Quantitative Models for Inventory and Production Planning in Closed-Loop Supply Chains[1]

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March 2009

Submitted for publication.

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[1]This research was supported by NSF Grants CMMI-0522960 and CMMI-0522980.

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Appendix: Summary of Work on I&PP

The existing works on deterministic I&PP models, reviewed in Section 4, are summarized in Tables A.1, A.2, and A.3, whereas the stochastic I&PP models, reviewed in Section 5, are summarized in Tables A.4 and A.5. In these tables, we identify the paper and the system setting in the first and second columns, respectively. We list the decision variables for each model in the third column. We note that the specific decisions of interest for I&PP relate to the specification of the operating parameters for the inventory and production control policy which designates the following:

- when and how much to manufacture,
- when and how much to remanufacture, and
- when and how much to dispose of.

We give the basic modeling assumptions and the objective function in the fourth and the fifth columns, respectively. Finally, the solution approach is noted in the sixth column.

Table A.1: Summary of existing work on constant demand I&PP models.

Paper	System	Inventory control policy (decisions)	Model characteristics	Objective function	Solution approach
Schrady [94]	Single-item CLSC-2SP-a	$(m = 1, q_m, r, q_r, b = 0)$	Infinite horizon Infinite manufacturing rate Infinite remanufacturing rate Stockouts not allowed Disposal not allowed $q_m, r, q_r \geq 0$	Minimize the average total cost considering manufacturing and remanufacturing setup costs along with linear inventory holding (in UII and MRII) disposal costs	Continuous optimization
Mabini et al. [70]	Single-item CLSC-2SP-a	$(m = 1, q_m, r, q_r, b)$	Infinite horizon Infinite manufacturing rate Infinite remanufacturing rate Backorders allowed Disposal not allowed $q_m, q_r, r \geq 0$	Minimize the average total cost considering manufacturing and remanufacturing setup costs along with linear inventory holding (in UII and MRII) backordering costs	Continuous optimization
Teunter [106]	Single-item CLSC-2SP-a	$(m = 1, q_m, r, q_r, b = 0)$ $(m, q_m, r = 1, q_r, b = 0)$ Disposal rate	Infinite horizon Infinite manufacturing rate Infinite remanufacturing rate Stockouts not allowed Disposal allowed $m, q_m, r, q_r \geq 0$	Minimize the average total cost considering manufacturing and remanufacturing setup costs along with linear inventory holding (in UII and MRII distinguishing between manufactured and remanufactured items) disposal costs	Continuous optimization
Nahmias & Rivera [77]	Single-item CLSC-2SP-a	$(m = 1, q_m, r, q_r, b = 0)$	Infinite horizon Infinite manufacturing rate Finite remanufacturing rate Stockouts not allowed Disposal not allowed $q_m, r, q_r \geq 0$	Minimize the average total cost considering manufacturing and remanufacturing setup costs along with linear inventory holding (in UII and MRII) costs	Continuous optimization
Koh et al. [63]	Single-item CLSC-2SP-a	$(m = 1, q_m, r, q_r, b = 0)$ $(m, q_m, r = 1, q_r, b = 0)$	Infinite horizon Infinite manufacturing rate Finite remanufacturing rate Stockouts not allowed Disposal not allowed $q_m, r, q_r \geq 0$ $m, q_m, q_r \geq 0$	Minimize the average total cost considering manufacturing and remanufacturing setup costs along with linear inventory holding (in UII and MRII) costs	Continuous optimization
Teunter [65, 108]	Single-item CLSC-2SP-a	$(m = 1, q_m, r, q_r, b = 0)$ $(m, q_m, r = 1, q_r, b = 0)$	Infinite horizon Finite manufacturing rate Finite remanufacturing rate Stockouts not allowed Disposal not allowed $q_m, q_r \geq 0$ and $r \in Z^+$ $q_m, q_r \geq 0$ and $m \in Z^+$	Minimize the average total cost considering manufacturing and remanufacturing setup costs along with linear inventory holding (in UII and MRII) and disposal costs	Continuous optimization and heuristic rounding

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Table A.1 – Continued

Paper	System	Inventory control policy (decisions)	Model characteristics	Objective function	Solution approach
Dobos & Richter [20], Richter & Dobos [87]	Single-item CLSC-2SP-a	$(m, q_m, r, q_r, b = 0)$ Disposal rate	Infinite horizon Finite manufacturing rate Finite remanufacturing rate Stockouts not allowed Disposal allowed $m, q_m, r, q_r \geq 0$	Minimize the average total cost considering manufacturing and remanufacturing setup costs along with linear inventory holding (in UII and MRII), manufacturing, acquisition, remanufacturing, and disposal costs	Continuous optimization
Konstantaras & Papachristos [64]	Single-item CLSC-2SP-a	$(m = 1, q_m, r, q_r, b = 0)$ $(m, q_m, r = 1, q_r, b = 0)$	Infinite horizon Infinite manufacturing rate Finite remanufacturing rate Backorders allowed Disposal not allowed $q_m, q_r \geq 0$ and $r \in Z^+$ $q_m, q_r \geq 0$ and $m \in Z^+$	Minimize the average total cost considering manufacturing and remanufacturing setup costs along with linear inventory holding (in UII and MRII) and backordering costs	Continuous optimization and integer search
Teunter & van der Laan [104]	Single-item CLSC-2SP-a	(q_m, q_r, d_0)	Infinite horizon Infinite manufacturing rate Infinite remanufacturing rate Stockouts not allowed Disposal not allowed $q_m, q_r, d_0 \geq 0$	Minimize the average (or discounted) total cost considering manufacturing and remanufacturing setup costs along with linear inventory holding (in UII and MRII distinguishing between manufactured and remanufactured items) and disposal costs	Continuous optimization
Minner & Lindner [73]	Single-item CLSC-2SP-a	$(m, \overrightarrow{t}, r, \overrightarrow{t}')$	Infinite horizon Infinite manufacturing rate Infinite remanufacturing rate Stockouts not allowed Disposal not allowed $\overrightarrow{t}_m, \overrightarrow{t'}_r \geq 0$ and $m, r \in Z^+$	Minimize the average (or discounted) total cost considering manufacturing and remanufacturing setup costs along with linear inventory holding (in UII and MRII) costs	Continuous optimization and integer search
Tang & Teunter [102] Teunter et al. [103]	Multi-item CLSC-2SP-a	$(\overrightarrow{\tau}, \overrightarrow{\tau}')$	Infinite horizon Finite manufacturing rate Finite remanufacturing rate Manufacturing setup time Remanufacturing setup time Stockouts not allowed Disposal not allowed $q_m, q_r \geq 0$	Minimize the average total cost considering manufacturing and remanufacturing setup costs along with linear inventory holding (in UII and MRII) costs	Commercial software [102] Heuristic [103]
Mabini et al. [70]	Multi-item CLSC-2SP-a	$(m = 1, q_m, r, q_r, b = 0)$	Infinite horizon Infinite manufacturing rate Finite remanufacturing rate Remanufacturing setup time Limited remanufacturing capacity Stockouts not allowed Disposal not allowed $q_m, r, q_r \geq 0$	Minimize the average total cost considering manufacturing and remanufacturing setup costs along with linear inventory holding (in UII-i and MRII-i), remanufacturing, and disposal costs	Continuous optimization

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Table A.1 – Continued

Paper	**System**	**Inventory control policy (decisions)**	**Model characteristics**	**Objective function**	**Solution approach**
Richter [83, 84, 85]	Single-item CLSC-3SP-a	(m, q_m, r, q_r, q_s) Disposal rate	Infinite horizon Infinite manufacturing rate Infinite remanufacturing rate Stockouts not allowed Disposal allowed $m, q_m, r, q_r, q_s \geq 0$ and $q_s = rq_r$	Minimize the average total cost considering manufacturing and remanufacturing setup costs along with linear inventory holding (in UII and MRII), manufacturing, acquisition, remanufacturing, and disposal costs	Continuous optimization
Richter & Dobos [86]	Single-item CLSC-3SP-a	(m, q_m, r, q_r, q_s) Disposal rate	Infinite horizon Infinite manufacturing rate Infinite remanufacturing rate Stockouts not allowed Disposal allowed $q_m, q_r, q_s \geq 0$, $q_s = rq_r$, and $m, r \in Z^+$	Minimize the average total cost considering manufacturing and remanufacturing setup costs along with linear inventory holding (in UII and MRII), manufacturing, acquisition, remanufacturing, and disposal costs	Continuous optimization
Atasu & Çetinkaya [3]	Single-item CLSC-3SP-a	$(1, q_m, r, q_r, q_s)$	Finite horizon Finite manufacturing rate Infinite remanufacturing rate $q_m, q_r, q_s \geq 0$, $q_s = q_r$, and $r \in Z^+$	Minimize the average total cost considering manufacturing and remanufacturing setup costs along with linear inventory holding (in UII and MRII) costs	Continuous optimization and integer search
Çorbacıoğlu & van der Laan [13]	Two-item CLSC-3SP-d	$(q_{m1}, q_{r1}, q_{m2}, q_{r2})$	Infinite horizon Infinite manufacturing rate Infinite remanufacturing rate Stockouts not allowed Disposal not allowed $q_{m1}, q_{m2}, q_{r1}, q_{r2} \geq 0$	Minimize the average (or discounted cash flow associated with) total cost considering manufacturing and remanufacturing setup costs along with linear inventory holding (in UII, MRII-1, and MRII-2) costs	Continuous optimization

Table A.2: Summary of existing work on dynamic deterministic continuous time I&PP models.

Paper	**System**	**Inventory control policy (decisions)**	**Model characteristics**	**Objective function**	**Solution approach**
Minner & Kleber [72]	Single-item CLSC-2SP-b	$(d(t), m(t), r(t))$	Finite horizon Zero mfg. and rmfg. LT[1] Stockouts not allowed Disposal allowed	Minimize the total cost considering linear manufacturing, remanufacturing, inventory holding (in UII and MRII), and disposal costs	Optimal control
Kiesmüller [56]	Single-item CLSC-2SP-b	$(d(t), m(t), r(t))$	Finite horizon Constant mfg. and rmfg. LT Backordering allowed Disposal allowed	Minimize the total cost considering linear manufacturing, remanufacturing, inventory holding (in UII and MRII), backordering, and disposal costs	Optimal control
Dobos [19]	Single-item CLSC-2SP-b	$(d(t), m(t), r(t))$	Finite horizon Zero mfg. and rmfg. LT Stockouts not allowed Disposal allowed	Minimize the total cost considering quadratic manufacturing, remanufacturing, inventory holding (in UII and MRII), and disposal costs	Optimal control
Kleber at al. [61]	Multi-item CLSC-MSP-a	$(d(t), \overrightarrow{m}(t), \overrightarrow{r}(t))$	Finite horizon Zero mfg. and rmfg. LT Stockouts not allowed Disposal allowed	Minimize the total cost considering linear manufacturing, remanufacturing, inventory holding (in UII and MRII-i) and disposal costs	Optimal control

[1] Lead time.

Table A.3: Summary of existing work on dynamic deterministic discrete time I&PP models.

Paper	System	Inventory control policy (decisions)	Model characteristics	Objective function	Solution approach
Richter & Sombrutzki [89] Richter & Weber [90]	Single-item CLSC-2SP-a	$(\vec{q}_r)$	Finite horizon Uncapacitated Stockouts not allowed Disposal not allowed	Minimize the sum of fixed remanufacturing setup and linear inventory holding (in UII and MRII) costs	Dynamic programming for a special case[a]
Richter & Sombrutzki [89]	Single-item CLSC-2SP-b	$(\vec{q}_m, \vec{q}_r)$	Finite horizon Uncapacitated Stockouts not allowed Disposal not allowed	Minimize the sum of fixed manufacturing and remanufacturing setup and linear manufacturing, remanufacturing, and inventory holding (in UII and MRII) costs	Dynamic programming for a special case[b]
Richter & Weber [90]	Single-item CLSC-2SP-b	$(\vec{q}_m, \vec{q}_r)$	Finite horizon Uncapacitated Stockouts not allowed Disposal not allowed	Minimize the sum of fixed manufacturing and remanufacturing setup and linear manufacturing, remanufacturing, inventory holding (in UII and MRII), and disposal costs	Dynamic programming for a special case[b]
Richter & Gobsch [88]	Single-item CLSC-2SP-c	$(\vec{q}_n, \vec{q}_m, \vec{q}_r)$	Finite horizon Uncapacitated Stockouts not allowed Disposal not allowed	Minimize the sum of fixed manufacturing and remanufacturing setup and linear used item acquisition, new material purchase, manufacturing, remanufacturing, and inventory holding (in NMI, UII, and MRII) costs	Dynamic programming for two special cases [c]
Beltrán & Krass [8]	Single-item CLSC-1SP-a	$(\vec{q}_m, \vec{q}_d)$	Finite horizon Uncapacitated Stockouts not allowed Disposal allowed	Minimize the sum of piecewise differentiable, concave manufacturing, inventory holding, and disposal costs	Dynamic programming
Golany et al. [36, 37]	Single-item CLSC-2SP-b	$(\vec{q}_m, \vec{q}_r, \vec{q}_d)$	Finite horizon Uncapacitated Stockouts not allowed Disposal allowed	Minimize the sum of general concave manufacturing, remanufacturing, inventory holding, and disposal costs	NP-hard when all costs are general concave Polynomial time solution when all costs are linear
Yang et al. [126]	Single-item CLSC-2SP-b	$(\vec{q}_m, \vec{q}_r, \vec{q}_d)$	Finite horizon Uncapacitated Stockouts not allowed Disposal allowed	Minimize the sum of stationary concave manufacturing, remanufacturing, inventory holding, and disposal costs	NP-hard when all costs are stationary concave A pseduo-polynomial time DP algorithm A heuristic based on the DP algorithm
Teunter et al. [109]	Single-item CLSC-2SP-b	$(\vec{q}_m, \vec{q}_r)$	Finite horizon Uncapacitated Stockouts not allowed Disposal not allowed	Minimize the sum of fixed manufacturing and remanufacturing setup and linear inventory holding (in UII and MRII) costs	Dynamic programming and heuristics for a special case[d] Heuristics for the general case
Pan et al. [80]	Single-item CLSC-2SP-b	$(\vec{q}_m, \vec{q}_r, \vec{q}_d)$	Finite horizon Capacitated Stockouts not allowed Disposal allowed	Minimize the sum of concave manufacturing, remanufacturing, inventory holding, and disposal costs	Dynamic programming

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Table A.3 – Continued

Paper	System	Inventory control policy (decisions)	Model characteristics	Objective function	Solution approach
Li et al. [67]	Two-item CLSC-MSP-b	$(\overrightarrow{q}_m, \overrightarrow{q}_r, \overrightarrow{q}_e, \overrightarrow{q}_{ij},)$	Finite horizon Capacitated Downward substitution Emergency procurements Stockouts not allowed Disposal not allowed	Minimize the sum of fixed manufacturing and remanufacturing setup and linear emergency procurement, manufacturing, remanufacturing, inventory holding (in UII-i and MRII-i), and substitution costs [e]	Hybrid genetic algorithm and dynamic programming approach
Li et al. [68]	Multi-item CLSC-MSP-b	$(\overrightarrow{q}_m, \overrightarrow{q}_r, \overrightarrow{q}_{ij})$	Finite horizon Uncapacitated Downward substitution Stockouts not allowed Disposal not allowed	Minimize the sum of fixed manufacturing and remanufacturing setup and linear inventory holding (in UII-i and MRII-i) and substitution costs	Dynamic programming for a special case[a] 2-stage heuristic approach for the general case

[a] Cumulative returns exceed cumulative demand throughout the planning horizon.
[b] Infinite supply of returns in the first period.
[c] Case 1: No inventory held in NMI and UII. Case 2: No inventory held in MRII.
[d] Joint setup-cost for manufacturing and remanufacturing.
[e] Unit substitution cost is assumed to be zero.

Table A.4: Summary of existing work on stochastic continuous review I&PP models.

Paper	System	Inventory control policy (decisions)	Model characteristics	Objective function	Solution approach
Heyman [47]	Single-item CLSC-1SP-a	$(r_m = -1, q_m = 1, d_m)$	Infinite horizon Exponential demand interarrival Exponential return interarrival indep. of demand Zero mfg. and rmfg. LT Stockouts not allowed Disposal allowed	Minimize expected discounted total cost (or long-run average cost per unit time) to include linear manufacturing, remanufacturing, inventory holding (in MRII), and disposal costs	Optimal policy
van der Laan [114]	Single-item CLSC-1SP-a	$(r_m = -1, q_m, d_m = \infty)$	Infinite horizon Exponential demand interarrival Exponential return interarrival indep. of demand Zero mfg. and rmfg. LT Stockouts not allowed Disposal not allowed	Maximize expected net present value of profit (or long-run average profit per unit time) to consider sales revenue and fixed manufacturing along with linear manufacturing, remanufacturing, and inventory holding (in MRII) costs	Closed form expression for q_m
Fleischmann et al. [32]	Single-item CLSC-1SP-a	$(r_m, q_m, d_m = \infty)$	Infinite horizon Exponential demand interarrival Exponential return interarrival indep. of demand Zero mfg. and rmfg. LT Backordering allowed Disposal not allowed	Minimize expected long-run average cost per unit time to include fixed manufacturing along with linear inventory holding (in MRII) and backordering costs	Optimal policy
Yuan & Cheung [127]	Single item CLSC-1SP-a	$(r_m, q_m, d_m = \infty)$	Infinite horizon Exponential demand interarrival Exponential return interarrival dep. on demand Zero mfg. and rmfg. LT Backordering allowed Disposal not allowed	Minimize expected long-run average cost per unit time to include fixed manufacturing along with linear inventory holding (in MRII) and backordering costs	Numerical search
Toktay et al. [113]	Single-item CLSC-1SP-b	$(q_r = 1, q_m = 1, r)$	Infinite horizon Exponential demand interarrival Exponential return interarrival dep. on demand Stochastic mfg.[a] and rmfg.[b] LT Lost sales allowed Disposal not allowed	Minimize expected long-run average cost per unit time to include fixed manufacturing along with linear procurement, inventory holding (in MRII) and lost sales costs	Approximation Simulation analysis
Bayındır et al. [5]	Single-item CLSC-1SP-c	$(q_r = 1, q_m = 1, r)$	Infinite horizon Exponential demand interarrival Exponential return interarrival dep. on demand Stochastic mfg.[c] and rmfg.[d] LT Backordering allowed Disposal not allowed	Minimize expected long-run average cost per unit time to include fixed manufacturing along with linear procurement, inventory holding (in preprocessing, disassembly, assembly activities as well as MRII) and backordering costs	Numerical search

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Table A.4 – Continued

Paper	System	Inventory control policy (decisions)	Model characteristics	Objective function	Solution approach
van der Laan [114]	Single-item CLSC-2SP-c	$(q_r, r_m = -1, q_m, d_u = \infty)$	Infinite horizon Exponential demand interarrival Exponential return interarrival indep. of demand Zero mfg. and rmfg. LT Stockouts not allowed Disposal not allowed	Maximize expected net present value of profit (or long-run average profit per unit time) to consider sales revenue and fixed manufacturing along with linear manufacturing, remanufacturing, and inventory holding (in UII and MRII) costs	Numerical search
Teunter et al. [105]	Single-item CLSC-2SP-c	$(r_r, q_r, r_m, q_m, d_u)$	Finite horizon Exponential demand interarrival Exponential return interarrival indep. of demand Constant mfg. and rmfg. LT Backordering allowed Disposal allowed	Minimize expected discounted cost (or long-run average cost per unit time) to include fixed manufacturing and remanufacturing along with linear manufacturing, remanufacturing, and inventory holding (in UII and MRII) costs	Numerical search Simulation analysis
Teunter [107]	Single-item CLSC-2SP-c	$(r_r = 0, q_r, r_m = 0, q_m, d_u = \infty)$	Finite horizon Exponential demand interarrival Exponential return interarrival indep. of demand Zero mfg. and rmfg. LT Stockouts not allowed Disposal not allowed	Minimize expected discounted cost to include fixed manufacturing and remanufacturing along with linear manufacturing, remanufacturing, and inventory holding (in UII and MRII) costs	Approximation Simulation analysis
van der Laan & Teunter [121]	Single-item CLSC-2SP-c	$(q_r, r_m, q_m, d_u = \infty)$ $(r_r, q_r, r_m, q_m, d_u = \infty)$	Infinite horizon Exponential demand interarrival Exponential return interarrival indep. of demand Constant and equal mfg. and rmfg. LT Backordering allowed Disposal not allowed	Minimize expected long-run average cost per unit time to include fixed manufacturing and remanufacturing along with linear inventory holding (in UII and MRII) and backordering costs	Approximation Numerical search
van der Laan and Salomon [118]	Single-item CLSC-2SP-c	(q_r, r_m, q_m, d_m) $(r_r, R_r, r_m, q_m, d_u)$	Infinite horizon Co-axian-2 demand interarrival Co-axian-2 return interarrival dep. on demand Constant mfg. and rmfg. LT Backordering allowed Disposal allowed	Minimize expected long-run average cost per unit time to include fixed manufacturing and remanufacturing along with linear manufacturing, remanufacturing, inventory holding (in UII and MRII), backordering, and disposal costs	Numerical search
van der Laan et al. [120]	Single-item CLSC-2SP-c	$(q_r, r_m, q_m, d_m = \infty)$ $(r_r, R_r, r_m, q_m, d_u = \infty)$	Infinite horizon Exponential an Co-axian-2 demand interarrival Exponential and Co-axian-2 return interarrival indep. of or dep. on demand Constant mfg. and rmfg. LT Backordering allowed Disposal not allowed	Minimize expected long-run average cost per unit time to include fixed manufacturing and remanufacturing along with linear manufacturing, remanufacturing, inventory holding (in UII and MRII), and backordering costs	Numerical search

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Table A.4 – Continued

Paper	System	Inventory control policy (decisions)	Model characteristics	Objective function	Solution approach
Teunter et al. [111]	Single item CLSC-2SP-c	$(r_r, q_r, r_m, q_m, d_u = \infty)$	Finite horizon Exponential demand interarrival Exponential return interarrival indep. of demand Constant mfg. and rmfg. LT Backorders allowed Disposal not allowed	Minimize expected long-run average cost per unit time to include fixed manufacturing and remanufacturing along with linear inventory holding (in UII and MRII) and backordering costs	Integer search by simulation
Muckstadt and Isaac [75]	Single-item CLSC-2SP-c	$(r_m, q_m, d_m = \infty, d_u = \infty)$	Infinite horizon Exponential demand interarrival Exponential return interarrival indep. of demand Constant mfg. and stochastic rmfg. LT Backordering allowed Disposal not allowed	Minimize expected long-run average cost per unit time to include fixed manufacturing along with linear inventory holding (in UII and MRII) and backordering costs	Numerical search
van der Laan et al. [116]	Single-item CLSC-2SP-c	$(r_m, q_m, d_m = \infty, d_u = \infty)$ $(r_m, q_m, d_m = \infty, d_u)$	Infinite horizon Exponential demand interarrival Exponential return interarrival indep. of demand Constant mfg. and stochastic rmfg. LT Backordering allowed Disposal allowed	Minimize expected long-run average cost per unit time to include fixed manufacturing along with linear inventory holding (in MRII), backordering, and disposal costs	Numerical search
van der Laan et al. [115]	Single-item CLSC-2SP-c	(r_m, q_m, d_m, d_u)	Infinite horizon Exponential demand interarrival Exponential return interarrival indep. of demand Constant mfg. and stochastic remfg. LT Backordering allowed Disposal allowed	Minimize expected long-run average cost per unit time to include fixed manufacturing along with linear manufacturing, remanufacturing, inventory holding (in UII and MRII), backordering, and disposal costs	Numerical search
van der Laan et al. [119]	Single-item CLSC-2SP-c	$(q_r, r_m, q_m, d_u = \infty)$ $(r_r, R_r, r_m, q_m, d_u = \infty)$	Infinite horizon Exponential demand interarrival Exponential return interarrival indep. of demand Stochastic discrete mfg. and rmfg. LT Backordering allowed Disposal allowed	Minimize expected long-run average cost per unit time to include fixed manufacturing and remanufacturing along with linear manufacturing, remanufacturing, inventory holding (in UII and MRII), backordering, and disposal costs	Numerical search
Bayındır et al. [6]	Single-item CLSC-2SP-d	$(r_r, q_r = 1, r_m, q_m = 1)$	Infinite horizon No explicit modeling of return process Exponential mfg'd item demand interarrival Exponential remfg'd item demand interarrival Exponential mfg. and rmfg. LT One-way substitution of mfg'd items for remfg'd items Lost sales allowed Disposal not allowed	Maximize expected net present value of profit (or long-run average profit per unit time) to consider sales revenue and linear manufacturing, remanufacturing, inventory holding (in UII and MRII), and substitution costs	Numerical search

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Table A.4 – Continued

Paper	**System**	**Inventory control policy (decisions)**	**Model characteristics**	**Objective function**	**Solution approach**
Aras et al. [1]	Single-item CLSC-3SP-b	$(r_r, q_r, q_m, d_{g1}, d_{g2})$	Infinite horizon Exponential demand interarrival Exponential return interarrival independent of demand Zero mfg. and exponential rmfg.[e] LT Stockouts not allowed Disposal not allowed	Minimize expected long-run average cost per unit time to include linear manufacturing, remanufacturing, inventory holding (in UII-g1, UII-g2, remanufacturing work-in-process inventory, and RII), and disposal costs	Numerical search

[a]Including supplier, shipping, production, and distribution stages.
[b]Including customer use, production, and distribution stages.
[c]Including supplier, preprocessing, and assembly stages.
[d]Including customer use, disassembly, and assembly stages.
[e]Remfg. LT for UII-g1 is shorter than that for UII-g2.

Table A.5: Summary of existing work on stochastic periodic review I&PP models.

Paper	System	Inventory control policy (decisions)	Model characteristics	Objective function	Solution approach
Whisler [123]	Single-item CLSC-1SP-a	$(\overrightarrow{R}_m, \overrightarrow{R}_d)$	Both finite and infinite horizon Poisson demands Negative exponential customer use time Zero mfg. and rmfg. LT Lost sales allowed Disposal allowed	Minimize expected total cost to include linear manufacturing, inventory holding (in MRII), shortage, and disposal costs	Optimal policy
Cohen et al. [14]	Single-item CLSC-1SP-a	$(\overrightarrow{R}_m, \overrightarrow{R}_d = \infty)$	Finite horizon Continuous demands Constant customer use time Zero mfg. and rmfg. LT Lost sales allowed Disposal not allowed A fraction of inventory is lost due to decay	Minimize expected discounted total cost to include linear manufacturing, inventory holding (in MRII), and shortage costs	Optimal policy when customer use time is one period
Kelle & Silver [54]	Single item CLSC-1SP-a	$(\overrightarrow{R}_m, \overrightarrow{R}_d)$	Finite horizon Normal demands net of returns Zero mfg. and rmfg. LT Backordering allowed Disposal not allowed	Minimize expected total cost to include manufacturing setup as well as linear manufacturing and inventory holding (in MRII) costs	Dynamic programming
Buchanan & Abad [11]	Single item CLSC-1SP-a	$(\overrightarrow{R}_m, \overrightarrow{R}_d = \infty)$	Finite horizon Continuous demands Continuous returns dependent on the number of items in use Zero mfg. and rmfg. LT Backordering allowed Disposal not allowed	Minimize expected sum of linear manufacturing, inventory holding (in MRII), backordering, and salvaging costs	Dynamic programming
Inderfurth [49]	Single-item CLSC-1SP-a	$(\overrightarrow{R}_m, \overrightarrow{R}_d)$	Finite horizon Continuous demands Continuous returns independent of demand Constant identical mfg. and rmfg. LT Backordering allowed Disposal allowed	Minimize expected total cost to include linear manufacturing, remanufacturing, inventory holding (in MRII), backordering, and disposal costs	Optimal policy
Kiesmüller & Scherer [59]	Single-item CLSC-1SP-a	$(\overrightarrow{R}_m, \overrightarrow{R}_d)$	Finite horizon Normal demands Normal returns independent of demand Constant identical mfg. and rmfg. LT Backordering allowed Disposal allowed	Minimize expected total cost to include manufacturing, remanufacturing, inventory holding (in MRII), backordering, and disposal costs	Approximation

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Table A.5 – Continued

Paper	System	Inventory control policy (decisions)	Model characteristics	Objective function	Solution approach
Fleischmann & Kuik [31]	Single-item CLSC-1SP-a	(r_m, R_m)	Infinite horizon Discrete demands[a] Discrete returns independent of demand Zero and constant identical mfg. and rmfg. LT[b] Backordering allowed Disposal not allowed	Minimize expected long-run average cost per unit time to include manufacturing setup as well as linear inventory holding (in MRII) and backordering costs	Optimal policy
Heisig & Fleischmann [46]	Single-item CLSC-1SP-a	(r_m, R_m)	Both finite and infinite horizon Poisson demands Poisson returns independent of demands Zero mfg. and rmfg. LT Backordering allowed Disposal not allowed	Stabilize system nervousness	Numerical study
Kiesmüller & van der Laan [60]	Single-item CLSC-1SP-a	(q_0, R_m)	Finite horizon Poisson demands Constant customer use time Constant mfg. and rmfg. LT Backordering allowed Disposal of unremanufacturable returns only Disposal of all returns only in the last period	Minimize sum of the manufacturing setup and linear manufacturing costs in the first period; expected average total cost to include linear manufacturing, inventory holding (in MRII), and backordering throughout the planning horizon; and expected disposal cost in the last period	Numerical search Simulation based optimization
Vlachos & Dekker [122]	Single item CLSC-1SP-a	$(\overrightarrow{R}_m, \overrightarrow{R}_d = \infty)$	Single period Continuous demands A fraction of demand is returned A fraction of returns is remanufacturable Zero mfg. and rmfg. LT Lost sales allowed Disposal allowed at the end of the period	Maximize expected net profit to consider linear selling and salvage revenues, remanufacturing setup along with linear manufacturing, collection, remanufacturing, and lost sales costs	Continuous optimization
Mostard & Teunter [74]	Single-item CLSC-1SP-a	$(\overrightarrow{R}_m, \overrightarrow{R}_d = \infty)$	Single period Continuous demands A fraction of demand is returned A fraction of returns is remanufacturable Zero mfg. and rmfg. LT Lost sales allowed Disposal allowed at the end of the period	Maximize expected net profit to consider linear selling and salvage revenues, remanufacturing setup along with linear manufacturing and lost sales costs	Continuous optimization Approximation
Nakashima et al. [78], Nakashima et al. [79]	Single-item CLSC-1SP-a	$(\overrightarrow{R}_m, \overrightarrow{R}_d = \infty)$	Infinite horizon Discrete demands A fraction of items in use is returned Zero mfg. and rmfg. LT Backordering allowed Disposal allowed	Minimize expected long-run average cost per unit time to include linear manufacturing, remanufacturing, inventory holding (in MRII), backordering, and disposal costs	Numerical search

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Table A.5 – Continued

Paper	System	Inventory control policy (decisions)	Model characteristics	Objective function	Solution approach
Simpson [95]	Single-item CLSC-2SP-c	$(\vec{R}_m, \vec{R}_r, \vec{R}_d)$	Finite horizon Continuous demands Continuous returns independent of demands Zero mfg. and rmfg. LT Backordering allowed Disposal allowed	Minimize expected discounted total cost to include linear manufacturing, remanufacturing, inventory holding (in UII and MRII), backordering, and disposal costs	Optimal policy
Inderfurth [49]	Single-item CLSC-2SP-c	$(\vec{R}_m, \vec{R}_r, \vec{R}_d)$	Finite horizon Continuous demands Continuous returns independent of demands Constant identical mfg. and rmfg. LT Backordering allowed Disposal allowed	Minimize expected total cost to include linear manufacturing, remanufacturing, inventory holding (in UII and MRII), backordering, and disposal costs	Optimal policy
Kiesmüller & Scherer [59]	Single-item CLSC-2SP-c	$(\vec{R}_m, \vec{R}_r, \vec{R}_d)$	Finite horizon Normal demands Normal returns independent of demands Constant identical mfg. and rmfg. LT Backordering allowed Disposal allowed	Minimize expected total cost to include linear manufacturing, remanufacturing, inventory holding (in UII and MRII), backordering, and disposal costs	Approximation
Mahadevan et al. [71]	Single-item CLSC-2SP-c	$(\vec{R}_m, \vec{R}d = \infty)$	Infinite horizon Poisson demands Poisson returns independent of demands Constant mfg. and rmfg. LT Backordering allowed Disposal not allowed	Minimize expected long-run average cost per unit time to include linear inventory holding (in UII and MRII) and backordering costs	Simulation-based optimization and heuristics
Kiesmüller [55]	Single-item CLSC-2SP-c	(R_m, R_r)-Type-1	Infinite horizon Both Normal and Gamma demands Botha Normal and Gamma returns independent of demands Constant mfg. and rmfg. LT Backordering allowed Disposal not allowed	Minimize expected total cost to include linear inventory holding (in UII and MRII) and backordering costs	Simulation-based optimization
Kiesmüller & Minner [57]	Single-item CLSC-2SP-c	(R_m, R_r)-Type-2	Finite horizon Gamma demands Gamma returns independent of demands Constant mfg. and rmfg. LT Backordering allowed Disposal not allowed	Minimize expected total cost to include linear inventory (in UII and MRII) and backordering costs	Simulation-based optimization Approximation

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Table A.5 – Continued

Paper	System	Inventory control policy (decisions)	Model characteristics	Objective function	Solution approach
Teunter & Vlachos [112]	Single-item CLSC-2SP-c	(r, q_r, q_m, R_d) $(r, q_r, q_m, R_d = \infty)$	Finite horizon Both Normal and Poisson demands Both Normal and Poisson returns independent of demands Constant mfg. and rmfg. LT Backordering allowed Disposal allowed	Minimize discounted expected total costs to include manufacturing and remanufacturing setup along with linear manufacturing, remanufacturing, inventory holding (in UII and MRII), backordering, and disposal costs	Simulation based optimization
Inderfurth [50]	Single-item CLSC-2SP-d	(R_m, R_r)	Single period Both continuous and discrete demands for mfg'd and rmfg'd products Both continuous and discrete returns independent of demands Constant mfg. and rmfg. LT One-way substitution of mfg'd products for remfg'd products Lost sales allowed Disposal allowed	Maximize expected net profit to consider linear mfg'd and remfg'd item selling revenues along with linear linear manufacturing, remanufacturing, substitution, and disposal costs	Optimal policy
Bayındır et al. [7]	Single-item CLSC-2SP-d	(R_m, R_r)	Single period Continuous or discrete demands for manufactured and remanufactured products One-way substitution of manufactured items for remanufactured items Zero mfg. and rmfg. LT Shared limited manufacturing/remanufacturing capacity Lost sales allowed Disposal allowed	Maximize expected net profit to consider linear mfg'd and remfg'd item selling revenues along with linear linear manufacturing and remanufacturing costs	Continuous optimization

[a]Demands net of returns in each period is strictly positive.
[b]Results remain valid when constant remfg. LT is shorter than mfg. LT.