
List of Symbols

Basic Notation Introduced in Chapters 2 and 3

Indices and general

t	time index
$(\cdot)(t)$	time dependence
\cdot^*	optimal values
x^-	left-side limit of x
x^+	right-side limit of x

Parameters of the dynamic environment

$d(t)$	demand rate at time t
$u(t)$	return rate at time t
T	planning horizon

Processes (states and variables)

$y_s(t)$	physical stock serviceables
$y_u(t)$	physical stock recoverables
y_s^0	initial stock serviceables
y_u^0	initial stock recoverables
$p(t)$	production rate
\bar{p}	production capacity
$r(t)$	remanufacturing rate
\bar{r}	remanufacturing capacity
$w(t)$	disposal rate
w_0	initial disposal quantity

Cost and cash flow parameters

α	discount rate or continuous interest rate
c_p	variable unit production cost

c_r	variable unit remanufacturing cost
c_w	variable unit disposal cost or negative salvage revenue
h_s	holding cost rate serviceables
h_u	holding cost rate recoverables

Important optimization variables

H	Hamiltonian
L	Lagrangian
λ	co-state / adjoint variable
μ	Kuhn-Tucker-Multiplier for pure control conditions
κ	Kuhn-Tucker-Multiplier for pure state conditions
$\theta \in \Theta$	time points where co-state jumps
η	jump heights at time points where co-state is not continuous
$\theta_{e,i}$	entry time of a Case i interval
$\theta_{x,i}$	exit time of a Case i interval

Miscellaneous

Case A \rightarrow Case B Transition from Case A to Case B

Additional Notation in Chapter 4*Learning related parameters*

b	learning rate parameter
$c_{(r)}^0$	unit costs of producing (remanufacturing) a first item
$R(t)$	cumulative remanufacturing up to t as a proxy to remanufacturing knowledge
R_0	initial stock of remanufacturing knowledge
\tilde{R}	break-even total remanufacturing quantity under zero discount rate conditions

Important optimization variables

$\lambda_R(t)$	value of acquiring knowledge at time t
λ_u^{\max}	maximum level of λ_u if remanufacturing takes place
θ_l	time after which remanufacturing takes place

Additional Notation in Chapter 5*Parameters of the dynamic environment*

M	number of potential adopters
P	coefficient of innovation

Q	coefficient of imitation
Δ	time delay of returns
F	fraction of demanded products being available for remanufacturing
t_d^{max}	time point of maximum demand rate
t_u^{max}	time point of maximum return rate
t_I	intersection point of demand and return functions

Cash flow parameters

K_p^s	initial investment expenditures for single use production
K_p^r	initial investment expenditures for reuse production
K_r	investment expenditures for remanufacturing facility
c_p^s	variable unit production cost at single use production
c_p^r	variable unit production cost at reuse production

Policy parameters

t_r	time of remanufacturing investment
t_e	start time of storing collected returns
t_x	time where all stored returns are used up

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