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Research article

Rolling-horizon supply chain capacity planning for IC design house considering forecast evolution and capacity regret

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Appendix

Appendix: Model notation description

Sets & Indices	
r	Index value of review epoch
t	Index value of planning period
W	Set of wafer types ($w = 1, 2, 3, \ldots, \lvert W \rvert$)
P	Set of product types ($p = 1, 2, 3, \ldots, \lvert P \rvert$)
B	Set of banks. Includes a wafer bank B_W and a FG bank B_P
L	Set of sites. Includes wafer fab sites L_F, wafer probe sites L_O, assembly sites L_A, and final test sites L_T
M	Set of machines ($m = 1, 2, 3, \ldots, \lvert M \rvert$)
S	Set of demand scenarios ($s = 1, 2, 3, \ldots, \lvert S \rvert$)
Parameters	

R	The total number of review epoch
T	The total length of planning periods at each epoch *r*
Δ	The length of planning periods for the back-end process based on receiving actual orders at each epoch *r*
δ	The length of planning periods for the wafer fab process based on demand forecasts at each epoch r
df_{pt}^{s}	Demand forecast quantity of product *p* required in period *t* under scenario *s*
cc_{lw}	Consumed capacity of site *l* to produce a unit of wafer *w*, $l \in L_F, L_O$
cc_{lwp}	Consumed capacity of site *l* to produce a unit of product *p* with wafer *w*, $l \in L_A$
cc_{lmp}	Consumed capacity of machine *m* in site *l* to produce a unit of product *p*, $l \in L_T$
yr_{lwp}	Yield rate of site *l* to process wafer *w* for product *p*, $l \in L_F, L_O$
yr_{lp}	Yield rate of site *l* for product *p*, $l \in L_A, L_T$
gd_{wp}	Gross die of wafer *w* for product *p*
lt_l	Lead time in non-bottlenecks site *l*, $l \in L_F, L_O, L_A, L_T$
$tt_{ll'}$	Transportation time from site l to site l', $l \in L_F, B_W, L_O, L_A, L_T, l' \in B_W, L_O, L_A, L_T, B_P$
fc_{lp}	Fixed cost when product *p* is processed in site *l*, $l \in L_F, L_O, L_A, L_T$
oc_l	Capacity oversupply cost of site *l*, $l \in L_F, L_O, L_A$
oc_{lm}	Capacity oversupply cost of site *l* with machine *m*, $l \in L_T$
oc_p	Capacity oversupply cost of product *p*
sc_l	Capacity shortage cost of site *l*,$l \in L_F, L_O, L_A$
sc_{lm}	Capacity shortage cost of site *l* with machine *m*, $l \in L_T$
sc_p	Capacity shortage cost of product *p*
pc_{lwp}	Production cost of site *l* to process wafer *w* for product *p*, $l \in L_F, L_O$
pc_{lp}	Production cost of site *l* to process product *p*, $l \in L_A$
pc_{lmp}	Production cost of site *l* with machine *m* to process product *p*, $l \in L_T$
$tc_{ll'}$	Transportation cost per unit from site l to location l', $l \in L_F, B_W, L_O, L_A, L_T, l \in B_W, L_O, L_A, L_T, B_P$
a_{wp}	Binary parameter: 1, if product *p* can be produced with wafer *w*; 0, otherwise
t_{lmp}	Binary parameter: 1, if product *p* can be tested with machine *m* in site *l*; 0, otherwise, $l \in L_T$
UBP	Upper bound for production quantity
UBT	Upper bound for transportation quantity
UBC_l	Upper bound for maximum reservable capacity of site *l*, $l \in L_F, L_O, L_A$
UBC_{lm}	Upper bound for maximum reservable capacity of machine *m* of site *l*, $l \in L_T$
Decision Variables	
Q_{lwpt}^{s1}	Quantity of wafer *w* for product *p* start to be processed in site *l* in period *t* under scenarios *s*, $l \in L_F, L_O, L_A$
Q_{lmpt}^{s1}	Quantity of product *p* start to be processed by machine *m* in site *l* in period *t* under scenarios *s*, $l \in L_T$

Q_{lwpt}^{s2}	Quantity of wafer w for product p completed in site l in period t under scenarios s, $l \in L_F, L_O$
Q_{lpt}^{s2}	Quantity of product p completed in site l in period t under scenarios s, $l \in L_A$
Q_{lmpt}^{s2}	Quantity of product p completed by machine m in site l in period t under scenarios s, $l \in L_T$
$T_{ll'wpt}^{s1}$	Quantity of wafer w for product p shipped from site l to site l' in period t under scenarios s, $l \in L_F, B_W, L_O$, $l' \in B_W, L_O, L_A$
$T_{ll'pt}^{s1}$	Quantity of product p shipped from site l to site l' in period t under scenarios s, $l \in L_A, L_T$, $l' \in L_T, B_P$
$T_{ll'wpt}^{s2}$	Quantity of wafer w for product p received by site l' come from site l in period t under scenarios s, $l \in L_F, B_W, L_O$, $l' \in B_W, L_O, L_A$
$T_{ll'pt}^{s2}$	Quantity of product p received by site l' come from site l in period t under scenarios s, $l \in L_A, L_T$, $l' \in L_T, B_P$
CE_{lt}	Existing available capacity of site l in period t, $l \in L_F, L_O, L_A$
CE_{lmt}	Existing available capacity of machine m of site l in period t, $l \in L_T$
OR_{lt}^{s}	Regret of capacity oversupply of site l in period t under scenarios s, $l \in L_F, L_O, L_A$
OR_{lmt}^{s}	Regret of capacity oversupply of machine m of site l in period t under scenarios s, $l \in L_T$
OR_{pt}^{s}	Regret of demand oversupply of product p in period t under scenarios s
SR_{lt}^{s}	Regret of capacity shortage of site l in period t under scenarios s, $l \in L_F, L_O, L_A$
SR_{lmt}^{s}	Regret of capacity shortage of machine m of site l in period t under scenarios s, $l \in L_T$
SR_{pt}^{s}	Regret of demand shortage of product p in period t under scenarios s
X_{lpt}^{s}	Binary variable: 1, if product p is processed in site l in period t under scenarios s; 0, otherwise, $l \in L_F$, L_O, L_A, L_T
Y_{lt}^{s}	Binary variable: 1, if capacity is shortage of site l in period t under scenario s; 0, otherwise, $l \in L_F, L_O, L_A$
Y_{lmt}^{s}	Binary variable: 1, if capacity is shortage of machine m of site l in period t under scenario s, $l \in L_T$
Y_{pt}^{s}	Binary variable: 1, if demand is shortage of product p in period t under scenario s; 0, otherwise