.00	0.00	4.00	0.13
M13	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M14	*Not Shown*	1.00	0.03	2.00	0.07	0.00	0.00	0.00	0.00
M15	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Slow Moving								
S01	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S02	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S03	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S04	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S05	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S06	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S07	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S08	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S09	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S10	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S11	*Not Shown*	0.00	0.00	7.00	0.23	5.00	0.16	2.00	0.07
S12	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.07
S13	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S14	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S15	*Not Shown*	0.00	0.00	0.00	0.00	3.00	0.10	0.00	0.00
	Fast Moving								
F01	*Not Shown*	0.00	0.00	0.00	0.00	1.00	0.03	2.00	0.07
F02	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	4.00	0.13
F03	*Not Shown*	3.00	0.10	7.00	0.23	3.00	0.10	8.00	0.27
F04	*Not Shown*	4.00	0.13	12.00	0.40	8.00	0.26	2.00	0.07
F05	*Not Shown*	1.00	0.03	6.00	0.20	6.00	0.19	6.00	0.20
F06	*Not Shown*	3.00	0.10	4.00	0.13	7.00	0.23	2.00	0.07
F07	*Not Shown*	4.00	0.13	2.00	0.07	11.00	0.35	2.00	0.07
F08	*Not Shown*	3.00	0.10	11.00	0.37	11.00	0.35	3.00	0.10
F09	*Not Shown*	5.00	0.16	7.00	0.23	10.00	0.32	6.00	0.20
F10	*Not Shown*	4.00	0.13	9.00	0.30	10.00	0.32	10.00	0.33
F11	*Not Shown*	5.00	0.16	11.00	0.37	11.00	0.35	6.00	0.20
F12	*Not Shown*	15.00	0.48	15.00	0.50	12.00	0.39	2.00	0.07
F13	*Not Shown*	7.00	0.23	11.00	0.37	11.00	0.35	2.00	0.07
F14	*Not Shown*	18.00	0.58	22.00	0.73	14.00	0.45	3.00	0.10
F15	*Not Shown*	20.00	0.65	26.00	0.87	14.00	0.45	5.00	0.17

Table A.3 Summarized Data of the Frequency of Absent Item at Pilot Store#3 The percent (%) of absent is the proportion of absent day over the observation day.

Service Level (Pilot Store#3)									
Product		Before				After			
Code	Name	August, 1997		September, 1997		March, 1998		April, 1998	
		fq.	%	fq.	%	fq.	%	fq.	%
	Medium Moving								
M01	*Not Shown*	0.00	0.00	2.00	0.07	0.00	0.00	2.00	0.07
M02	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M03	*Not Shown*	1.00	0.03	1.00	0.03	0.00	0.00	0.00	0.00
M04	*Not Shown*	0.00	0.00	1.00	0.03	0.00	0.00	0.00	0.00
M05	*Not Shown*	2.00	0.06	4.00	0.13	4.00	0.13	5.00	0.17
M06	*Not Shown*	3.00	0.10	1.00	0.03	0.00	0.00	0.00	0.00
M07	*Not Shown*	2.00	0.06	1.00	0.03	0.00	0.00	0.00	0.00
M08	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M09	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M10	*Not Shown*	0.00	0.00	3.00	0.10	2.00	0.06	0.00	0.00
M11	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M12	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.03
M13	*Not Shown*	0.00	0.00	1.00	0.03	0.00	0.00	0.00	0.00
M14	*Not Shown*	0.00	0.00	1.00	0.03	0.00	0.00	1.00	0.03
M15	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Slow Moving								
S01	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S02	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S03	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S04	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S05	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S06	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S07	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S08	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S09	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S10	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S11	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S12	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S13	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S14	*Not Shown*	2.00	0.06	2.00	0.07	3.00	0.10	0.00	0.00
S15	*Not Shown*	2.00	0.06	2.00	0.07	3.00	0.10	0.00	0.00
	Fast Moving								
F01	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.07
F02	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F03	*Not Shown*	0.00	0.00	0.00	0.00	2.00	0.06	0.00	0.00
F04	*Not Shown*	0.00	0.00	0.00	0.00	1.00	0.03	0.00	0.00
F05	*Not Shown*	0.00	0.00	0.00	0.00	3.00	0.10	0.00	0.00
F06	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F07	*Not Shown*	1.00	0.03	0.00	0.00	1.00	0.03	1.00	0.03
F08	*Not Shown*	0.00	0.00	0.00	0.00	1.00	0.03	0.00	0.00
F09	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F10	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F11	*Not Shown*	0.00	0.00	0.00	0.00	1.00	0.03	0.00	0.00
F12	*Not Shown*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F13	*Not Shown*	1.00	0.03	1.00	0.03	4.00	0.13	2.00	0.07
F14	*Not Shown*	0.00	0.00	0.00	0.00	2.00	0.06	1.00	0.03
F15	*Not Shown*	0.00	0.00	0.00	0.00	2.00	0.06	0.00	0.00

Table A.4 Summarized Service Level of Each Representative Item at Pilot Store#1 Percentage show in colume 'Before' are the service level performed by the ECR system while 'After' are performed by the POS system.

Service Level (Pilot Store#1)			
Product		Service Level	
Code	Name	Before	After
	Medium Moving		
M01	*Not Shown*	100.00%	100.00%
M02	*Not Shown*	100.00%	100.00%
M03	*Not Shown*	100.00%	96.72%
M04	*Not Shown*	96.72%	95.08%
M05	*Not Shown*	91.80%	90.16%
M06	*Not Shown*	96.72%	100.00%
M07	*Not Shown*	95.08%	100.00%
M08	*Not Shown*	98.36%	100.00%
M09	*Not Shown*	100.00%	100.00%
M10	*Not Shown*	100.00%	100.00%
M11	*Not Shown*	100.00%	100.00%
M12	*Not Shown*	98.36%	96.72%
M13	*Not Shown*	100.00%	93.44%
M14	*Not Shown*	100.00%	95.08%
M15	*Not Shown*	100.00%	100.00%
	Slow Moving		
S01	*Not Shown*	98.36%	100.00%
S02	*Not Shown*	98.36%	100.00%
S03	*Not Shown*	95.08%	100.00%
S04	*Not Shown*	93.44%	100.00%
S05	*Not Shown*	100.00%	98.36%
S06	*Not Shown*	96.72%	100.00%
S07	*Not Shown*	96.72%	98.36%
S08	*Not Shown*	93.44%	100.00%
S09	*Not Shown*	95.08%	100.00%
S10	*Not Shown*	95.08%	100.00%
S11	*Not Shown*	98.36%	100.00%
S12	*Not Shown*	98.36%	100.00%
S13	*Not Shown*	96.72%	100.00%
S14	*Not Shown*	95.08%	100.00%
S15	*Not Shown*	95.08%	100.00%
	Fast Moving		
F01	*Not Shown*	95.08%	100.00%
F02	*Not Shown*	93.44%	96.72%
F03	*Not Shown*	95.08%	98.36%
F04	*Not Shown*	90.16%	98.36%
F05	*Not Shown*	91.80%	98.36%
F06	*Not Shown*	86.89%	95.08%
F07	*Not Shown*	90.16%	95.08%
F08	*Not Shown*	85.25%	90.16%
F09	*Not Shown*	93.44%	98.36%
F10	*Not Shown*	90.16%	93.44%
F11	*Not Shown*	98.36%	98.36%
F12	*Not Shown*	90.16%	95.08%
F13	*Not Shown*	95.08%	91.80%
F14	*Not Shown*	93.44%	93.44%
F15	*Not Shown*	88.52%	95.08%

Table A.5 Summarized Service Level of Each Representative Item at Pilot Store#2 Percentage show in colume 'Before' are the service level performed by the ECR system while 'After' are performed by the POS system.

Service Level (Pilot Store#2)			
Product		Service Level	
Code	Name	Before	After
	Medium Moving		
M01	*Not Shown*	100.00%	100.00%
M02	*Not Shown*	100.00%	100.00%
M03	*Not Shown*	100.00%	100.00%
M04	*Not Shown*	100.00%	98.36%
M05	*Not Shown*	95.08%	96.72%
M06	*Not Shown*	100.00%	100.00%
M07	*Not Shown*	95.08%	98.36%
M08	*Not Shown*	91.80%	98.36%
M09	*Not Shown*	96.72%	96.72%
M10	*Not Shown*	88.52%	60.66%
M11	*Not Shown*	86.89%	68.85%
M12	*Not Shown*	93.44%	93.44%
M13	*Not Shown*	100.00%	100.00%
M14	*Not Shown*	95.08%	100.00%
M15	*Not Shown*	100.00%	100.00%
	Slow Moving		
S01	*Not Shown*	100.00%	100.00%
S02	*Not Shown*	100.00%	100.00%
S03	*Not Shown*	100.00%	100.00%
S04	*Not Shown*	100.00%	100.00%
S05	*Not Shown*	100.00%	100.00%
S06	*Not Shown*	100.00%	100.00%
S07	*Not Shown*	100.00%	100.00%
S08	*Not Shown*	100.00%	100.00%
S09	*Not Shown*	100.00%	100.00%
S10	*Not Shown*	100.00%	100.00%
S11	*Not Shown*	88.52%	88.52%
S12	*Not Shown*	100.00%	96.72%
S13	*Not Shown*	100.00%	100.00%
S14	*Not Shown*	100.00%	100.00%
S15	*Not Shown*	100.00%	95.08%
	Fast Moving		
F01	*Not Shown*	100.00%	95.08%
F02	*Not Shown*	100.00%	93.44%
F03	*Not Shown*	83.61%	81.97%
F04	*Not Shown*	73.77%	83.61%
F05	*Not Shown*	88.52%	80.33%
F06	*Not Shown*	88.52%	85.25%
F07	*Not Shown*	90.16%	78.69%
F08	*Not Shown*	77.05%	77.05%
F09	*Not Shown*	80.33%	73.77%
F10	*Not Shown*	78.69%	67.21%
F11	*Not Shown*	73.77%	72.13%
F12	*Not Shown*	50.82%	77.05%
F13	*Not Shown*	70.49%	78.69%
F14	*Not Shown*	34.43%	72.13%
F15	*Not Shown*	24.59%	68.85%

Table A.6 Summarized Service Level of Each Representative Item at Pilot Store#3 Percentage show in colume 'Before' are the service level performed by the ECR system while 'After' are performed by the POS system.

Service Level (Pilot Store#3)			
Product		Service Level	
Code	Name	Before	After
	Medium Moving		
M01	*Not Shown*	96.72%	96.72%
M02	*Not Shown*	100.00%	100.00%
M03	*Not Shown*	96.72%	100.00%
M04	*Not Shown*	98.36%	100.00%
M05	*Not Shown*	90.16%	85.25%
M06	*Not Shown*	93.44%	100.00%
M07	*Not Shown*	95.08%	100.00%
M08	*Not Shown*	100.00%	100.00%
M09	*Not Shown*	100.00%	100.00%
M10	*Not Shown*	95.08%	96.72%
M11	*Not Shown*	100.00%	100.00%
M12	*Not Shown*	100.00%	98.36%
M13	*Not Shown*	98.36%	100.00%
M14	*Not Shown*	98.36%	98.36%
M15	*Not Shown*	100.00%	100.00%
	Slow Moving		
S01	*Not Shown*	100.00%	100.00%
S02	*Not Shown*	100.00%	100.00%
S03	*Not Shown*	100.00%	100.00%
S04	*Not Shown*	100.00%	100.00%
S05	*Not Shown*	100.00%	100.00%
S06	*Not Shown*	100.00%	100.00%
S07	*Not Shown*	100.00%	100.00%
S08	*Not Shown*	100.00%	100.00%
S09	*Not Shown*	100.00%	100.00%
S10	*Not Shown*	100.00%	100.00%
S11	*Not Shown*	100.00%	100.00%
S12	*Not Shown*	100.00%	100.00%
S13	*Not Shown*	100.00%	100.00%
S14	*Not Shown*	93.44%	95.08%
S15	*Not Shown*	93.44%	95.08%
	Fast Moving		
F01	*Not Shown*	100.00%	96.72%
F02	*Not Shown*	100.00%	100.00%
F03	*Not Shown*	100.00%	96.72%
F04	*Not Shown*	100.00%	98.36%
F05	*Not Shown*	100.00%	95.08%
F06	*Not Shown*	100.00%	100.00%
F07	*Not Shown*	98.36%	96.72%
F08	*Not Shown*	100.00%	98.36%
F09	*Not Shown*	100.00%	100.00%
F10	*Not Shown*	100.00%	100.00%
F11	*Not Shown*	100.00%	98.36%
F12	*Not Shown*	100.00%	100.00%
F13	*Not Shown*	96.72%	90.16%
F14	*Not Shown*	100.00%	95.08%
F15	*Not Shown*	100.00%	96.72%

These sets of data of each pilot store consisted of 15 items from each group of products : fast moving, slow moving and medium moving. For this situation where it is uncertain that the population is a normal distribution or not, the non-parametric statistic namely " Sign Test " is selected. This test is based on the number of " + " and " - " signs performed in order to know whether there is a significant difference between the two population means. The sign test begins by specifying null hypothesis and alternative hypothesis for testing as the following :

H_0 = Assume there is no difference between population means of service level while using the POS system and the ECR system.

H_1 = Assume there is a difference between population means of service level while using the POS system and the ECR system.

X_{1i} = Service level of item number i while using the ECR system

X_{2i} = Service level of item number i while using the POS system

The difference in service level while using the ECR system and the POS system ($X_{2i} - X_{1i}$) indicated with the positive or negative signs are shown as follows :

Table A.7 Sign Test of Service Level of Each Representative Item at Pilot Store#1

The positive(+) sign shows that the service level of that item is improved.

The negative(-) sign shows that the service level of that item is reduced.

Zero (0) shows that the service level is not improved nor reduced.

Service Level (Pilot Store#1)				
Code	Name	Before	After	Sign Test
	Medium Moving			
M01	*Not Shown*	100.00%	100.00%	0
M02	*Not Shown*	100.00%	100.00%	0
M03	*Not Shown*	100.00%	96.72%	-
M04	*Not Shown*	96.72%	95.08%	-
M05	*Not Shown*	91.80%	90.16%	-
M06	*Not Shown*	96.72%	100.00%	+
M07	*Not Shown*	95.08%	100.00%	+
M08	*Not Shown*	98.36%	100.00%	+
M09	*Not Shown*	100.00%	100.00%	0
M10	*Not Shown*	100.00%	100.00%	0
M11	*Not Shown*	100.00%	100.00%	0
M12	*Not Shown*	98.36%	96.72%	-
M13	*Not Shown*	100.00%	93.44%	-
M14	*Not Shown*	100.00%	95.08%	-
M15	*Not Shown*	100.00%	100.00%	0
	Slow Moving			
S01	*Not Shown*	98.36%	100.00%	+
S02	*Not Shown*	98.36%	100.00%	+
S03	*Not Shown*	95.08%	100.00%	+
S04	*Not Shown*	93.44%	100.00%	+
S05	*Not Shown*	100.00%	98.36%	-
S06	*Not Shown*	96.72%	100.00%	+
S07	*Not Shown*	96.72%	98.36%	+
S08	*Not Shown*	93.44%	100.00%	+
S09	*Not Shown*	95.08%	100.00%	+
S10	*Not Shown*	95.08%	100.00%	+
S11	*Not Shown*	98.36%	100.00%	+
S12	*Not Shown*	98.36%	100.00%	+
S13	*Not Shown*	96.72%	100.00%	+
S14	*Not Shown*	95.08%	100.00%	+
S15	*Not Shown*	95.08%	100.00%	+
	Fast Moving			
F01	*Not Shown*	95.08%	100.00%	+
F02	*Not Shown*	93.44%	96.72%	+
F03	*Not Shown*	95.08%	98.36%	+
F04	*Not Shown*	90.16%	98.36%	+
F05	*Not Shown*	91.80%	98.36%	+
F06	*Not Shown*	86.89%	95.08%	+
F07	*Not Shown*	90.16%	95.08%	+
F08	*Not Shown*	85.25%	90.16%	+
F09	*Not Shown*	93.44%	98.36%	+
F10	*Not Shown*	90.16%	93.44%	+
F11	*Not Shown*	98.36%	98.36%	0
F12	*Not Shown*	90.16%	95.08%	+
F13	*Not Shown*	95.08%	91.80%	-
F14	*Not Shown*	93.44%	93.44%	0
F15	*Not Shown*	88.52%	95.08%	+

Table A.8 Sign Test of Service Level of Each Representative Item at Pilot Store#2

The positive(+) sign shows that the service level of that item is improved.

The negative(-) sign shows that the service level of that item is reduced.

Zero (0) shows that the service level is not improved nor reduced.

Service Level (Pilot Store#2)				
Code	Name	Before	After	Sign Test
	Medium Moving			
M01	*Not Shown*	100.00%	100.00%	0
M02	*Not Shown*	100.00%	100.00%	0
M03	*Not Shown*	100.00%	100.00%	0
M04	*Not Shown*	100.00%	98.36%	-
M05	*Not Shown*	95.08%	96.72%	+
M06	*Not Shown*	100.00%	100.00%	0
M07	*Not Shown*	95.08%	98.36%	+
M08	*Not Shown*	91.80%	98.36%	+
M09	*Not Shown*	96.72%	96.72%	0
M10	*Not Shown*	88.52%	60.66%	-
M11	*Not Shown*	86.89%	68.85%	-
M12	*Not Shown*	93.44%	93.44%	0
M13	*Not Shown*	100.00%	100.00%	0
M14	*Not Shown*	95.08%	100.00%	+
M15	*Not Shown*	100.00%	100.00%	0
	Slow Moving			
S01	*Not Shown*	100.00%	100.00%	0
S02	*Not Shown*	100.00%	100.00%	0
S03	*Not Shown*	100.00%	100.00%	0
S04	*Not Shown*	100.00%	100.00%	0
S05	*Not Shown*	100.00%	100.00%	0
S06	*Not Shown*	100.00%	100.00%	0
S07	*Not Shown*	100.00%	100.00%	0
S08	*Not Shown*	100.00%	100.00%	0
S09	*Not Shown*	100.00%	100.00%	0
S10	*Not Shown*	100.00%	100.00%	0
S11	*Not Shown*	88.52%	88.52%	0
S12	*Not Shown*	100.00%	96.72%	-
S13	*Not Shown*	100.00%	100.00%	0
S14	*Not Shown*	100.00%	100.00%	0
S15	*Not Shown*	100.00%	95.08%	-
	Fast Moving			
F01	*Not Shown*	100.00%	95.08%	-
F02	*Not Shown*	100.00%	93.44%	-
F03	*Not Shown*	83.61%	81.97%	-
F04	*Not Shown*	73.77%	83.61%	+
F05	*Not Shown*	88.52%	80.33%	-
F06	*Not Shown*	88.52%	85.25%	-
F07	*Not Shown*	90.16%	78.69%	-
F08	*Not Shown*	77.05%	77.05%	0
F09	*Not Shown*	80.33%	73.77%	-
F10	*Not Shown*	78.69%	67.21%	-
F11	*Not Shown*	73.77%	72.13%	-
F12	*Not Shown*	50.82%	77.05%	+
F13	*Not Shown*	70.49%	78.69%	+
F14	*Not Shown*	34.43%	72.13%	+
F15	*Not Shown*	24.59%	68.85%	+

Table A.9 Sign Test of Service Level of Each Representative Item at Pilot Store#3

The positive(+) sign shows that the service level of that item is improved.

The negative(-) sign shows that the service level of that item is reduced.

Zero (0) shows that the service level is not improved nor reduced.

Service Level (Pilot Store#3)				
Code	Name	Before	After	Sign Test
	Medium Moving			
M01	*Not Shown*	96.72%	96.72%	0
M02	*Not Shown*	100.00%	100.00%	0
M03	*Not Shown*	96.72%	100.00%	+
M04	*Not Shown*	98.36%	100.00%	+
M05	*Not Shown*	90.16%	85.25%	-
M06	*Not Shown*	93.44%	100.00%	+
M07	*Not Shown*	95.08%	100.00%	+
M08	*Not Shown*	100.00%	100.00%	0
M09	*Not Shown*	100.00%	100.00%	0
M10	*Not Shown*	95.08%	96.72%	+
M11	*Not Shown*	100.00%	100.00%	0
M12	*Not Shown*	100.00%	98.36%	-
M13	*Not Shown*	98.36%	100.00%	+
M14	*Not Shown*	98.36%	98.36%	0
M15	*Not Shown*	100.00%	100.00%	0
	Slow Moving			
S01	*Not Shown*	100.00%	100.00%	0
S02	*Not Shown*	100.00%	100.00%	0
S03	*Not Shown*	100.00%	100.00%	0
S04	*Not Shown*	100.00%	100.00%	0
S05	*Not Shown*	100.00%	100.00%	0
S06	*Not Shown*	100.00%	100.00%	0
S07	*Not Shown*	100.00%	100.00%	0
S08	*Not Shown*	100.00%	100.00%	0
S09	*Not Shown*	100.00%	100.00%	0
S10	*Not Shown*	100.00%	100.00%	0
S11	*Not Shown*	100.00%	100.00%	0
S12	*Not Shown*	100.00%	100.00%	0
S13	*Not Shown*	100.00%	100.00%	0
S14	*Not Shown*	93.44%	95.08%	+
S15	*Not Shown*	93.44%	95.08%	+
	Fast Moving			
F01	*Not Shown*	100.00%	96.72%	-
F02	*Not Shown*	100.00%	100.00%	0
F03	*Not Shown*	100.00%	96.72%	-
F04	*Not Shown*	100.00%	98.36%	-
F05	*Not Shown*	100.00%	95.08%	-
F06	*Not Shown*	100.00%	100.00%	0
F07	*Not Shown*	98.36%	96.72%	-
F08	*Not Shown*	100.00%	98.36%	-
F09	*Not Shown*	100.00%	100.00%	0
F10	*Not Shown*	100.00%	100.00%	0
F11	*Not Shown*	100.00%	98.36%	-
F12	*Not Shown*	100.00%	100.00%	0
F13	*Not Shown*	96.72%	90.16%	-
F14	*Not Shown*	100.00%	95.08%	-
F15	*Not Shown*	100.00%	96.72%	-

From the above table, the number of positive "+" and negative "-" signs of each product group in each store are counted and summarized as shown in the following :

Table A.10 Summary of Sign Test for Service Level

	Medium Moving		Slow Moving		Fast Moving	
	Positive Sign (+)	Negative Sign (-)	Positive Sign (+)	Negative Sign (-)	Positive Sign (+)	Negative Sign (-)
Store#1	3	6	14	1	12	1
Store#2	4	3	0	2	5	9
Store#3	6	2	2	0	0	10

The sign test will not consider the pair of data which is not different in quantity or $(X_{2i} - X_{1i}) = 0$. By sign test statistic, assume that :

S(P) = The number of positive signs with the binomial distribution and the probability to succeed (positive sign) = 0.5

S(N) = The number of negative signs with the binomial distribution and the probability to succeed (negative sign) = 0.5

C = The critical value that makes the probability of $S \geq C$

For Pilot Store #1

The medium moving products :

The number of positive signs (+) = 3

The number of negative signs (-) = 6

The number of "0" = 6

Sample size (n) = 15 - 6 = 9

By using 5% significant level, refer to the binomial distribution function while n = 9 and p = 0.5

Prob ($S \geq 6 / p = 0.5$) = 0.0898

Prob ($S \geq 7 / p = 0.5$) = 0.0195

For this case, C = 7 because it makes the probability nearest but not more than the significant level (0.05). It means for this case, H_0 is rejected and H_1 is accepted while the number of positive or negative signs $S(P) \geq 7$ or $S(N) \geq 7$.

The number of positive signs (+) = 3

The number of negative signs (-) = 6

Both sides are not equal or more than 7 [S(P) and S(N) < 7], that means H_0 is accepted or there is no difference between the population means of service level while using the POS system and the ECR system.

So the service level of this case is not significant to be increased or decreased.

The slow moving products :

The number of positive signs (+) = 14

The number of negative signs (-) = 1

The number of "0" = 0

Sample size (n) = 15 - 0 = 15

By using 5% significant level, refer to the binomial distribution function while n = 15 and p = 0.5

Prob ($S \geq 10 / p = 0.5$) = 0.0593

Prob ($S \geq 11 / p = 0.5$) = 0.0176

For this case C = 11 because it makes the probability nearest but not more than the significant level (0.05). It means for this case, H_0 is rejected and H_1 is accepted while the number of positive or negative signs S(P) $\geq$ 11 or S (N) $\geq$ 11

The number of positive signs (+) = 14

The number of negative signs (-) = 1

The number of positive signs are more than 11 [S(P) > 11], that means H_0 is rejected or there is a difference between the population means of service level while using the POS system and the ECR system.

So the service level of this case is significant to be increased.

The fast moving products :

The number of positive signs (+)	=	12
The number of negative signs (-)	=	1
The number of "0"	=	2
Sample size (n) = 15 - 2	=	13

By using 5% significant level, refer to the binomial distribution function while n = 13 and p = 0.5

Prob (S $\geq$ 8 / p = 0.5)	=	0.1334
Prob (S $\geq$ 9 / p = 0.5)	=	0.0461

For this case, C = 9 because it makes the probability nearest but not more than the significant level (0.05). It means for this case, H_0 is rejected and

H_1 is accepted while the number of positive or negative signs S(P) ≥ 9 or S(N) ≥ 9

The number of positive signs (+) = 12

The number of negative signs (-) = 1

The number of positive signs are more than 9 [S(P) > 9], that means H_0 is rejected or there is a difference between the population means of service level while using the POS system and the ECR system.

So the service level of this case is not significant to be increased.

For Pilot Store #2

The medium moving products :

The number of positive signs (+)	=	4
The number of negative signs (-)	=	3
The number of "0"	=	8
Sample size (n) = 15 - 8	=	7

By using 5% significant level, refer to the binomial distribution function while n = 7 and p = 0.5

Prob (S $\geq$ 5 / p = 0.5)	=	0.063
Prob (S $\geq$ 6 / p = 0.5)	=	0.0083

For this case, C = 6 because it makes the probability nearest but not more than the significant level (0.05). It means for this case, H_0 is rejected and H_1 is accepted while the number of positive or negative signs S(P) ≥ 6 or S(N) ≥ 6

The number of positive signs (+) = 4

The number of negative signs (-) = 3

Both sides are not equal or more than 6 [S(P) and S(N) < 6], that means H_0 is accepted or there is no difference between the population means of service level while using the POS system and the ECR system.

So the service level of this case is not significant to be increased or decreased.

The slow moving products :

The number of positive signs (+)		=	0
The number of negative signs (-)		=	2
The number of "0"		=	13
Sample size (n)	= 15 - 13	=	2

By using 5% significant level, refer to the binomial distribution function while n = 2 and p = 0.5

Prob (S ≥ 1 / p = 0.5)	=	0.25
Prob (S ≥ 2 / p = 0.5)	=	0

For this case, C = 2 because it makes the probability nearest but not more than significant level (0.05). It means for this case, H_0 is rejected and H_1 is accepted while the number of positive or negative signs S(P) ≥ 2 or S(N) ≥ 2

The number of positive signs (+) = 0

The number of negative signs (-) = 2

The number of negative signs are equal to 2 [S(N) = 2], that means H_0 is rejected or there is a difference between the population means of service level while using the POS system and the ECR system.

So the service level of this case is not significant to be decreased.

The fast moving products :

The number of positive signs (+) = 5

The number of negative signs (-) = 9

The number of "0" = 1

Sample size (n) = 15 - 1 = 14

By using 5% significant level, refer to the binomial distribution function while $n = \bar{14}$ and $p = 0.5$

Prob ($S \geq 9 / p = 0.5$) = 0.0896

Prob ($S \geq 10 / p = 0.5$) = 0.0285

For this case, C = 10 because it makes the probability nearest but not more than the significant level (0.05). It means for this case, H_0 is rejected and H_1 is accepted while the number of positive or negative signs $S(P) \geq 10$ or $S(N) \geq 10$

The number of positive signs (+) = 5

The number of negative signs (-) = 9

Both sides are not equal or more than 10 [S(P) and S(N) < 10], that means H_0 is accepted or there is no difference between the population means of service level while using the POS system and the ECR system.

So the service level of this case is not significant to be increased.

For Pilot Store #3

The medium moving products :

The number of positive signs (+) = 6

The number of negative signs (-) = 2

The number of "0" = 7

Sample size (n) = 15 - 7 = 8

By using 5% significant level, refer to the binomial distribution function while n = 8 and p = 0.5

Prob ($S \geq 5 / p = 0.5$) = 0.1445

Prob ($S \geq 6 / p = 0.5$) = 0.0351

For this case, C = 6 because it makes the probability nearest but not more than the significant level (0.05). It means for this case, H_0 is rejected and H_1 is accepted while the number of positive or negative signs $S(P) \geq 6$ or $S(N) \geq 6$

The number of positive signs (+) = 6

The number of negative signs (-) = 2

The number of positive signs are equal to 6 [S(P) = 6], that means H_0 is rejected or there is a difference between the population means of service level while using the POS system and the ECR system.

So the service level of this case is significant to be increased.

The slow moving products :

The number of positive signs (+) = 2

The number of negative signs (-) = 0

The number of "0" = 13

Sample size (n) = 15 - 13 = 2

By using 5% significant level, refer to the binomial distribution function while n = 2 and p = 0.5

Prob ($S \geq 1 / p = 0.5$) = 0.25

Prob ($S \geq 2 / p = 0.5$) = 0

For this case, C = 2 because it makes the probability nearest but not more than the significant level (0.05). It means for this case, H_0 is rejected and H_1 is accepted while the number of positive or negative signs $S(P) \geq 2$ or $S(N) \geq 2$

The number of positive signs (+) = 2

The number of negative signs (-) = 0

The number of positive signs are equal to 2 [S(P) = 2], that means H_0 is rejected or there is a difference between the population means of service level while using the POS system and the ECR system.

So the service level of this case is not significant to be increased.

The fast moving products :

The number of positive signs (+) = 0

The number of negative signs (-) = 10

The number of "0" = 5

Sample size (n) = 15 - 5 = 10

By using 5% significant level, refer to the binomial distribution function while n = 10 and p = 0.5

Prob ($S \geq 7 / p = 0.5$) = 0.1172

Prob ($S \geq 8 / p = 0.5$) = 0.0493

For this case, C = 8 because it makes the probability nearest but not more than the significant level (0.05). It means for this case, H_0 is rejected and H_1 is accepted while the number of positive or negative signs $S(P) \geq 8$ or $S(N) \geq 8$

The number of positive signs (+) = 0

The number of negative signs (-) = 10

The number of negative signs are more than 8 [$S(N) > 8$], that means H_0 is rejected or there is a difference between the population means of service level while using the POS system and the ECR system.

So the service level of this case is significant to be decreased.

The results of sign test are summarized and shown again in table A.11 as follows :

Table A.11 Summarized Sign Test Results for Service Level

	Service Level		
	Medium Moving	***Slow Moving***	***Fast Moving***
Pilot Store#1	Not Significant	Improved	Improved
Pilot Store#2	Not Significant	Reduced	Not Significant
Pilot Store#3	Improved	Improved	Reduced

APPENDIX B

Statistical Tests to Determine Whether there is a Significant Difference between the **Service Speed** resulting from using the POS System and the ECR system

The POS system is a new system for the firm though having been implemented in other convenience stores in other countries. However, the working environment in Thai convenience stores is different from any other country which has already implemented this system. In order to evaluate the service speed of each system, the operating time of each system (unit in seconds) of are collected. There are 40 data for each system at each pilot store. The data of the first, second, and third pilot stores are collected and summarized as shown in table B.1.

Exploratory Data Analysis

Before applying the statistical method to find out the relationship between any set of data, one of the most important issues is the quality of the data which we will analyze. The poor quality data will lead to the poor analysis result causing misunderstanding or ' Garbage in, garbage out '. The quality of the data should therefore be carefully evaluated by the technique of exploratory data analysis to identify errors and outliners data. To easily analyze the original data are sorted as shown in table B.2.

Table B.1 Summarized Data of Operating Time (in seconds) at the Cashier The data of operating time (in seconds) using different systems at each store. 40 samples are taken for each case.

ECR (s)			POS (s)		
Pilot Store#1	Pilot Store#2	Pilot Store#3	Pilot Store#1	Pilot Store#2	Pilot Store#3
11.12	25.15	10.51	14.27	15.42	8.97
23.33	20.41	16.95	8.99	9.05	9.99
22.10	21.05	20.78	9.52	19.03	11.07
12.24	14.01	10.21	10.14	15.66	19.18
8.91	11.66	11.46	18.37	12.64	11.02
14.66	18.42	17.93	10.99	23.07	12.06
17.99	10.54	9.07	16.02	17.89	15.35
12.35	17.01	14.10	10.62	10.65	24.44
11.19	16.69	9.55	17.18	16.58	19.77
12.90	12.49	11.16	10.24	16.37	10.31
21.16	12.93	10.03	12.46	18.62	22.38
9.87	16.64	9.52	23.96	14.24	26.02
14.21	12.73	12.31	10.21	13.54	13.18
19.99	12.51	12.98	9.55	13.93	11.02
13.45	16.64	9.02	11.74	11.50	11.36
18.59	15.95	9.65	9.33	10.99	12.17
23.46	21.24	12.97	9.68	26.10	10.20
14.41	13.27	12.76	10.02	14.29	20.94
14.25	13.52	11.12	16.09	9.96	9.02
17.27	22.41	10.75	10.80	9.82	19.79
16.59	10.49	17.01	17.24	13.13	16.93
15.00	10.62	17.02	10.71	10.97	12.16
13.15	16.48	13.30	12.68	11.31	15.78
11.30	10.58	16.98	10.37	12.12	19.61
23.10	12.18	23.49	12.08	10.15	10.71
12.23	11.38	13.08	10.30	19.99	14.76
13.56	23.22	10.00	11.43	11.49	15.14
16.89	22.60	11.85	9.86	15.79	12.54
12.87	23.01	23.48	22.49	16.97	13.56
14.67	12.70	12.08	19.03	9.10	9.07
12.34	18.11	18.56	21.67	18.80	17.49
14.76	12.79	11.30	9.49	9.77	9.60
12.76	13.74	23.13	22.89	9.62	9.81
12.56	26.81	11.43	9.52	23.49	18.94
13.78	21.39	12.00	11.93	12.08	16.44
15.49	17.50	13.70	17.97	22.67	12.22
9.84	13.01	10.51	12.75	9.49	15.51
9.53	16.71	21.12	24.49	11.93	24.84
14.56	23.45	14.08	13.49	14.33	18.94
13.42	10.55	10.87	8.34	11.24	9.58

Table B.2 Sorted data of Operating Time (in seconds) at the Cashier of the two systems

	Pilot Store #1	
	ECR (s)	POS(s)
1	8.91	8.34
2	9.53	8.99
3	9.84	9.33
4	9.87	9.49
5	11.12	9.52
6	11.19	9.52
7	11.30	9.55
8	12.23	9.68
9	12.24	9.86
10	12.34	10.02
11	12.35	10.14
12	12.56	10.21
13	12.76	10.24
14	12.87	10.30
15	12.90	10.37
16	13.15	10.62
17	13.42	10.71
18	13.45	10.80
19	13.56	10.99
20	13.78	11.43
21	14.21	11.74
22	14.25	11.93
23	14.41	12.08
24	14.56	12.46
25	14.66	12.68
26	14.67	12.75
27	14.76	13.49
28	15.00	14.27
29	15.49	16.02
30	16.59	16.09
31	16.89	17.18
32	17.27	17.24
33	17.99	17.97
34	18.59	18.37
35	19.99	19.03
36	21.16	21.67
37	22.10	22.49
38	23.10	22.89
39	23.33	23.96
40	23.46	24.49

	Pilot Store #2	
	ECR (s)	POS(s)
1	10.49	9.05
2	10.54	9.10
3	10.55	9.49
4	10.58	9.62
5	10.62	9.77
6	11.38	9.82
7	11.66	9.96
8	12.18	10.15
9	12.49	10.65
10	12.51	10.97
11	12.70	10.99
12	12.73	11.24
13	12.79	11.31
14	12.93	11.49
15	13.01	11.50
16	13.27	11.93
17	13.52	12.08
18	13.74	12.12
19	14.01	12.64
20	15.95	13.13
21	16.48	13.54
22	16.64	13.93
23	16.64	14.24
24	16.69	14.29
25	16.71	14.33
26	17.01	15.42
27	17.50	15.66
28	18.11	15.79
29	18.42	16.37
30	20.41	16.58
31	21.05	16.97
32	21.24	17.89
33	21.39	18.62
34	22.41	18.80
35	22.60	19.03
36	23.01	19.99
37	23.22	22.67
38	23.45	23.07
39	25.15	23.49
40	26.81	26.10

	Pilot Store #3	
	ECR (s)	POS(s)
1	9.02	8.97
2	9.07	9.02
3	9.52	9.07
4	9.55	9.58
5	9.65	9.60
6	10.00	9.81
7	10.03	9.99
8	10.21	10.20
9	10.51	10.31
10	10.51	10.71
11	10.75	11.02
12	10.87	11.02
13	11.12	11.07
14	11.16	11.36
15	11.30	12.06
16	11.43	12.16
17	11.46	12.17
18	11.85	12.22
19	12.00	12.54
20	12.08	13.18
21	12.31	13.56
22	12.76	14.76
23	12.97	15.14
24	12.98	15.35
25	13.08	15.51
26	13.30	15.78
27	13.70	16.44
28	14.08	16.93
29	14.10	17.49
30	16.95	18.94
31	16.98	18.94
32	17.01	19.18
33	17.02	19.61
34	17.93	19.77
35	18.56	19.79
36	20.78	20.94
37	21.12	22.38
38	23.13	24.44
39	23.48	24.84
40	23.49	26.02

In this case, a Box-plots technique should be used as a powerful tool to reveal the important features of distribution namely mean, upper and lower quartiles and the highest and lowest values. Furthermore, inner and outer fences can also be used to create boundaries for testing the outliner as follows :

*Data of operating time while using the **ECR** system :*

n = sample size = 40

$Q_{lECR(i)}$ = Lower quartile of pilot store number i

$Q_{uECR(i)}$ = Upper quartile of pilot store number I

While

Lower quartile position = (n + 1)/4 = 10.25

Then, for the first pilot store (Q_{lECR1}) = 12.34

for the second pilot store (Q_{lECR2}) = 12.56

for the third pilot store (Q_{lECR3}) = 10.57

Median rank = (n + 1)/2 = 20.50

Then, for the first pilot store median $_{ECR}1$ = 14.00

for the second pilot store median $_{ECR}2$ = 16.22

for the third pilot store median $_{ECR}3$ = 12.20

Upper quartile position = 3(n + 1)/4 = 30.75

Then, for the first pilot store (Q_{uECR1}) = 16.82

for the second pilot store (Q_{uECR2}) = 20.89

for the third pilot store (Q_{uECR3}) = 16.97

Inner fences

Lower = $Q_{lECR(i)} - 1.5 (Q_{uECR(i)} - Q_{lECR(i)})$

Then Lower $_{ECR}1$ = 12.34 - 1.5 (16.82 - 12.34)

= 5.62

Lower $_{ECR}2$ = 12.56 - 1.5 (20.89 - 12.56)

= 0.07

$\text{Lower}_{ECR}3 = 10.57 - 1.5\,(16.97 - 10.57)$

$= 0.97$

$\text{Upper} = Q_{uECR(i)} + 1.5\,(Q_{uECR(i)} - Q_{lECR(i)})$

Then $\text{Upper}_{ECR}1 = 16.82 + 1.5\,(16.82 - 12.34)$

$= 23.54$

$\text{Upper}_{ECR}2 = 20.89 + 1.5\,(20.89 - 12.56)$

$= 33.39$

$\text{Upper}_{ECR}3 = 16.97 + 1.5\,(16.97 - 10.57)$

$= 26.57$

Outer fences

$\text{Lower} = Q_{lECR(i)} - 3\,(Q_{uECR(i)} - Q_{lECR(i)})$

Then $\text{Lower}_{ECR}1 = 12.34 - 3\,(16.82 - 12.34)$

$= -1.1$

$\text{Lower}_{ECR}2 = 12.56 - 3\,(20.89 - 12.56)$

$= -12.43$

$\text{Lower}_{ECR}3 = 10.57 - 3\,(16.97 - 10.57)$

$= -8.63$

$\text{Upper} = Q_{uECR(i)} + 3\,(Q_{uECR(i)} - Q_{lECR(i)})$

Then $\text{Upper}_{ECR}1 = 16.82 + 3\,(16.82 - 12.34)$

$= 30.26$

$\text{Upper}_{ECR}2 = 20.89 + 3\,(20.89 - 12.56)$

$= 45.88$

$\text{Upper}_{ECR}3 = 16.97 + 3\,(16.97 - 10.57)$

$= 36.17$

*Data of operating time while using the **POS** system :*

n	=	sample size	= 40
$Q_{lPOS(i)}$	=	Lower quartile of pilot store number i	
$Q_{uPOS(i)}$	=	Upper quartile of pilot store number i	

While

	Lower quartile position	= (n + 1)/4	=	10.25
Then,	for the first pilot store	(Q_{lPOS1})	=	10.05
	for the second pilot store	(Q_{lPOS2})	=	10.98
	for the third pilot store	(Q_{lPOS3})	=	10.79
	Median rank	= (n + 1)/2	=	20.50
Then,	for the first pilot store	median $_{POS}1$	=	11.59
	for the second pilot store	median $_{POS}2$	=	13.34
	for the third pilot store	median $_{POS}3$	=	13.37
	Upper quartile position	= 3(n + 1)/4	=	30.75
Then,	for the first pilot store	(Q_{uPOS1})	=	16.91
	for the second pilot store	(Q_{uPOS2})	=	16.87
	for the third pilot store	(Q_{uPOS3})	=	18.94

Inner fence

	Lower	=	$Q_{lPOS(i)} - 1.5 (Q_{uPOS(i)} - Q_{lPOS(i)})$
Then	Lower $_{POS}1$	=	10.05 - 1.5 (16.91 - 10.05)
		=	-0.24
	Lower $_{POS}2$	=	10.98 - 1.5 (16.87 - 10.98)

$= 2.15$

Lower $_{POS}3 = 10.79 - 1.5\ (18.94 - 10.79)$

$= -1.44$

Upper $= Q_{uPOS(i)} + 1.5\ (Q_{uPOS(i)} - Q_{lPOS(i)})$

Then Upper $_{POS}1 = 16.91 + 1.5\ (16.91 - 10.05)$

$= 27.20$

Upper $_{POS}2 = 16.87 + 1.5\ (16.87 - 10.98)$

$= 25.71$

Upper $_{POS}3 = 18.94 + 1.5\ (18.94 - 10.79)$

$= 31.17$

Outer fence

Lower $= Q_{lPOS(i)} - 3\ (Q_{uPOS(i)} - Q_{lPOS(i)})$

Then Lower $_{POS}1 = 10.05 - 3\ (16.91 - 10.05)$

$= -10.53$

Lower $_{POS}2 = 10.98 - 3\ (16.87 - 10.98)$

$= -6.69$

Lower $_{POS}3 = 10.79 - 3\ (18.94 - 10.79)$

$= -13.66$

Upper $= Q_{uPOS(i)} + 3\ (Q_{uPOS(i)} - Q_{lPOS(i)})$

Then Upper $_{POS}1 = 16.91 + 3\ (16.91 - 10.05)$

$= 37.49$

Upper $_{POS}2 = 16.87 + 3\ (16.87 - 10.98)$

$= 34.54$

Upper $_{POS}3 = 18.94 + 3\ (18.94 - 10.79)$

$= 43.39$

	Lower Outer Fence	Lower Inner Fence	Lowest Obs.* Value	Lower quartile	Median Rank	Upper quartile	Highest Obs.* Value	Upper Inner Fence	Upper Outer Fence
ECR									
Store#1	-1.1	5.62	8.91	12.34	14.00	16.82	23.46	23.54	30.26
Store#2	-12.43	0.07	10.49	12.56	16.22	20.89	26.81	33.39	45.88
Store#3	-8.63	0.97	9.02	10.57	12.20	16.97	23.49	26.57	36.17
POS									
Store#1	-10.53	-0.24	8.34	10.05	11.59	16.91	24.49	27.20	37.49
Store#2	-6.69	2.15	9.05	10.98	13.34	16.87	26.10	25.71	34.54
Store#3	-13.66	-1.44	8.97	10.79	13.37	18.94	26.02	31.17	43.39

* Obs. = Observation

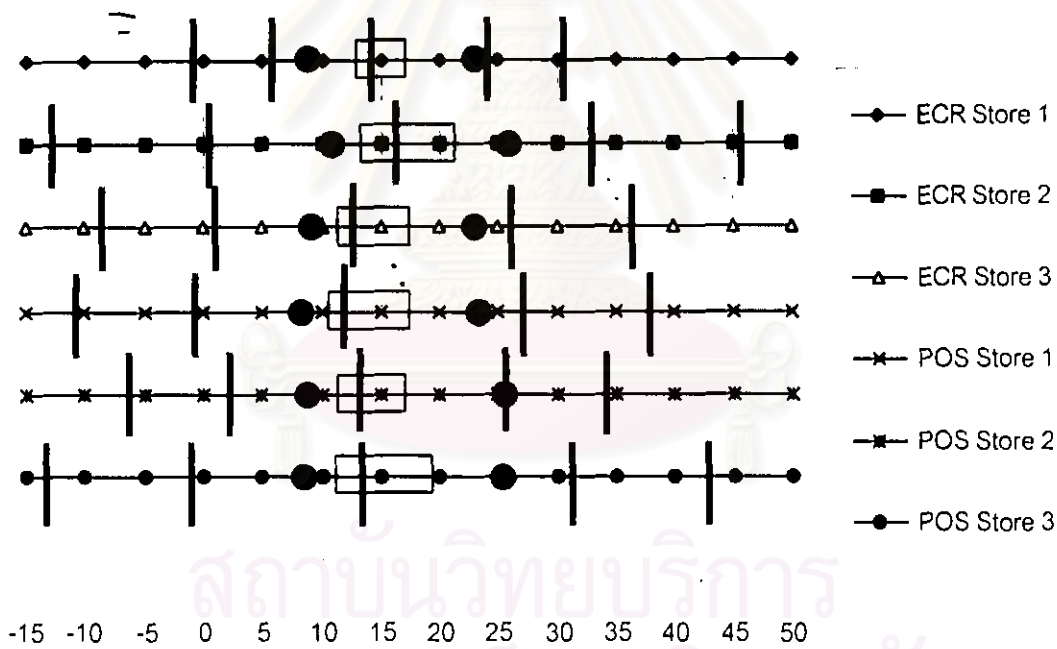


Figure B.1 Box-plots

From figure B.1, the result from both systems of each pilot store shows that there is no data outside the lower and upper inner fence (except for the

POS data of the second pilot store which has data at the outside of the upper inner fence but not outside the upper outer fence). It may be concluded that there is no outliner. According to the central limited theorem, a sample size of 40 is large enough to approximate that data spreads with normal distribution. By Box-plots, it can be concluded that the quality for each set of data is acceptable overall.

Before applying the statistical method to these data, the objective for this test should be clarified. This analysis is performed in order to test for a significant difference between two populations' mean of operating time while using the ECR system and the POS system.

F-ratio Test

This test is performed in order to know whether there is a significant difference between two populations' variance. The result of this test will be used for selecting the appropriate statistical method for mean testing. The F-ratio test begins by specifying null hypothesis and alternative hypothesis for testing as the following ;

H_0 : Assume there is no difference between population variance of operating time while using the POS system and the ECR system. ($\sigma 1 = \sigma 2$)

H_1 : Assume there is a difference between population variance of operating time while using the POS system and the ECR system. ($\sigma 1 \neq \sigma 2$)

From table B.2, we can calculate the required value for calculating the test statistics as follows :

Table B.3 Required value calculation of pilot store#1

Pilot Store #1				
	ECR		POS	
j	X1j	(X1j-X)2	X2j	(X2j-X)2
1	8.91	34.65	8.34	26.35
2	9.53	27.73	8.99	20.10
3	9.84	24.56	9.33	17.16
4	9.87	24.27	9.49	15.86
5	11.12	13.51	9.52	15.62
6	11.19	13.01	9.52	15.62
7	11.30	12.22	9.55	15.39
8	12.23	6.59	9.68	14.38
9	12.24	6.53	9.86	13.05
10	12.34	6.03	10.02	11.92
11	12.35	5.98	10.14	11.11
12	12.56	5.00	10.21	10.65
13	12.76	4.15	10.24	10.45
14	12.87	3.71	10.30	10.07
15	12.90	3.60	10.37	9.63
16	13.15	2.71	10.62	8.14
17	13.42	1.89	10.71	7.63
18	13.45	1.81	10.80	7.14
19	13.56	1.53	10.99	6.16
20	13.78	1.03	11.43	4.17
21	14.21	0.34	11.74	3.00
22	14.25	0.30	11.93	2.38
23	14.41	0.15	12.08	1.94
24	14.56	0.06	12.46	1.03
25	14.66	0.02	12.68	0.63
26	14.67	0.02	12.75	0.52
27	14.76	0.00	13.49	0.00
28	15.00	0.04	14.27	0.64
29	15.49	0.48	16.02	6.49
30	16.59	3.22	16.09	6.85
31	16.89	4.38	17.18	13.74
32	17.27	6.12	17.24	14.19
33	17.99	10.20	17.97	20.23
34	18.59	14.39	18.37	23.98
35	19.99	26.98	19.03	30.88
36	21.16	40.50	21.67	67.19
37	22.10	53.34	22.49	81.31
38	23.10	68.95	22.89	88.68
39	23.33	72.82	23.96	109.98
40	23.46	75.06	24.49	121.38
Total	**591.85**	**577.90**	**538.91**	**845.66**

Table B.4 Required value calculation of pilot store#2

Pilot Store #2				
	ECR		POS	
j	X1j	(X1j-X)2	X2j	(X2j-X)2
1	10.49	33.93	9.05	28.03
2	10.54	33.35	9.10	27.51
3	10.55	33.23	9.49	23.57
4	10.58	32.89	9.62	22.32
5	10.62	32.43	9.77	20.93
6	11.38	24.35	9.82	20.47
7	11.66	21.67	9.96	19.23
8	12.18	17.10	10.15	17.60
9	12.49	14.63	10.65	13.65
10	12.51	14.48	10.97	11.39
11	12.70	13.07	10.99	11.25
12	12.73	12.85	11.24	9.64
13	12.79	12.42	11.31	9.21
14	12.93	11.46	11.49	8.15
15	13.01	10.92	11.50	8.09
16	13.27	9.27	11.93	5.83
17	13.52	7.81	12.08	5.13
18	13.74	6.63	12.12	4.95
19	14.01	5.31	12.64	2.91
20	15.95	0.13	13.13	1.48
21	16.48	0.03	13.54	0.65
22	16.64	0.11	13.93	0.17
23	16.64	0.11	14.24	0.01
24	16.69	0.14	14.29	0.00
25	16.71	0.16	14.33	0.00
26	17.01	0.48	15.42	1.16
27	17.50	1.40	15.66	1.73
28	18.11	3.22	15.79	2.09
29	18.42	4.43	16.37	4.10
30	20.41	16.77	16.58	5.00
31	21.05	22.42	16.97	6.89
32	21.24	24.26	17.89	12.57
33	21.39	25.76	18.62	18.28
34	22.41	37.15	18.80	19.85
35	22.60	39.50	19.03	21.95
36	23.01	44.83	19.99	31.87
37	23.22	47.68	22.67	69.31
38	23.45	50.91	23.07	76.13
39	25.15	78.06	23.49	83.64
40	26.81	110.15	26.10	138.19
Total	**652.59**	**855.50**	**573.79**	**764.91**

Table B.5 Required value calculation of pilot store#3

Pilot Store #3				
	ECR		POS	
j	X1j	(X1j-X)2	X2j	(X2j-X)2
1	9.02	21.86	8.97	33.95
2	9.07	21.40	9.02	33.37
3	9.52	17.43	9.07	32.80
4	9.55	17.19	9.58	27.21
5	9.65	16.37	9.60	27.01
6	10.00	13.66	9.81	24.87
7	10.03	13.44	9.99	23.10
8	10.21	12.15	10.20	21.13
9	10.51	10.15	10.31	20.13
10	10.51	10.15	10.71	16.70
11	10.75	8.68	11.02	14.26
12	10.87	7.98	11.02	14.26
13	11.12	6.63	11.07	13.89
14	11.16	6.43	11.36	11.81
15	11.30	5.74	12.06	7.49
16	11.43	5.13	12.16	6.95
17	11.46	5.00	12.17	6.90
18	11.85	3.41	12.22	6.64
19	12.00	2.87	12.54	5.09
20	12.08	2.61	13.18	2.61
21	12.31	1.92	13.56	1.53
22	12.76	0.88	14.76	0.00
23	12.97	0.53	15.14	0.12
24	12.98	0.51	15.35	0.31
25	13.08	0.38	15.51	0.51
26	13.30	0.16	15.78	0.97
27	13.70	0.00	16.44	2.70
28	14.08	0.15	16.93	4.55
29	14.10	0.16	17.49	7.25
30	16.95	10.59	18.94	17.17
31	16.98	10.79	18.94	17.17
32	17.01	10.99	19.18	19.21
33	17.02	11.05	19.61	23.17
34	17.93	17.93	19.77	24.73
35	18.56	23.66	19.79	24.93
36	20.78	50.19	20.94	37.74
37	21.12	55.12	22.38	57.51
38	23.13	89.01	24.44	92.99
39	23.48	95.74	24.84	100.87
40	23.49	95.93	26.02	125.96
Total	**547.82**	**683.94**	**591.87**	**909.57**

n_1 = Sample size of operating time while using the ECR system = 40

n_2 = Sample size of operating time while using the POS system = 40

σ_1 = Best estimates of operating time while using the ECR system

σ_2 = Best estimates of operating time while using the POS system

ν_1 = Degree of freedom of operating time while using the ECR system

ν_2 = Degree of freedom of operating time while using the POS system

$\nu_1 = (n_1 - 1) = 40 - 1 = 39$

$\nu_2 = (n_2 - 1) = 40 - 1 = 39$

For Pilot Store #1

$\sigma_1 = \sqrt{\sum(X1j - X1)^2 / (n_1 - 1)} = \sqrt{577.90 / 39} = 3.85$

$\sigma_2 = \sqrt{\sum(X2j - X2)^2 / (n_2 - 1)} = \sqrt{845.66 / 39} = 4.66$

Test Statistic: $\sigma_1^2 / \sigma_2^2 = 3.85^2 / 4.66^2 =$ **0.68**

For Pilot Store #2

$\sigma_1 = \sqrt{\sum(X1j - X1)^2 / (n_1 - 1)} = \sqrt{855.50 / 39} = 4.68$

$\sigma_2 = \sqrt{\sum(X2j - X2)^2 / (n_2 - 1)} = \sqrt{764.91 / 39} = 4.43$

Test Statistic: $\sigma_1^2 / \sigma_2^2 = 4.68^2 / 4.43^2 =$ **1.12**

For Pilot Store #3

$\sigma_1 = \sqrt{\sum(X1j - X1)^2 / (n_1 - 1)} = \sqrt{683.94 / 39} = 4.19$

$\sigma_2 = \sqrt{\sum(X2j - X2)^2 / (n_2 - 1)} = \sqrt{909.57 / 39} = 4.83$

Test Statistic: $\sigma_1^2 / \sigma_2^2 = 4.19^2 / 4.83^2 =$ **0.75**

By using 5% significant level, refer to table of Percentage points of the F distribution at $\nu_1 = \nu_2 = 39$;

$F_{0.05,39,39} \approx$ **1.51**

Referring to the previous hypothesis, the result of the F-ratio test for three pilot stores shows that H_0 is accepted. That means there is no evidence of significant difference between population variance of operating time while using the POS system and the ECR system at 5% significant level.

The result of the F-ratio test together with the variance F-ratio is not greater than 2. The appropriate statistical method for this case used for determining the significant difference between two means are Student's t-Test and two tailed test.

Student's t-Test

H_0 : Assume there is no difference between population mean of operating time while using the POS system and the ECR system. ($\mu 1 = \mu 2$)

H_1 : Assume there is a difference between population mean of operating time while using the POS system and the ECR system. ($\mu 1 \neq \mu 2$)

X_1 : Average operating time while using the ECR system

X_2 : Average operating time while using the POS system

For Pilot Store #1

$X_1 = \Sigma X_1 / n1 = 591.85/40 = 14.80$

$X_2 = \Sigma X_2 / n2 = 538.91/40 = 13.47$

$\nu = n1 + n2 - 2 = 40 + 40 - 2 = 78$

k = assumed to be 0

σ = pooled estimate of the unknown standard deviation

$= \sqrt{[(n1 - 1)\sigma 1^2 + (n2 - 1)\sigma 2^2]/[n1 + n2 - 2]}$

$= \sqrt{[(40 - 1)3.85^2 + (40 - 1)4.66^2]/[40 + 40 - 2]}$

$= 4.27$

Test Statistics $= \dfrac{X_2 - X_1 - k}{\sigma \sqrt{(1/n1) + (1/n2)}}$

$= \dfrac{13.47 - 14.80}{4.27\sqrt{(1/40) + (1/40)}}$

$= -1.39$

For Pilot Store #2

$X_1 = \Sigma X_1 / n1 = 652.59/40 = 16.31$

$X_2 = \Sigma X_2 / n2 = 573.79/40 = 14.34$

$\nu = n1 + n2 - 2 = 40 + 40 - 2 = 78$

$k =$ assumed to be 0

$\sigma =$ pooled estimate of the unknown standard deviation

$= \sqrt{[(n1 - 1)\sigma 1^2 + (n2 - 1)\sigma 2^2]/[n1 + n2 - 2]}$

$= \sqrt{[(40 - 1)4.86^2 + (40 - 1)4.43^2]/[40 + 40 - 2]}$

$= 4.65$

Test Statistics $= \dfrac{X_2 - X_1 - k}{\sigma \sqrt{(1/n1) + (1/n2)}}$

$= \dfrac{14.34 - 16.31}{4.65\sqrt{(1/40) + (1/40)}}$

$= -1.89$

For Pilot Store #3

$X_1 = \Sigma X_1 / n1 = 547.82/40 = 13.70$

$X_2 = \Sigma X_2 / n2 = 591.87/40 = 14.80$

$\nu = n1 + n2 - 2 = 40 + 40 - 2 = 78$

k = assumed to be 0

σ = pooled estimate of the unknown standard deviation

$= \sqrt{[(n1 - 1)\sigma 1^2 + (n2 - 1)\sigma 2^2]/[n1 + n2 - 2]}$

$= \sqrt{[(40 - 1)4.19^2 + (40 - 1)4.83^2]/[40 + 40 - 2]}$

$= 4.52$

Test Statistics $= \dfrac{X_2 - X_1 - k}{\sigma\sqrt{(1/n1) + (1/n2)}}$

$= \dfrac{14.80 - 13.70}{4.52\sqrt{(1/40) + (1/40)}}$

$= 1.09$

By using 5% significant level, refer to table of percentage points of the t-distribution at $\nu = 78$. However, the test is a two tailed test and the significant level is divided by two to $\alpha = 0.025$ then

$t_{0.025, 78} \approx 1.99$

The result of Student's t-Test-of three pilot stores shows that H_0 are accepted while H_1 are rejected. This implies that there is no evidence of difference between two population means of operating time while using the POS system and the ECR system. The statistical testing result concludes that the use of the POS system for our current environment is not significant to improve the service speed of the case study.

APPENDIX C

Statistical Tests to Determine Whether there is a Significant Difference between the **Inventory Level** resulting from using the POS System and the ECR system

Inventory level of the stores translate to the level of investment at each store. In order to have high service level, most items in the inventory have to be available. However, inventory also adds costs to the operation. Therefore, the optimized way is the balancing between service level and inventory level. This following statistical tests are performed in order to evaluate the performance of the proposed POS (Point of Sales) system comparing with the current ECR (Electronic Cash Register) system. Data are collected for four months, two before the installation of the new system, and two after. Table C.1, C.2, and C.3 show the data of inventory level of pilot store#1, pilot store#2, and pilot store#3 respectively.

The summarized data of the inventory are presented as monthly in the first column and in daily in the next. The product codes and names are not shown due to the company's confidentiality. For easy analysis, the inventory level is calculated and presented before and after implementing the proposed system at the pilot store#1, pilot store#2, and pilot store#3 and summarized as shown in table C.4, C.5, and C.6 respectively.

Table C.1 Summarized Inventory Level of Pilot Store#1 The data in column 'Before' are the inventory level using the ECR system and 'After' are the inventory level using the POS system.

Inventory Level (Pilot Store#1)									
Product		Before				After			
Code	Name	August, 1997		September, 1997		March, 1998		April, 1998	
	Medium Moving								
M01	*Not Shown*	437	14.10	352	11.73	404	13.03	393	13.10
M02	*Not Shown*	341	11.00	322	10.73	362	11.68	249	8.30
M03	*Not Shown*	260	8.39	268	8.93	294	9.48	278	9.27
M04	*Not Shown*	709	22.87	1010	33.67	1441	46.48	801	26.70
M05	*Not Shown*	1063	34.29	1574	52.47	1247	40.23	1173	39.10
M06	*Not Shown*	573	18.48	362	12.07	461	14.87	358	11.93
M07	*Not Shown*	619	19.97	618	20.60	902	29.10	556	18.53
M08	*Not Shown*	1332	42.97	2134	71.13	2311	74.55	1160	38.67
M09	*Not Shown*	2346	75.68	2070	69.00	2254	72.71	2092	69.73
M10	*Not Shown*	13142	423.94	11712	390.40	9797	316.03	12679	422.63
M11	*Not Shown*	14935	481.77	6102	203.40	12031	388.10	9131	304.37
M12	*Not Shown*	23611	761.65	24482	816.07	26422	852.32	18550	618.33
M13	*Not Shown*	4254	137.23	3826	127.53	3948	127.35	2111	70.37
M14	*Not Shown*	11277	363.77	6905	230.17	5917	190.87	4189	139.63
M15	*Not Shown*	4221	136.16	2246	74.87	3029	97.71	2578	85.93
	Slow Moving								
S01	*Not Shown*	437	14.10	259	8.63	344	11.10	224	7.47
S02	*Not Shown*	298	9.61	154	5.13	403	13.00	270	9.00
S03	*Not Shown*	357	11.52	383	12.77	323	10.42	383	12.77
S04	*Not Shown*	347	11.19	658	21.93	479	15.45	231	7.70
S05	*Not Shown*	354	11.42	253	8.43	316	10.19	251	8.37
S06	*Not Shown*	544	17.55	422	14.07	702	22.65	289	9.63
S07	*Not Shown*	1656	53.42	1778	59.27	1529	49.32	1159	38.63
S08	*Not Shown*	604	19.48	366	12.20	598	19.29	454	15.13
S09	*Not Shown*	299	9.65	228	7.60	396	12.77	317	10.57
S10	*Not Shown*	507	16.35	318	10.60	339	10.94	368	12.27
S11	*Not Shown*	356	11.48	260	8.67	351	11.32	270	9.00
S12	*Not Shown*	354	11.42	286	9.53	263	8.48	270	9.00
S13	*Not Shown*	483	15.58	575	19.17	365	11.77	598	19.93
S14	*Not Shown*	381	12.29	288	9.60	229	7.39	283	9.43
S15	*Not Shown*	273	8.81	213	7.10	684	22.06	371	12.37
	Fast Moving								
F01	*Not Shown*	2666	86.00	2226	74.20	2026	65.35	1836	61.20
F02	*Not Shown*	2641	85.19	2972	99.07	1638	52.84	1816	60.53
F03	*Not Shown*	2241	72.29	2480	82.67	1817	58.61	1741	58.03
F04	*Not Shown*	1959	63.19	2147	71.57	1427	46.03	1863	62.10
F05	*Not Shown*	1378	44.45	1303	43.43	1279	41.26	1193	39.77
F06	*Not Shown*	1174	37.87	1471	49.03	1385	44.68	1034	34.47
F07	*Not Shown*	1127	36.35	1676	55.87	1550	49.98	1406	46.87
F08	*Not Shown*	1172	37.81	1568	52.27	1381	44.55	1155	38.50
F09	*Not Shown*	898	28.97	1306	43.53	1167	37.65	874	29.13
F10	*Not Shown*	888	28.65	1026	34.20	858	27.68	921	30.70
F11	*Not Shown*	1651	53.26	1487	49.57	1361	43.90	1165	38.83
F12	*Not Shown*	1270	40.97	1399	46.63	1128	36.39	1117	37.23
F13	*Not Shown*	1479	47.71	1607	53.57	1479	47.71	1154	38.47
F14	*Not Shown*	901	29.06	861	28.70	846	27.29	757	25.23
F15	*Not Shown*	1085	35.00	774	25.80	662	21.35	748	24.93

Table C.2 Summarized Inventory Level of Pilot Store#2 The data in column 'Before' are the inventory level using the ECR system and 'After' are the inventory level using the POS system.

Inventory Level (Pilot Store#2)									
Product		Before				After			
Code	Name	August, 1997		September, 1997		March, 1998		April, 1998	
	Medium Moving								
M01	*Not Shown*	163	5.26	257	8.57	220	7.10	378	12.60
M02	*Not Shown*	250	8.06	216	7.20	224	7.23	254	8.47
M03	*Not Shown*	278	8.97	233	7.77	275	8.87	222	7.40
M04	*Not Shown*	310	10.00	363	12.10	267	8.61	252	8.40
M05	*Not Shown*	406	13.10	277	9.23	404	13.03	379	12.63
M06	*Not Shown*	167	5.39	208	6.93	217	7.00	111	3.70
M07	*Not Shown*	416	13.42	314	10.47	454	14.65	424	14.13
M08	*Not Shown*	829	26.74	568	18.93	1141	36.81	894	29.80
M09	*Not Shown*	928	29.94	764	25.47	954	30.77	827	27.57
M10	*Not Shown*	1282	41.35	1586	52.87	1476	47.61	875	29.17
M11	*Not Shown*	1842	59.42	1602	53.40	1676	54.06	1345	44.83
M12	*Not Shown*	3037	97.97	2397	79.90	2826	91.16	2689	89.63
M13	*Not Shown*	807	26.03	617	20.57	2832	91.35	1487	49.57
M14	*Not Shown*	1197	38.61	899	29.97	1472	47.48	2022	67.40
M15	*Not Shown*	372	12.00	243	8.10	242	7.81	478	15.93
	Slow Moving								
S01	*Not Shown*	335	10.81	380	12.67	333	10.74	316	10.53
S02	*Not Shown*	437	14.10	429	14.30	419	13.52	379	12.63
S03	*Not Shown*	654	21.10	509	16.97	668	21.55	487	16.23
S04	*Not Shown*	239	7.71	360	12.00	277	8.94	248	8.27
S05	*Not Shown*	661	21.32	484	16.13	226	7.29	347	11.57
S06	*Not Shown*	429	13.84	1006	33.53	1111	35.84	801	26.70
S07	*Not Shown*	560	18.06	407	13.57	458	14.77	376	12.53
S08	*Not Shown*	325	10.48	293	9.77	367	11.84	411	13.70
S09	*Not Shown*	507	16.35	593	19.77	304	9.81	500	16.67
S10	*Not Shown*	630	20.32	1375	45.83	665	21.45	480	16.00
S11	*Not Shown*	230	7.42	124	4.13	135	4.35	151	5.03
S12	*Not Shown*	1255	40.48	1889	62.97	480	15.48	1088	36.27
S13	*Not Shown*	695	22.42	850	28.33	422	13.61	360	12.00
S14	*Not Shown*	357	11.52	986	32.87	690	22.26	975	32.50
S15	*Not Shown*	374	12.06	332	11.07	239	7.71	210	7.00
	Fast Moving								
F01	*Not Shown*	2680	86.45	2040	68.00	1304	42.06	1084	36.13
F02	*Not Shown*	3719	119.97	2566	85.53	1138	36.71	977	32.57
F03	*Not Shown*	1862	60.06	1193	39.77	1259	40.61	1085	36.17
F04	*Not Shown*	1882	60.71	1112	37.07	1177	37.97	1269	42.30
F05	*Not Shown*	1455	46.94	843	28.10	1252	40.39	1007	33.57
F06	*Not Shown*	1106	35.68	775	25.83	783	25.26	625	20.83
F07	*Not Shown*	857	27.65	940	31.33	629	20.29	597	19.90
F08	*Not Shown*	777	25.06	472	15.73	502	16.19	576	19.20
F09	*Not Shown*	767	24.74	359	11.97	704	22.71	627	20.90
F10	*Not Shown*	1199	38.68	721	24.03	680	21.94	848	28.27
F11	*Not Shown*	1316	42.45	821	27.37	670	21.61	1152	38.40
F12	*Not Shown*	614	19.81	573	19.10	618	19.94	1814	60.47
F13	*Not Shown*	1082	34.90	552	18.40	606	19.55	1814	60.47
F14	*Not Shown*	615	19.84	174	5.80	713	23.00	1364	45.47
F15	*Not Shown*	541	17.45	100	3.33	693	22.35	929	30.97

Table C.3 Summarized Inventory Level of Pilot Store#3 The data in column 'Before' are the inventory level using the ECR system and 'After' are the inventory level using the POS system.

Inventory Level (Pilot Store#3)									
Product		Before				After			
Code	Name	August, 1997		September, 1997		March, 1998		April, 1998	
	Medium Moving								
M01	*Not Shown*	744	24.00	570	19.00	558	18.00	466	15.53
M02	*Not Shown*	483	15.58	425	14.17	594	19.16	615	20.50
M03	*Not Shown*	465	15.00	451	15.03	562	18.13	561	18.70
M04	*Not Shown*	433	13.97	327	10.90	723	23.32	403	13.43
M05	*Not Shown*	1334	43.03	1261	42.03	1079	34.81	1170	39.00
M06	*Not Shown*	647	20.87	924	30.80	1022	32.97	942	31.40
M07	*Not Shown*	433	13.97	491	16.37	759	24.48	877	29.23
M08	*Not Shown*	409	13.19	329	10.97	675	21.77	446	14.87
M09	*Not Shown*	295	9.52	240	8.00	280	9.03	255	8.50
M10	*Not Shown*	2803	90.42	2471	82.37	2402	77.48	2709	90.30
M11	*Not Shown*	2306	74.39	2297	76.57	2588	83.48	3222	107.40
M12	*Not Shown*	22780	734.84	21285	709.50	19894	641.74	20445	681.50
M13	*Not Shown*	1542	49.74	1774	59.13	2490	80.32	2547	84.90
M14	*Not Shown*	4668	150.58	4345	144.83	14386	464.06	3595	119.83
M15	*Not Shown*	1200	38.71	1686	56.20	1968	63.48	1804	60.13
	Slow Moving								
S01	*Not Shown*	378	12.19	395	13.17	508	16.39	271	9.03
S02	*Not Shown*	367	11.84	319	10.63	415	13.39	428	14.27
S03	*Not Shown*	368	11.87	247	8.23	422	13.61	418	13.93
S04	*Not Shown*	384	12.39	299	9.97	442	14.26	372	12.40
S05	*Not Shown*	256	8.26	216	7.20	264	8.52	206	6.87
S06	*Not Shown*	254	8.19	246	8.20	294	9.48	266	8.87
S07	*Not Shown*	252	8.13	249	8.30	252	8.13	295	9.83
S08	*Not Shown*	367	11.84	356	11.87	429	13.84	443	14.77
S09	*Not Shown*	300	9.68	305	10.17	467	15.06	549	18.30
S10	*Not Shown*	361	11.65	272	9.07	333	10.74	319	10.63
S11	*Not Shown*	332	10.71	315	10.50	442	14.26	361	12.03
S12	*Not Shown*	372	12.00	329	10.97	373	12.03	600	20.00
S13	*Not Shown*	372	12.00	337	11.23	384	12.39	630	21.00
S14	*Not Shown*	323	10.42	311	10.37	351	11.32	370	12.33
S15	*Not Shown*	301	9.71	320	10.67	389	12.55	316	10.53
	Fast Moving								
F01	*Not Shown*	3251	104.87	2679	89.30	2480	80.00	1656	55.20
F02	*Not Shown*	2433	78.48	2422	80.73	1929	62.23	1456	48.53
F03	*Not Shown*	2837	91.52	2852	95.07	1929	62.23	1513	50.43
F04	*Not Shown*	2207	71.19	2325	77.50	1621	52.29	1480	49.33
F05	*Not Shown*	2528	81.55	2340	78.00	1899	61.26	1617	53.90
F06	*Not Shown*	2440	78.71	2274	75.80	1612	52.00	1370	45.67
F07	*Not Shown*	2918	94.13	3537	117.90	2258	72.84	1818	60.60
F08	*Not Shown*	1970	63.55	1757	58.57	1698	54.77	1536	51.20
F09	*Not Shown*	1957	63.13	1660	55.33	1212	39.10	1418	47.27
F10	*Not Shown*	2024	65.29	1524	50.80	1540	49.68	1184	39.47
F11	*Not Shown*	2211	71.32	2221	74.03	1421	45.84	1626	54.20
F12	*Not Shown*	2184	70.45	1687	56.23	1451	46.81	1305	43.50
F13	*Not Shown*	4222	136.19	4017	133.90	2509	80.94	2764	92.13
F14	*Not Shown*	3296	106.32	2759	91.97	2094	67.55	1730	57.67
F15	*Not Shown*	2989	96.42	2402	80.07	1699	54.81	1744	58.13

Table C.4 Calculated Inventory Level of Pilot Store#1 The data in column 'Before' are the inventory level using the ECR system and 'After' are the inventory level using the POS system

Inventory Level (Pilot Store#1)			
Code	Name	Before	After
	Medium Moving		
M01	*Not Shown*	25.83	26.13
M02	*Not Shown*	21.73	19.98
M03	*Not Shown*	17.32	18.75
M04	*Not Shown*	56.54	73.18
M05	*Not Shown*	86.76	79.33
M06	*Not Shown*	30.55	26.80
M07	*Not Shown*	40.57	47.63
M08	*Not Shown*	114.10	113.22
M09	*Not Shown*	144.68	142.44
M10	*Not Shown*	814.34	738.67
M11	*Not Shown*	685.17	692.46
M12	*Not Shown*	1577.71	1470.66
M13	*Not Shown*	264.76	197.72
M14	*Not Shown*	593.94	330.50
M15	*Not Shown*	211.03	183.64
	Slow Moving		
S01	*Not Shown*	22.73	18.56
S02	*Not Shown*	14.75	22.00
S03	*Not Shown*	24.28	23.19
S04	*Not Shown*	33.13	23.15
S05	*Not Shown*	19.85	18.56
S06	*Not Shown*	31.62	32.28
S07	*Not Shown*	112.69	87.96
S08	*Not Shown*	31.68	34.42
S09	*Not Shown*	17.25	23.34
S10	*Not Shown*	26.95	23.20
S11	*Not Shown*	20.15	20.32
S12	*Not Shown*	20.95	17.48
S13	*Not Shown*	34.75	31.71
S14	*Not Shown*	21.89	16.82
S15	*Not Shown*	15.91	34.43
	Fast Moving		
F01	*Not Shown*	160.20	126.55
F02	*Not Shown*	184.26	113.37
F03	*Not Shown*	154.96	116.65
F04	*Not Shown*	134.76	108.13
F05	*Not Shown*	87.88	81.02
F06	*Not Shown*	86.90	79.14
F07	*Not Shown*	92.22	96.85
F08	*Not Shown*	90.07	83.05
F09	*Not Shown*	72.50	66.78
F10	*Not Shown*	62.85	58.38
F11	*Not Shown*	102.82	82.74
F12	*Not Shown*	87.60	73.62
F13	*Not Shown*	101.28	86.18
F14	*Not Shown*	57.76	52.52
F15	*Not Shown*	60.80	46.29

Table C.5 Calculated Inventory Level of Pilot Store#2 The data in column 'Before' are the inventory level using the ECR system and 'After' are the inventory level using the POS system

Inventory Level (Pilot Store#2)			
Code	Name	Before	After
	Medium Moving		
M01	*Not Shown*	13.82	19.70
M02	*Not Shown*	15.26	15.69
M03	*Not Shown*	16.73	16.27
M04	*Not Shown*	22.10	17.01
M05	*Not Shown*	22.33	25.67
M06	*Not Shown*	12.32	10.70
M07	*Not Shown*	23.89	28.78
M08	*Not Shown*	45.68	66.61
M09	*Not Shown*	55.40	58.34
M10	*Not Shown*	94.22	76.78
M11	*Not Shown*	112.82	98.90
M12	*Not Shown*	177.87	180.79
M13	*Not Shown*	46.60	140.92
M14	*Not Shown*	68.58	114.88
M15	*Not Shown*	20.10	23.74
	Slow Moving		
S01	*Not Shown*	23.47	21.28
S02	*Not Shown*	28.40	26.15
S03	*Not Shown*	38.06	37.78
S04	*Not Shown*	19.71	17.20
S05	*Not Shown*	37.46	18.86
S06	*Not Shown*	47.37	62.54
S07	*Not Shown*	31.63	27.31
S08	*Not Shown*	20.25	25.54
S09	*Not Shown*	36.12	26.47
S10	*Not Shown*	66.16	37.45
S11	*Not Shown*	11.55	9.39
S12	*Not Shown*	103.45	51.75
S13	*Not Shown*	50.75	25.61
S14	*Not Shown*	44.38	54.76
S15	*Not Shown*	23.13	14.71
	Fast Moving		
F01	*Not Shown*	154.45	78.20
F02	*Not Shown*	205.50	69.28
F03	*Not Shown*	99.83	76.78
F04	*Not Shown*	97.78	80.27
F05	*Not Shown*	75.04	73.95
F06	*Not Shown*	61.51	46.09
F07	*Not Shown*	58.98	40.19
F08	*Not Shown*	40.80	35.39
F09	*Not Shown*	36.71	43.61
F10	*Not Shown*	62.71	50.20
F11	*Not Shown*	69.82	60.01
F12	*Not Shown*	38.91	80.40
F13	*Not Shown*	53.30	80.02
F14	*Not Shown*	25.64	68.47
F15	*Not Shown*	20.78	53.32

Table C.6 Calculated Inventory Level of Pilot Store#3 The data in column 'Before' are the inventory level using the ECR system and 'After' are the inventory level using the POS system

Inventory Level (Pilot Store#3)			
Code	Name	Before	After
	Medium Moving		
M01	*Not Shown*	43.00	33.53
M02	*Not Shown*	29.75	39.66
M03	*Not Shown*	30.03	36.83
M04	*Not Shown*	24.87	36.76
M05	*Not Shown*	85.07	73.81
M06	*Not Shown*	51.67	64.37
M07	*Not Shown*	30.33	53.72
M08	*Not Shown*	24.16	36.64
M09	*Not Shown*	17.52	17.53
M10	*Not Shown*	172.79	167.78
M11	*Not Shown*	150.95	190.88
M12	*Not Shown*	1444.34	1323.24
M13	*Not Shown*	108.88	165.22
M14	*Not Shown*	295.41	583.90
M15	*Not Shown*	94.91	123.62
	Slow Moving		
S01	*Not Shown*	25.36	25.42
S02	*Not Shown*	22.47	27.65
S03	*Not Shown*	20.10	27.55
S04	*Not Shown*	22.35	26.66
S05	*Not Shown*	15.46	15.38
S06	*Not Shown*	16.39	18.35
S07	*Not Shown*	16.43	17.96
S08	*Not Shown*	23.71	28.61
S09	*Not Shown*	19.84	33.36
S10	*Not Shown*	20.71	21.38
S11	*Not Shown*	21.21	26.29
S12	*Not Shown*	22.97	32.03
S13	*Not Shown*	23.23	33.39
S14	*Not Shown*	20.79	23.66
S15	*Not Shown*	20.38	23.08
	Fast Moving		
F01	*Not Shown*	194.17	135.20
F02	*Not Shown*	159.22	110.76
F03	*Not Shown*	186.58	112.66
F04	*Not Shown*	148.69	101.62
F05	*Not Shown*	159.55	115.16
F06	*Not Shown*	154.51	97.67
F07	*Not Shown*	212.03	133.44
F08	*Not Shown*	122.12	105.97
F09	*Not Shown*	118.46	86.36
F10	*Not Shown*	116.09	89.14
F11	*Not Shown*	145.36	100.04
F12	*Not Shown*	126.68	90.31
F13	*Not Shown*	270.09	173.07
F14	*Not Shown*	198.29	125.22
F15	*Not Shown*	176.49	112.94

These sets of data of each pilot store consist of 15 items from each group of products : fast moving, slow moving and medium moving. For this situation where it is uncertain that the population is a normal distribution or not, the non-parametric statistic namely " Sign Test " is selected. This test is based on the number of " + " and " - " signs and performed in order to know whether there is a significant difference between the two population means. The sign test begins by specifying null hypothesis and alternative hypothesis for testing as the following :

H_0 = Assume there is no difference between population means of inventory level while using the POS system and the ECR system.

H_1 = Assume there is a difference between population means of inventory level while using the POS system and the ECR system.

X_{1i} = Inventory level of item number i while using the ECR system

X_{2i} = Inventory level of item number i while using the POS system

The difference in inventory level while using the ECR system and the POS system ($X_{2i} - X_{1i}$) indicated with the positive or negative signs are shown as follows :

Table C.7 Sign Test of Inventory Level of Each Representative Item at Pilot Store#1

The positive(+) sign shows that the inventory level of that item is increased.

The negative(-) sign shows that the service level of that item is decreased.

Zero (0) shows that the service level is not increased nor decreased.

Inventory Level (Pilot Store#1)				
Code	Name	Before	After	Sign Test
	Medium Moving			
M01	*Not Shown*	25.83	26.13	+
M02	*Not Shown*	21.73	19.98	-
M03	*Not Shown*	17.32	18.75	+
M04	*Not Shown*	56.54	73.18	+
M05	*Not Shown*	86.76	79.33	-
M06	*Not Shown*	30.55	26.80	-
M07	*Not Shown*	40.57	47.63	+
M08	*Not Shown*	114.10	113.22	-
M09	*Not Shown*	144.68	142.44	-
M10	*Not Shown*	814.34	738.67	-
M11	*Not Shown*	685.17	692.46	+
M12	*Not Shown*	1577.71	1470.66	-
M13	*Not Shown*	264.76	197.72	-
M14	*Not Shown*	593.94	330.50	-
M15	*Not Shown*	211.03	183.64	-
	Slow Moving			
S01	*Not Shown*	22.73	18.56	-
S02	*Not Shown*	14.75	22.00	+
S03	*Not Shown*	24.28	23.19	-
S04	*Not Shown*	33.13	23.15	-
S05	*Not Shown*	19.85	18.56	-
S06	*Not Shown*	31.62	32.28	+
S07	*Not Shown*	112.69	87.96	-
S08	*Not Shown*	31.68	34.42	+
S09	*Not Shown*	17.25	23.34	+
S10	*Not Shown*	26.95	23.20	-
S11	*Not Shown*	20.15	20.32	+
S12	*Not Shown*	20.95	17.48	-
S13	*Not Shown*	34.75	31.71	-
S14	*Not Shown*	21.89	16.82	-
S15	*Not Shown*	15.91	34.43	+
	Fast Moving			
F01	*Not Shown*	160.20	126.55	-
F02	*Not Shown*	184.26	113.37	-
F03	*Not Shown*	154.96	116.65	-
F04	*Not Shown*	134.76	108.13	-
F05	*Not Shown*	87.88	81.02	-
F06	*Not Shown*	86.90	79.14	-
F07	*Not Shown*	92.22	96.85	+
F08	*Not Shown*	90.07	83.05	-
F09	*Not Shown*	72.50	66.78	-
F10	*Not Shown*	62.85	58.38	-
F11	*Not Shown*	102.82	82.74	-
F12	*Not Shown*	87.60	73.62	-
F13	*Not Shown*	101.28	86.18	-
F14	*Not Shown*	57.76	52.52	-
F15	*Not Shown*	60.80	46.29	-

Table C.8 Sign Test of Inventory Level of Each Representative Item at Pilot Store#2

The positive(+) sign shows that the inventory level of that item is increased.

The negative(-) sign shows that the service level of that item is decreased.

Zero (0) shows that the service level is not increased nor decreased.

Inventory Level (Pilot Store#2)				
Code	Name	Before	After	Sign Test
	Medium Moving			
M01	*Not Shown*	13.82	19.70	+
M02	*Not Shown*	15.26	15.69	+
M03	*Not Shown*	16.73	16.27	-
M04	*Not Shown*	22.10	17.01	-
M05	*Not Shown*	22.33	25.67	+
M06	*Not Shown*	12.32	10.70	-
M07	*Not Shown*	23.89	28.78	+
M08	*Not Shown*	45.68	66.61	+
M09	*Not Shown*	55.40	58.34	+
M10	*Not Shown*	94.22	76.78	-
M11	*Not Shown*	112.82	98.90	-
M12	*Not Shown*	177.87	180.79	+
M13	*Not Shown*	46.60	140.92	+
M14	*Not Shown*	68.58	114.88	+
M15	*Not Shown*	20.10	23.74	+
	Slow Moving			
S01	*Not Shown*	23.47	21.28	-
S02	*Not Shown*	28.40	26.15	-
S03	*Not Shown*	38.06	37.78	-
S04	*Not Shown*	19.71	17.20	-
S05	*Not Shown*	37.46	18.86	-
S06	*Not Shown*	47.37	62.54	+
S07	*Not Shown*	31.63	27.31	-
S08	*Not Shown*	20.25	25.54	+
S09	*Not Shown*	36.12	26.47	-
S10	*Not Shown*	66.16	37.45	-
S11	*Not Shown*	11.55	9.39	-
S12	*Not Shown*	103.45	51.75	-
S13	*Not Shown*	50.75	25.61	-
S14	*Not Shown*	44.38	54.76	+
S15	*Not Shown*	23.13	14.71	-
	Fast Moving			
F01	*Not Shown*	154.45	78.20	-
F02	*Not Shown*	205.50	69.28	-
F03	*Not Shown*	99.83	76.78	-
F04	*Not Shown*	97.78	80.27	-
F05	*Not Shown*	75.04	73.95	-
F06	*Not Shown*	61.51	46.09	-
F07	*Not Shown*	58.98	40.19	-
F08	*Not Shown*	40.80	35.39	-
F09	*Not Shown*	36.71	43.61	+
F10	*Not Shown*	62.71	50.20	-
F11	*Not Shown*	69.82	60.01	-
F12	*Not Shown*	38.91	80.40	+
F13	*Not Shown*	53.30	80.02	+
F14	*Not Shown*	25.64	68.47	+
F15	*Not Shown*	20.78	53.32	+

Table C.9 Sign Test of Inventory Level of Each Representative Item at Pilot Store#3

The positive(+) sign shows that the inventory level of that item is increased.

The negative(-) sign shows that the service level of that item is decreased.

Zero (0) shows that the service level is not increased nor decreased.

Inventory Level (Pilot Store#3)				
Code	Name	Before	After	Sign Test
	Medium Moving			
M01	*Not Shown*	43.00	33.53	-
M02	*Not Shown*	29.75	39.66	+
M03	*Not Shown*	30.03	36.83	+
M04	*Not Shown*	24.87	36.76	+
M05	*Not Shown*	85.07	73.81	-
M06	*Not Shown*	51.67	64.37	+
M07	*Not Shown*	30.33	53.72	+
M08	*Not Shown*	24.16	36.64	+
M09	*Not Shown*	17.52	17.53	+
M10	*Not Shown*	172.79	167.78	-
M11	*Not Shown*	150.95	190.88	+
M12	*Not Shown*	1444.34	1323.24	-
M13	*Not Shown*	108.88	165.22	+
M14	*Not Shown*	295.41	583.90	+
M15	*Not Shown*	94.91	123.62	+
	Slow Moving			
S01	*Not Shown*	25.36	25.42	+
S02	*Not Shown*	22.47	27.65	+
S03	*Not Shown*	20.10	27.55	+
S04	*Not Shown*	22.35	26.66	+
S05	*Not Shown*	15.46	15.38	-
S06	*Not Shown*	16.39	18.35	+
S07	*Not Shown*	16.43	17.96	+
S08	*Not Shown*	23.71	28.61	+
S09	*Not Shown*	19.84	33.36	+
S10	*Not Shown*	20.71	21.38	+
S11	*Not Shown*	21.21	26.29	+
S12	*Not Shown*	22.97	32.03	+
S13	*Not Shown*	23.23	33.39	+
S14	*Not Shown*	20.79	23.66	+
S15	*Not Shown*	20.38	23.08	+
	Fast Moving			
F01	*Not Shown*	194.17	135.20	-
F02	*Not Shown*	159.22	110.76	-
F03	*Not Shown*	186.58	112.66	-
F04	*Not Shown*	148.69	101.62	-
F05	*Not Shown*	159.55	115.16	-
F06	*Not Shown*	154.51	97.67	-
F07	*Not Shown*	212.03	133.44	-
F08	*Not Shown*	122.12	105.97	-
F09	*Not Shown*	118.46	86.36	-
F10	*Not Shown*	116.09	89.14	-
F11	*Not Shown*	145.36	100.04	-
F12	*Not Shown*	126.68	90.31	-
F13	*Not Shown*	270.09	173.07	-
F14	*Not Shown*	198.29	125.22	-
F15	*Not Shown*	176.49	112.94	-

From the above table, the number of positive "+" and negative "-" signs of each product group in each store are counted and summarized as shown in the following :

Table C.10 Summary of Sign Test for Inventory Level

	Medium Moving		Slow Moving		Fast Moving	
	Positive Sign (+)	Negative Sign (-)	Positive Sign (+)	Negative Sign (-)	Positive Sign (+)	Negative Sign (-)
Store#1	5	10	6	9	1	14
Store#2	10	5	3	12	5	10
Store#3	11	4	14	1	0	15

Assumed that :

S(P) = The number of positive signs with the binomial distribution and the probability to succeed (positive sign) = 0.5

S(N) = The number of negative signs with the binomial distribution and the probability to succeed (negative sign) = 0.5

C = The critical value that make the probability of $S \geq C$

For Pilot Store #1

The medium moving products :

The number of positive signs (+) = 5

The number of negative signs (-) = 10

Sample size (n) = 15

By using 5% significant level, refer to the binomial distribution function while n = 15 and p = 0.5

Prob ($S \geq 10 / p = 0.5$) = 0.0916

Prob ($S \geq 11 / p = 0.5$) = 0.0417

For this case, C = 11 because it makes the probability nearest but not more than the significant level (0.05). It means for this case, H_0 is rejected and H_1 is accepted while the number of positive or negative signs S(P) ≥ 11 or S (N) ≥ 11

The number of positive signs (+) = 5

The number of negative signs (-) = 10

S(P) < 11 and S(N) < 11, that means H_0 is accepted or there is no difference between the population means of inventory level while using the POS system and the ECR system.

So the inventory level of this case is not significant to be increased or decreased.

The slow moving products :

The number of positive signs (+) = 6

The number of negative signs (-) = 9

Sample size (n) = 15

By using 5% significant level, refer to the binomial distribution function while n = 15 and p = 0.5

Prob ($S \geq 10 / p = 0.5$) = 0.0916

Prob ($S \geq 11 / p = 0.5$) = 0.0417

For this case, C = 11 because it makes the probability nearest but not more than significant level (0.05). It means for this case, H_0 is rejected and H_1

is accepted while the number of positive or negative signs S(P) $\geq$ 11 or S(N) $\geq$ 11

The number of positive signs (+) = 6

The number of negative signs (-) = 9

S(P) < 11 and S(N) < 11, that means H_0 is accepted or there is no difference between the population means of inventory level while using the POS system and the ECR system.

So the inventory level of this case is not significant to be increased or decreased.

The fast moving products :

The number of positive signs (+) = 1

The number of negative signs (-) = 14

Sample size (n) = 15

By using 5% significant level, refer to the binomial distribution function while n = 15 and p = 0.5

Prob (S $\geq$ 10 / p = 0.5) = 0.0916

Prob (S $\geq$ 11 / p = 0.5) = 0.0417

For this case, C = 11 because it makes the probability nearest but not more than the significant level (0.05). It means for this case, H_0 is rejected and H_1 is accepted while the number of positive or negative signs S(P) $\geq$ 11 or S (N) $\geq$ 11

The number of positive signs (+) = 1

The number of negative signs (-) = 14

S(P) < 11 but S(N) > 11, that means H_0 is rejected or there is a difference between the population means of inventory level while using the POS system and the ECR system.

So the inventory level of this case is significant to be decreased.

For Pilot Store #2

The medium moving products :

The number of positive signs (+) = 10

The number of negative signs (-) = 5

Sample size (n) = 15

By using 5% significant level, refer to the binomial distribution function while n = 15 and p = 0.5

Prob ($S \geq 10 / p = 0.5$) = 0.0916

Prob ($S \geq 11 / p = 0.5$) = 0.0417

For this case, C = 11 because it makes the probability nearest but not more than the significant level (0.05). It means for this case, H_0 is rejected and H_1 is accepted while the number of positive or negative signs S(P) $\geq$ 11 or S (N) $\geq$ 11

The number of positive signs (+) = 10

The number of negative signs (-) = 5

S(P) < 11 and S(N) < 11, that means H_0 is accepted or there is no difference between the population means of inventory level while using the POS system and the ECR system.

So the inventory level of this case is not significant to be increased or decreased.

The slow moving products :

The number of positive signs (+) = 3

The number of negative signs (-) = 12

Sample size (n) = 15

By using 5% significant level, refer to the binomial distribution function while $n = \bar{1}5$ and $p = 0.5$

Prob ($S \geq 10 / p = 0.5$) = 0.0916

Prob ($S \geq 11 / p = 0.5$) = 0.0417

For this case, C = 11 because it makes the probability nearest but not more than the significant level (0.05). It means for this case, H_0 is rejected and H_1 is accepted while the number of positive or negative signs $S(P) \geq 11$ or $S(N) \geq 11$

The number of positive signs (+) = 3

The number of negative signs (-) = 12

S(P) < 11 but S(N) > 11, that means H_0 is rejected or there is a difference between the population means of inventory level while using the POS system and the ECR system.

So the inventory level of this case is significant to be decreased.

The fast moving products :

The number of positive signs (+) = 5

The number of negative signs (-) = 10

Sample size (n) = 15

By using 5% significant level, refer to the binomial distribution function while n = 15 and p = 0.5

Prob ($S \geq 10 / p = 0.5$) = 0.0916

Prob ($S \geq 11 / p = 0.5$) = 0.0417

For this case, C = 11 because it makes the probability nearest but not more than the significant level (0.05). It means for this case, H_0 is rejected and H_1 is accepted while the number of positive or negative signs $S(P) \geq 11$ or $S(N) \geq 11$

The number of positive signs (+) = 5

The number of negative signs (-) = 10

$S(P) < 11$ and $S(N) < 11$, that means H_0 is accepted or there is no difference between the population means of inventory level while using the POS system and the ECR system.

So the inventory level of this case is not significant to be increased or decreased.

For Pilot Store #3

The medium moving :

The number of positive sign (+) = 11

The number of negative sign (-) = 4

Sample size (n) = 15

By using 5% significant level, refer to the binomial distribution function while n = 15 and p = 0.5

Prob ($S \geq 10 / p = 0.5$) = 0.0916

Prob ($S \geq 11 / p = 0.5$) = 0.0417

For this case, C = 11 because it makes the probability nearest but not more than the significant level (0.05). It means for this case, H_0 is rejected and H_1 is accepted while the number of positive or negative signs $S(P) \geq 11$ or $S(N) \geq 11$

The number of positive signs (+) = 11

The number of negative signs (-) = 4

S(P) = 11 and S(N) < 11, that means H_0 is rejected or there is a difference between the population means of inventory level while using the POS system and the ECR system.

So the inventory level of this case is significant to be increased.

The slow moving products :

The number of positive signs (+) = 14

The number of negative signs (-) = 1

Sample size (n) = 15

By using 5% significant level, refer to the binomial distribution function while n = 15 and p = 0.5

Prob ($S \geq 10 / p = 0.5$) = 0.0916

Prob ($S \geq 11 / p = 0.5$) = 0.0417

For this case, C = 11 because it makes the probability nearest but not more than the significant level (0.05). It means for this case, H_0 is rejected and H_1 is accepted while the number of positive or negative signs $S(P) \geq 11$ or $S(N) \geq 11$

The number of positive signs (+) = 14

The number of negative signs (-) = 1

$S(\bar{P}) > 11$ and $S(N) < 11$, that means H_0 is rejected or there is a difference between the population means of inventory level while using the POS system and the ECR system.

So the inventory level of this case is not significant to be increased.

The fast moving products :

The number of positive signs (+) = 0

The number of negative signs (-) = 15

Sample size (n) = 15

By using 5% significant level, refer to the binomial distribution function while n = 15 and p = 0.5

Prob ($S \geq 10 / p = 0.5$) = 0.0916

Prob ($S \geq 11 / p = 0.5$) = 0.0417

For this case, C = 11 because it makes the probability nearest but not more than the significant level (0.05). It means for this case, H_0 is rejected and H_1 is accepted while the number of positive or negative signs S(P) $\geq$ 11 or S (N) $\geq$ 11

The number of positive signs (+) = 0

The number of negative signs (-) = 15

S(P) < 11 but S(N) > 11, that means H_0 is rejected or there is a difference between the population means of inventory level while using the POS system and the ECR system.

So the inventory level of this case is not significant to be decreased.

The results of sign test are summarized and shown again in table C.11 as follows :

Table C.11 Summarized Sign Test Results for Inventory Level

	Inventory Level		
	Medium Moving	***Slow Moving***	***Fast Moving***
Pilot Store#1	Not Significant	Not Significant	Decreased
Pilot Store#2	Not Significant	Decreased	Not Significant
Pilot Store#3	Increased	Increased	Decreased

APPENDIX D

Cost Work Sheets for POS System

Cost Work Sheets for POS System

Hardware Estimated One -Time Costs

Hardware:

_____ Personal computers (or controllers) needed at store level _____

_____ Personal computers needed at headquarters _____

_____ Total personal computers at ____ $ _____ ea .____=$ _____

_____ Cost of upgrading current equipment _=$_____

_____ Printers needed at store level _____

_____ Printers needed at headquarters level _____

_____ Total printers at _____ $ _____ ea .____ _____

_____ Stores needing 1 Point of Sales terminal _____x 1_____ _____

_____ Stores needing 2 Point of Sales terminal _____x 2_____ _____

_____ Stores needing 3 Point of Sales terminal _____x 3_____ _____

_____ Total point-of-sale terminals at ___$ _____ _ ea . _____ _=$_____

_____ Modems needed at store level _____

_____ Modems needed at headquarters level _____

_____ Total modems needed at _____$ _____ ea .____ __=$_____

Other Hardware:

_____ _____

_____ _____

_____ _=$_____

Hardware maintenance agreement: _____ _____

_____ One-time _____ _____

TOTAL HARDWARE COSTS:_____ _=$ _____

Cost Work Sheets for POS System

Software and Other Estimated One -Time Costs

Software _____ _=$_____

Software maintenance agreement : _____ _____

One-time _____ _=$ _____

Modification, testing, and installation : _____ _____

One-time _____ _____

_____ _____

_____ _=$ _____

Computer use, systems testing : _____ _____

One-time _____ _=$_____

_____ _____

TOTAL SOFTWARE COSTS: _____ _=$_____

Telecommunications: _____ _____

One-time _____ _=$_____

_____ New phone lines at $ _____ ea. _____ _=$_____

Technical services, help desk : _____ _____

One-time _____ _=$_____

Installation, including preparation of facilities : _____ _____

One-time _____ _=$ _____

Supplies : _____ =$ _____ _____

_____ =$ _____ _____

_____ =$ _____ _____

TOTAL OTHER COSTS : _____ _=$ _____

Cost Work Sheets for POS System

Personal and Training Estimated One-Time Costs

Personnel : _____ _____

Business design analysis : _____ _=$_____

Development support : _____ _=$_____

Training : _____ _____

_____ $ _____ per store clerk X # of clerks _____=$ _____ _____

_____ $ _____ per store manager X # of manager _____=$ _____ _____

_____ $ _____ for headquarters _____=$ _____

Total training : _____ _=$ _____

_____

TOTAL PERSONNEL AND TRAINING COSTS: _____ _=$_____

_____

TOTAL ESTIMATES ONE-TIME COSTS OF IMPLEMENTING SYSTEM : __=$ ___

Cost Work Sheets for POS System

Estimated On-going Costs

Computer use, systems testing: _____

Ongoing _____ =$ _____

Communications : _____

Ongoing _____ =$ _____

Technical services, help desk : _____

Ongoing _____ =$ _____

Software upgrades : _____

_____ =$ _____

Lease payments and software license : _____

_____ =$ _____

Training : _____

Annual salaries and benefits of trainer 1 _____ =$ _____

Annual salaries and benefits of trainer 2 _____ =$ _____

Annual salaries and benefits of trainer 3 _____ =$ _____

Annual salaries and benefits of etc. _____ =$ _____

Other ongoing annual : _____

_____

_____

_____ =$ _____

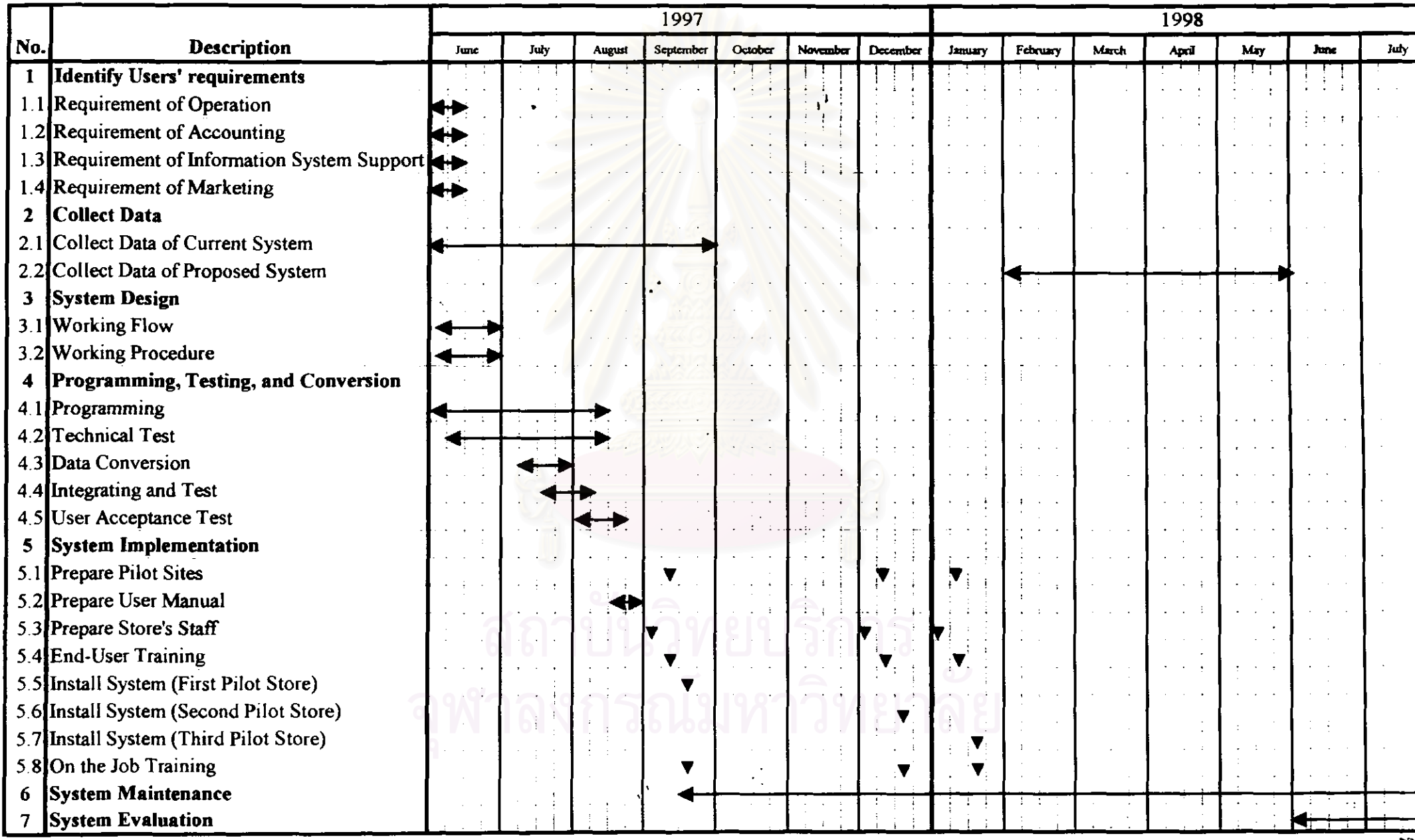
_____

TOTAL ESTIMATED ON-GOING ANNUAL COSTS : _____ =$ _____

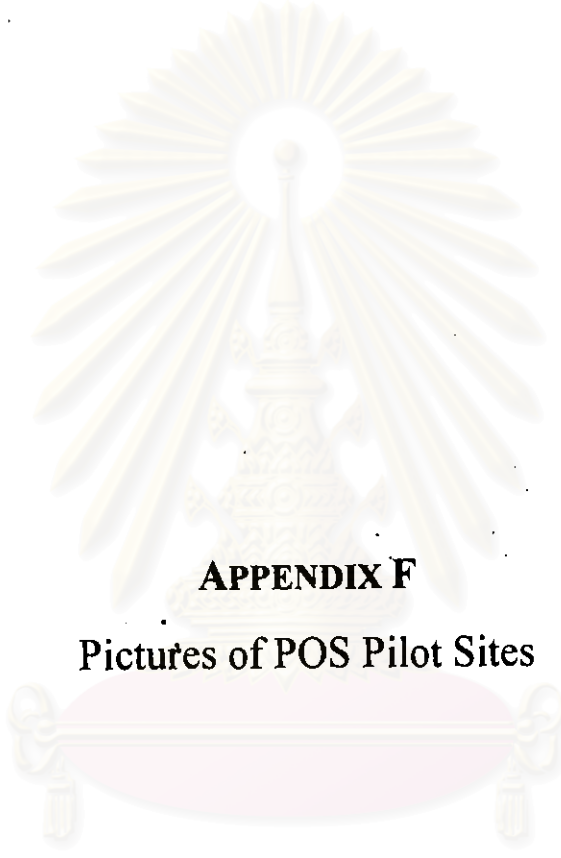
APPENDIX E

POS Pilot Project Schedule

POS PILOT PROJECT
SCHEDULE



No.	Description
1	**Identify Users' requirements**
1.1	Requirement of Operation
1.2	Requirement of Accounting
1.3	Requirement of Information System Support
1.4	Requirement of Marketing
2	**Collect Data**
2.1	Collect Data of Current System
2.2	Collect Data of Proposed System
3	**System Design**
3.1	Working Flow
3.2	Working Procedure
4	**Programming, Testing, and Conversion**
4.1	Programming
4.2	Technical Test
4.3	Data Conversion
4.4	Integrating and Test
4.5	User Acceptance Test
5	**System Implementation**
5.1	Prepare Pilot Sites
5.2	Prepare User Manual
5.3	Prepare Store's Staff
5.4	End-User Training
5.5	Install System (First Pilot Store)
5.6	Install System (Second Pilot Store)
5.7	Install System (Third Pilot Store)
5.8	On the Job Training
6	**System Maintenance**
7	**System Evaluation**



APPENDIX F

Pictures of POS Pilot Sites

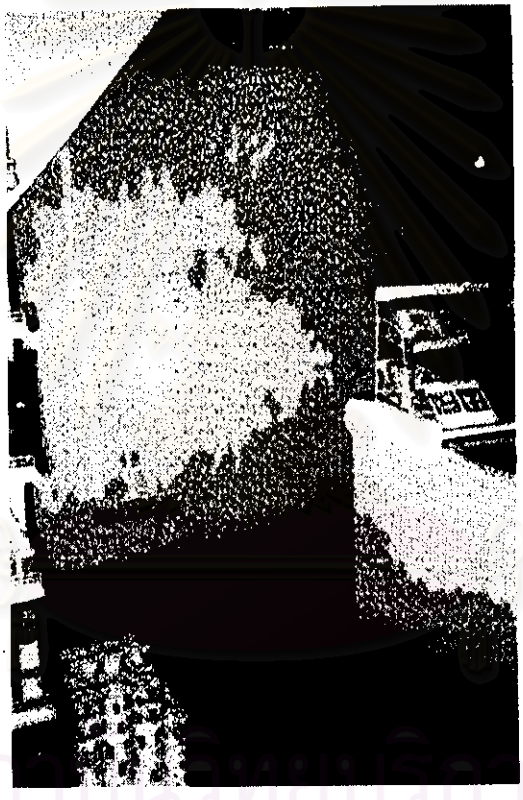


Figure F.1 Space for Store Controller at the Pilot Store

Figure F.2 Store Controller Room

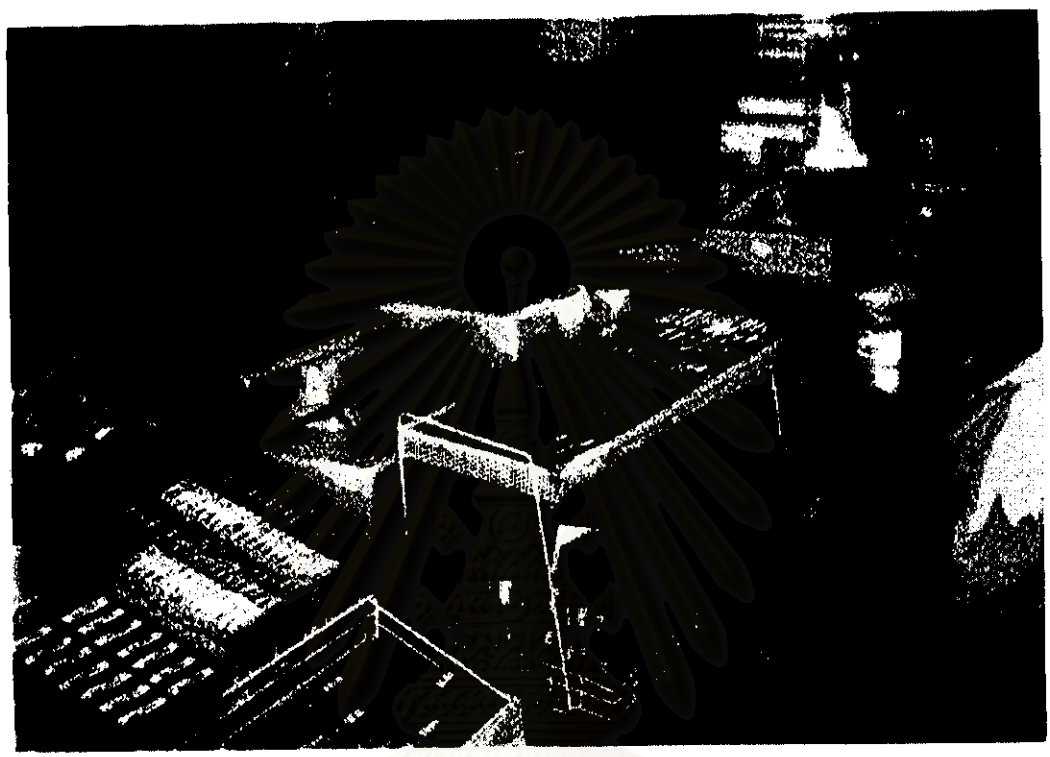


Figure F.3 Electronic Cash Register with Candy Shelves

Figure F.4 Point of Sales without Candy Shelf

Figure F.5 Additional Electrical Outlets for Store Controller

Figure F.6 Local Area Network Cable Installation

Figure F.7 Telephone Line Preparation

Figure F.8 Working Environment of Store Controller Room

APPENDIX G

POS Hardware Specification

The hardware for POS pilot project of the case study at the pilot store consists of a set of store controller terminal and two or three sets of Point of Sales Terminal depend on the number of customer. The specification of those hardware are shown as the following :

One set of Store Controller Terminal consists of :

1 Personal Computer (Pentium 120)

1 UPS 500 VA

1 Hub 8 Port

1 LAN Card

One set of Point of Sales Terminal consists of :

1 Beetle 5L

- Pentium 133 MHz., Memory 16 MB
- Hard disk 1.2 GB., FD 3.5" 1.44 MB

1 External Printer ND69

- Journal/ Receipt/ A4 Document

1 Alpha/ POS Keyboard TA57

1 Monitor Mono 9"

1 Cash Drawer KA14

1 Customer Display BA63

1 UPS 500 VA

1 LAN Card

VITA

Santichai CHALAKULPUTTI was born on April 23, 1972 in Sisaket, Thailand. He obtained his Bachelor's Degree in Industrial Engineering from Chulalongkorn University in 1993 academic year. He continued his graduate study in Engineering Management at the Regional Centre for Manufacturing System Engineering at the same university in 1996.

He has been working with CP. Seven-Eleven Co., Ltd. since 1995 as a Project Engineer, Assistant Manager, and Section Manager of Innovation and Technology Department respectively. He is fully responsible for projects management, and has been closely involved with the POS (Point of Sales) pilot project from the very beginning to its completion.