

Constraints(5h) – (5k), (5r) – (5u) (7a)

$$\begin{aligned} \partial L_i / \partial \lambda_t &= \sum_{g \in S_i^G, k} P_{gkt}^G + \sum_{g, k} \beta_{igkt}^a - \sum_{d, l} \beta_{idlt}^b - \\ &\sum_{g \in S_i^G} h(\rho_{gt} - K) \min(\sum_k P_{gkt}^G, \sum_k P_{gk}^{\text{ROG}}) = 0, \\ &\forall i, \forall t \end{aligned}$$

$$\begin{aligned} \partial L_j / \partial \lambda_t &= - \sum_{d \in S_j^D, l} P_{dlt}^D + \sum_{g, k} \beta_{jgkt}^a - \\ &\sum_{d, l} \beta_{jdlt}^b = 0, \forall j, \forall t \end{aligned}$$

$$\begin{aligned} \partial L_i / \partial \mu_{ft}^{\min} &= - \sum_{g \in S_i^G, k} T_{f(n: g \in \Phi_n^G)} P_{gkt}^G + \\ &\sum_{d, l} T_{f(n: d \in \Phi_n^D)} \beta_{idlt}^b - \sum_{g, k} T_{f(n: g \in \Phi_n^G)} \beta_{igkt}^a + \\ &\sum_{g \in S_i^G} T_{f(n: g \in \Phi_n^G)} h(\rho_{gt} - K) \min(\sum_k P_{gkt}^G, \\ &\sum_k P_{gk}^{\text{ROG}}) + F_f \beta_{it}^{\text{SDT}} - \gamma_{ift}^{\mu, \min} = 0, \forall i, \forall f, \forall t \end{aligned} \quad (7d)$$

$$\begin{aligned} \partial L_j / \partial \mu_{ft}^{\min} &= - \sum_{d \in S_j^D, l} T_{f(n: d \in \Phi_n^D)} P_{dlt}^D - \\ &\sum_{g, k} T_{f(n: g \in \Phi_n^G)} \beta_{jgkt}^a + \sum_{d, l} T_{f(n: d \in \Phi_n^D)} \beta_{jdlt}^b + \\ &F_f \beta_{jt}^{\text{SDT}} - \gamma_{jft}^{\mu, \min} = 0, \forall j, \forall f, \forall t \\ \partial L_i / \partial \mu_{ft}^{\max} &= \sum_{g \in S_i^G, k} T_{f(n: g \in \Phi_n^G)} P_{gkt}^G - \end{aligned}$$

$$\begin{aligned} &\sum_{d, l} T_{f(n: d \in \Phi_n^D)} \beta_{idlt}^b + \sum_{g, k} T_{f(n: g \in \Phi_n^G)} \beta_{igkt}^a - \\ &\sum_{g \in S_i^G} T_{f(n: g \in \Phi_n^G)} h(\rho_{gt} - K) \min(\sum_k P_{gkt}^G, \\ &\sum_k P_{gk}^{\text{ROG}}) + F_f \beta_{it}^{\text{SDT}} - \gamma_{ift}^{\mu, \max} = 0, \forall i, \forall f, \forall t \end{aligned} \quad (7f)$$

$$\begin{aligned} \partial L_j / \partial \mu_{ft}^{\max} &= \sum_{d \in S_j^D, l} T_{f(n: d \in \Phi_n^D)} P_{dlt}^D + \\ &\sum_{g, k} T_{f(n: g \in \Phi_n^G)} \beta_{jgkt}^a - \sum_{d, l} T_{f(n: d \in \Phi_n^D)} \beta_{jdlt}^b + \\ &F_f \beta_{jt}^{\text{SDT}} - \gamma_{jft}^{\mu, \max} = 0, \forall j, \forall f, \forall t \end{aligned} \quad (7g)$$

$$\begin{aligned} \partial L_{i(j)} / \partial \tau_{gkt}^{\text{Gmin}} &= -\beta_{i(j)gkt}^a - \gamma_{i(j)gkt}^{\tau, \text{Gmin}} = 0, \\ &\forall i(j), \forall g, \forall k, \forall t \end{aligned} \quad (7h)$$

$$\begin{aligned} \partial L_{i(j)} / \partial \tau_{gkt}^{\text{Gmax}} &= \beta_{i(j)gkt}^a - \gamma_{i(j)gkt}^{\tau, \text{Gmax}} + P_{gk}^{\text{Gmax}} \beta_{i(j)t}^{\text{SDT}} \\ &= 0, \forall i(j), \forall g, \forall k, \forall t \end{aligned} \quad (7i)$$

$$\begin{aligned} \partial L_{i(j)} / \partial \tau_{dlt}^{\text{Dmin}} &= -\beta_{i(j)dlt}^b - \gamma_{i(j)dlt}^{\tau, \text{Dmin}} = 0, \\ &\forall i(j), \forall g, \forall k, \forall t \end{aligned} \quad (7j)$$

$$\begin{aligned} \partial L_{i(j)} / \partial \tau_{dlt}^{\text{Dmax}} &= \beta_{i(j)dlt}^b - \gamma_{i(j)dlt}^{\tau, \text{Dmax}} + P_{dlt}^{\text{Dmax}} \beta_{i(j)t}^{\text{SDT}} = 0, \\ &\forall i(j), \forall g, \forall k, \forall t \end{aligned} \quad (7k)$$

$$\partial L_i / \partial P_{gkt}^G = -(\rho_{gt} - c_{gk}) + \beta_{it}^{\text{SDT}} a_{gkt} + \beta_{it}^P -$$

$$\begin{aligned} &c^{\text{Ph}}(\rho_{gt} - K)h(\sum_k P_{gk}^{\text{ROG}} - \sum_k P_{gkt}^G) + \gamma_{igkt}^{\text{P, Gmax}} - \\ &\gamma_{igkt}^{\text{P, Gmin}} + \max(\rho_{gt} - K, 0)h(\sum_k P_{gk}^{\text{ROG}} - \sum_k P_{gkt}^G) + \\ &\sum_f T_{f(n: g \in \Phi_n^G)} (\gamma_{ift}^{\text{F, max}} - \gamma_{ift}^{\text{F, min}}) = 0, \\ &\forall i, \forall g \in S_i^G, \forall k, \forall t \end{aligned} \quad (7l)$$

$$\begin{aligned} \partial L_{i(j)} / \partial P_{gkt}^G &= \beta_{i(j)t}^{\text{SDT}} a_{gkt} + \beta_{i(j)t}^P + \gamma_{i(j)gkt}^{\text{P, Gmax}} - \\ &\gamma_{i(j)gkt}^{\text{P, Gmin}} + \sum_f T_{f(n: g \in \Phi_n^G)} (\gamma_{i(j)ft}^{\text{F, max}} - \gamma_{i(j)ft}^{\text{F, min}}) = 0, \\ &\forall i(j), \forall g \notin S_i^G(g), \forall k, \forall t \end{aligned} \quad (7m)$$

$$\begin{aligned} \partial L_j / \partial P_{dlt}^D &= \rho_{dt} - u_{dl} - \beta_{jt}^P - \gamma_{jdl}^{\text{P, Dmin}} + \gamma_{jdl}^{\text{P, Dmax}} + \\ &\sum_f T_{f(n: d \in \Phi_n^D)} (\gamma_{jft}^{\text{F, max}} - \gamma_{jft}^{\text{F, min}}) - \beta_{jt}^{\text{SDT}} b_{dlt} = 0, \\ &\forall j, \forall d \in S_j^D, \forall l, \forall t \end{aligned} \quad (7n)$$

$$\begin{aligned} \partial L_{i(j)} / \partial P_{dlt}^D &= -\beta_{i(j)t}^P - \gamma_{i(j)dlt}^{\text{P, Dmin}} + \gamma_{i(j)dlt}^{\text{P, Dmax}} + \\ &\sum_f T_{f(n: d \in \Phi_n^D)} (\gamma_{jft}^{\text{F, max}} - \gamma_{i(j)ft}^{\text{F, min}}) - \beta_{i(j)t}^{\text{SDT}} b_{dlt} = 0, \\ &\forall i(j), \forall d(d \notin S_j^D), \forall l, \forall t \end{aligned} \quad (7o)$$

$$\begin{aligned} \partial L_i / \partial a_{gkt} &= -\gamma_{gkt}^a + \gamma_{g(k+1)t}^a + \beta_{igkt}^a + \beta_{it}^{\text{SDT}} P_{gkt}^G = 0, \\ &\forall i, \forall g \in S_i^G, \forall k, \forall t \end{aligned} \quad (7p)$$

$$\begin{aligned} \partial L_j / \partial b_{dlt} &= \gamma_{dlt}^b - \gamma_{d(l+1)t}^b - \beta_{jdl}^b - \beta_{jt}^{\text{SDT}} P_{dlt}^D = 0, \\ &\forall j, \forall d \in S_j^D, \forall l, \forall t \end{aligned} \quad (7q)$$

$$\begin{aligned} \partial L_i / \partial \lambda^{\text{RO}} &= \sum_{g \in S_i^G, k} P_{gk}^{\text{ROG}} + \sum_{g, k} \beta_{igk}^x - \sum_{\Lambda} \beta_{i\Lambda}^m = 0, \\ &\forall i \end{aligned} \quad (7r)$$

$$\partial L_j / \partial \lambda^{\text{RO}} = \sum_{g, k} \beta_{jgk}^x - \sum_{\Lambda} \beta_{j\Lambda}^m = 0, \forall j \quad (7s)$$

$$\begin{aligned} \partial L_{i(j)} / \partial \tau_{gk}^{\text{RO, Gmin}} &= -\beta_{i(j)gk}^x - \gamma_{i(j)gk}^{\text{RO}\tau, \text{Gmin}} = 0, \\ &\forall i(j), \forall g, \forall k \end{aligned} \quad (7t)$$

$$\begin{aligned} \partial L_{i(j)} / \partial \tau_{gk}^{\text{RO, Gmax}} &= \beta_{i(j)gk}^x - \gamma_{i(j)gk}^{\text{RO}\tau, \text{Gmax}} + \\ &\beta_{i(j)}^{\text{RO, SDT}} P_{gk}^{\text{Gmax}} = 0, \forall i(j), \forall g, \forall k \end{aligned} \quad (7u)$$

$$\begin{aligned} \partial L_{i(j)} / \partial \tau_{\Lambda}^{\text{RO, Dmin}} &= -\beta_{i(j)\Lambda}^m - \gamma_{i(j)\Lambda}^{\text{RO}\tau, \text{Dmin}} = 0, \\ &\forall i(j), \forall \Lambda \end{aligned} \quad (7v)$$

$$\begin{aligned} \partial L_{i(j)} / \partial \tau_{\Lambda}^{\text{RO, Dmax}} &= \beta_{i(j)\Lambda}^m - \gamma_{i(j)\Lambda}^{\text{RO}\tau, \text{Dmax}} + \\ &\beta_{i(j)}^{\text{RO, SDT}} P_{\Lambda}^{\text{RO, Dmax}} = 0, \forall i(j), \forall \Lambda \end{aligned} \quad (7w)$$

$$\begin{aligned} \partial L_i / \partial P_{gk}^{\text{ROG}} &= \sum_t [c^{\text{Ph}}(\rho_{gt} - K)h(\sum_k P_{gk}^{\text{ROG}} - \\ &\sum_k P_{gkt}^G) + \max(\rho_{gt} - K, 0) - \max(\rho_{gt} - K, \\ &0)h(\sum_k P_{gk}^{\text{ROG}} - \sum_k P_{gkt}^G)] + \lambda^{\text{RO}} + \beta_i^{\text{RO, P}} - \\ &\gamma_{igk}^{\text{ROP, Gmin}} + \gamma_{igk}^{\text{ROP, Gmax}} + \beta_i^{\text{RO, SDT}} x_{gk} = 0, \\ &\forall i, \forall g \in S_i^G, \forall k \end{aligned} \quad (7x)$$

$$\begin{aligned} \partial L_{i(j)} / \partial P_{gk}^{\text{ROG}} &= \beta_{i(j)}^{\text{RO, P}} - \gamma_{i(j)gk}^{\text{ROP, Gmin}} + \gamma_{i(j)gk}^{\text{ROP, Gmax}} + \\ &\beta_{i(j)}^{\text{RO, SDT}} x_{gk} = 0, \forall i(j), \forall g \notin S_i^G(g), \forall k \end{aligned} \quad (7y)$$

$$\begin{aligned} \partial L_{i(j)}/\partial P_{\Lambda}^{\text{ROD}} &= -\beta_{i(j)}^{\text{RO,P}} - \gamma_{i(j)\Lambda}^{\text{ROP,Dmin}} + \gamma_{i(j)\Lambda}^{\text{ROP,Dmax}} - \\ &\beta_{i(j)}^{\text{RO,SDT}} m_{\Lambda} = 0, \forall i(j), \forall \Lambda \end{aligned} \quad (7z)$$

$$\begin{aligned} \partial L_i/\partial x_{gk} &= -\gamma_{gk}^x + \gamma_{g(k+1)}^x + \beta_{igk}^x + \\ \beta_i^{\text{RO,SDT}} P_{gk}^{\text{ROG}} &= 0, \forall i, \forall g \in S_i^G, \forall k \end{aligned} \quad (7aa)$$

$$0 \leq a_{gkt} - a_g^{\min} \perp \gamma_{gkt}^a \geq 0, \forall g, k = 1, \forall t \quad (8a)$$

$$0 \leq a_{gkt} - a_{g(k-1)t} \perp \gamma_{gkt}^a \geq 0, \forall g, \forall k \geq 2, \forall t \quad (8b)$$

$$0 \leq a_g^{\max} - a_{gkt} \perp \gamma_{g(k+1)t}^a \geq 0, \forall g, k = k^{\max}, \forall t \quad (8c)$$

$$0 \leq x_{gk} - x_g^{\min} \perp \gamma_{gk}^x \geq 0, \forall g, k = 1 \quad (8d)$$

$$0 \leq x_{gk} - x_{g(k-1)} \perp \gamma_{gk}^x \geq 0, \forall g, \forall k \geq 2 \quad (8e)$$

$$0 \leq x_g^{\max} - x_{gk} \perp \gamma_{g(k+1)}^x \geq 0, \forall g, k = k^{\max} \quad (8f)$$

$$0 \leq b_d^{\max} - b_{dlt} \perp \gamma_{dlt}^b \geq 0, \forall d, l = 1, \forall t \quad (8g)$$

$$0 \leq b_{dlt} - b_{d(l-1)t} \perp \gamma_{dlt}^b \geq 0, \forall d, \forall l \geq 2, \forall t \quad (8h)$$

$$0 \leq b_{dlt} - b_d^{\min} \perp \gamma_{d(l+1)t}^b \geq 0, \forall d, l = l^{\max}, \forall t \quad (8i)$$

$$0 \leq P_{gkt}^G \perp \gamma_{i(j)gkt}^{\text{P,Gmin}} \geq 0, \forall i(j), \forall g, \forall k, \forall t \quad (8j)$$

$$0 \leq P_{gk}^{\text{Gmax}} - P_{gkt}^G \perp \gamma_{i(j)gkt}^{\text{P,Gmax}} \geq 0, \forall i(j), \forall g, \forall k, \forall t \quad (8k)$$

$$0 \leq P_{dlt}^D \perp \gamma_{i(j)dlt}^{\text{P,Dmin}} \geq 0, \forall i(j), \forall d, \forall l, \forall t \quad (8l)$$

$$0 \leq P_{dlt}^{\text{Dmax}} - P_{dlt}^D \perp \gamma_{i(j)dlt}^{\text{P,Dmax}} \geq 0, \forall i(j), \forall d, \forall l, \forall t \quad (8m)$$

$$\begin{aligned} 0 \leq F_f + \sum_n T_{fn} \left( \sum_{g \in \Phi_n^G, k} P_{gkt}^G - \sum_{d \in \Phi_n^D, l} P_{dlt}^D \right) \perp \gamma_{i(j)ft}^{\text{F,min}} \\ \geq 0, \forall i(j), \forall f, \forall t \end{aligned} \quad (8n)$$

$$\begin{aligned} 0 \leq F_f - \sum_n T_{fn} \left( \sum_{g \in \Phi_n^G, k} P_{gkt}^G - \sum_{d \in \Phi_n^D, l} P_{dlt}^D \right) \perp \gamma_{i(j)ft}^{\text{F,max}} \\ \geq 0, \forall i(j), \forall f, \forall t \end{aligned} \quad (8o)$$

$$0 \leq \tau_{gkt}^{\text{Gmin}} \perp \gamma_{i(j)gkt}^{\tau, \text{Gmin}} \geq 0, \forall i(j), \forall g, \forall k, \forall t \quad (8p)$$

$$0 \leq \tau_{gkt}^{\text{Gmax}} \perp \gamma_{i(j)gkt}^{\tau, \text{Gmax}} \geq 0, \forall i(j), \forall g, \forall k, \forall t \quad (8q)$$

$$0 \leq \tau_{dlt}^{\text{Dmin}} \perp \gamma_{i(j)dlt}^{\tau, \text{Dmin}} \geq 0, \forall i(j), \forall d, \forall l, \forall t \quad (8r)$$

$$0 \leq \tau_{dlt}^{\text{Dmax}} \perp \gamma_{i(j)dlt}^{\tau, \text{Dmax}} \geq 0, \forall i(j), \forall d, \forall l, \forall t \quad (8s)$$

$$0 \leq \mu_{ft}^{\min} \perp \gamma_{i(j)ft}^{\mu, \min} \geq 0, \forall i(j), \forall f, \forall t \quad (8t)$$

$$0 \leq \mu_{ft}^{\max} \perp \gamma_{i(j)ft}^{\mu, \max} \geq 0, \forall i(j), \forall f, \forall t \quad (8u)$$

$$0 \leq P_{gk}^{\text{ROG}} \perp \gamma_{i(j)gk}^{\text{ROP,Gmin}} \geq 0, \forall i(j), \forall g, \forall k \quad (8v)$$

$$0 \leq P_{gk}^{\text{Gmax}} - P_{gk}^{\text{ROG}} \perp \gamma_{i(j)gk}^{\text{ROP,Gmax}} \geq 0, \forall i(j), \forall g, \forall k \quad (8w)$$

$$0 \leq P_{\Lambda}^{\text{ROD}} \perp \gamma_{i(j)\Lambda}^{\text{ROP,Dmin}} \geq 0, \forall i(j), \forall \Lambda \quad (8x)$$

$$0 \leq P_{\Lambda}^{\text{RO,Dmax}} - P_{\Lambda}^{\text{ROD}} \perp \gamma_{i(j)\Lambda}^{\text{ROP,Dmax}} \geq 0, \forall i(j), \forall \Lambda \quad (8y)$$

$$0 \leq \tau_{gk}^{\text{RO,Gmin}} \perp \gamma_{i(j)gk}^{\text{RO}\tau, \text{Gmin}} \geq 0, \forall i(j), \forall g, \forall k \quad (8z)$$

$$0 \leq \tau_{gk}^{\text{RO,Gmax}} \perp \gamma_{i(j)gk}^{\text{RO}\tau, \text{Gmax}} \geq 0, \forall i(j), \forall g, \forall k \quad (8aa)$$

$$0 \leq \tau_{\Lambda}^{\text{RO,Dmin}} \perp \gamma_{i(j)\Lambda}^{\text{RO}\tau, \text{Dmin}} \geq 0, \forall i(j), \forall \Lambda \quad (8bb)$$

$$0 \leq \tau_{\Lambda}^{\text{RO,Dmax}} \perp \gamma_{i(j)\Lambda}^{\text{RO}\tau, \text{Dmax}} \geq 0, \forall i(j), \forall \Lambda \quad (8cc)$$