STANDARD FORM OF THE MODEL

$$\min_x f(x)$$
$$\text{s.t.:}\quad h(x) = 0 \quad : \lambda$$
$$g(x) \leq 0 \quad : \mu$$

$$\min_x \sum_e \sum_m \sum_t C_e \times q_{e,m,t} \qquad \text{mit } x = \Big[q_{e,m,t},\ \underbrace{\bar{q}_{e,t}}_{\forall e \setminus \{i\},t},\ q^{del}_{e,m,t},\ q^{arb}_{e,m,t}\Big]$$

$$\text{s.t.:}\quad -\sum_m q_{e,m,t} \leq 0 \quad : \forall e,t \quad (\mu^3_{e,t})$$

$$\Big[\sum_m q_{e,m,t}\Big] - \bar{q}_{e,t} \leq 0 \quad : \forall e,t \quad (\mu^4_{e,t})$$

$$q^{del}_{e,m,t} + q^{arb}_{e,m,t} - q_{e,m,t} = 0 \quad : \forall e,m,t \quad (\lambda^5_{e,m,t})$$

$$\Big[\sum_e q^{del}_{e,M1,t} + q^{arb}_{e,M2,t}\Big] - d_{M1,t} = 0 \quad : \forall t \quad (\lambda^6_t)$$

$$\Big[\sum_e q^{del}_{e,M2,t} + q^{arb}_{e,M1,t}\Big] - d_{M2,t} = 0 \quad : \forall t \quad (\lambda^7_t)$$

$$q_{e,M1,t} = 0 \quad : \forall e \in \mathcal{E}_{embargo}, t \quad (\lambda^8_{e,t})$$

$$q^{del}_{e,M1,t} + q^{arb}_{e,M2,t} - \alpha\, d_{M1,t} \leq 0 \quad : \forall e,t \quad (\mu^9_{e,t})$$

$$-q_{e,m,t} \leq 0 \quad : \forall e,m,t \quad (\mu^{10}_{e,m,t})$$

$$-\bar{q}_{e,t} \leq 0 \quad : \forall e \setminus \{i\},t \quad (\mu^{11}_{e,t})$$

$$-q^{del}_{e,m,t} \leq 0 \quad : \forall e,m,t \quad (\mu^{12}_{e,m,t})$$

$$-q^{arb}_{e,m,t} \leq 0 \quad : \forall e,m,t \quad (\mu^{13}_{e,m,t})$$

DUAL VARIABLE VECTORS

$$\lambda = \Big[\lambda^5_{e,m,t},\ \lambda^6_t,\ \lambda^7_t,\ \underbrace{\lambda^8_{e,t}}_{\forall e \in \mathcal{E}_{embargo}}\Big]$$

$$\mu = \Big[\mu^3_{e,t},\ \mu^4_{e,t},\ \mu^9_{e,t},\ \mu^{10}_{e,m,t},\ \underbrace{\mu^{11}_{e,t}}_{\forall e \setminus \{i\},t},\ \mu^{12}_{e,m,t},\ \mu^{13}_{e,m,t}\Big]$$

LAGRANGIAN FUNCTION

$$\begin{aligned}
\mathcal{L}(x,\lambda,\mu) = \sum_e \sum_m \sum_t C_e \times q_{e,m,t} &+ \lambda^5_{e,m,t}\Big\{q^{del}_{e,m,t} + q^{arb}_{e,m,t} - q_{e,m,t}\Big\} \\
&+ \lambda^6_t \Big\{\sum_e \Big[q^{del}_{e,M1,t} + q^{arb}_{e,M2,t}\Big] - d_{M1,t}\Big\} \\
&+ \lambda^7_t \Big\{\sum_e \Big[q^{del}_{e,M2,t} + q^{arb}_{e,M1,t}\Big] - d_{M2,t}\Big\} \\
&+ \lambda^8_t \Big\{q_{e,M1,t}\Big\} \\
&+ \mu^3_{e,t}\Big\{-\sum_m q_{e,m,t}\Big\} \\
&+ \mu^4_{e,t}\Big\{\sum_m \big[q_{e,m,t}\big] - \bar{q}_{e,t}\Big\} \\
&+ \mu^9_{e,t}\Big\{q^{del}_{e,M1,t} + q^{arb}_{e,M2,t} - \alpha \times d_{M1,t}\Big\} \\
&+ \mu^{10}_{e,m,t}\Big\{-q_{e,m,t}\Big\} \\
&+ \mu^{11}_{e,t}\Big\{-\bar{q}_{e,t}\Big\} \\
&+ \mu^{12}_{e,m,t}\Big\{-q^{del}_{e,m,t}\Big\} \\
&+ \mu^{13}_{e,m,t}\Big\{-q^{arb}_{e,m,t}\Big\}
\end{aligned}$$

KKT CONDITIONS

$$\frac{\partial \mathcal{L}}{\partial q_{e,m,t}} = \begin{cases} C_e - \lambda^5_{e,m,t} + \lambda^8_t - \mu^3_{e,t} + \mu^4_{e,t} - \mu^{10}_{e,m,t} = 0 & \text{if } m = M1 \\ C_e - \lambda^5_{e,m,t} - \mu^3_{e,t} + \mu^4_{e,t} - \mu^{10}_{e,m,t} = 0 & \text{otherwise} \end{cases}$$

$\partial\mathcal{L} \qquad 4$

$$\left\{ c_e \quad \lambda_{e,m,t} - \mu_{e,t} + \mu_{e,t} - \mu^{10}_{e,m,t} = 0 \quad \text{otherwise} \right.$$

$$\frac{\partial \mathcal{L}}{\bar{q}_{e,t}} = -\mu^{4}_{e,t} - \mu^{11}_{e,t} = 0 \qquad \forall e \in \mathcal{E} \setminus \{i\}, t$$

$$\frac{\partial \mathcal{L}}{\partial q^{del}_{e,m,t}} = \begin{cases} \lambda^{5}_{e,m,t} + \lambda^{6}_{t} + \mu^{9}_{e,t} - \mu^{12}_{e,m,t} = 0 & \text{if } m = M1 \\ \lambda^{5}_{e,m,t} + \lambda^{7}_{t} + \mu^{9}_{e,t} - \mu^{12}_{e,m,t} = 0 & \text{otherwise} \end{cases}$$

$$\frac{\partial \mathcal{L}}{\partial q^{arb}_{e,m,t}} = \begin{cases} \lambda^{5}_{e,m,t} + \lambda^{7}_{t} - \mu^{13}_{e,m,t} = 0 & \text{if } m = M1 \\ \lambda^{5}_{e,m,t} + \lambda^{6}_{t} + \mu^{9}_{e,t} - \mu^{13}_{e,m,t} = 0 & \text{otherwise} \end{cases}$$

$$\frac{\partial \mathcal{L}}{\partial \lambda^{5}_{e,m,t}} = q^{del}_{e,m,t} + q^{arb}_{e,m,t} - q_{e,m,t} = 0$$

$$\frac{\partial \mathcal{L}}{\partial \lambda^{6}_{t}} = \sum_e \left[q^{del}_{e,M1,t} + q^{arb}_{e,M2,t} \right] - d_{M1,t} = 0$$

$$\frac{\partial \mathcal{L}}{\partial \lambda^{7}_{t}} = \sum_e \left[q^{del}_{e,M2,t} + q^{arb}_{e,M1,t} \right] - d_{M2,t} = 0$$

FORTUNY-AMAT („BIG M")

$$0 \le \sum_m q_{e,m,t} \perp \mu^{3}_{e,t} \ge 0 \iff \boxed{\mu^{3}_{e,t} \ge \psi^{3}_{e,t} \cdot M^{3}; \; \sum_m q_{e,m,t} \le (1-\psi^{3}_{e,t}) M^{3}; \; \psi^{3}_{e,t} \in [0,1]}$$

$$0 \le \bar{q}_{e,t} - \sum_m q_{e,m,t} \perp \mu^{4}_{e,t} \ge 0 \iff \mu^{4}_{e,t} \ge \psi^{4}_{e,t} \cdot M^{4}; \; \bar{q}_{e,t} - \sum_m q_{e,m,t} \le (1-\psi^{4}_{e,t}) M^{4}; \; \psi^{4}_{e,t} \in [0,1]$$

$$\alpha \times d_{M1,t} - q^{del}_{e,M1,t} - q^{arb}_{e,M2,t} \ge 0 \perp \mu^{9}_{e,t} \ge 0 \iff \mu^{9}_{e,t} \ge \psi^{9}_{e,t} \cdot M^{9}; \; \alpha \times d_{M1,t} - q^{del}_{e,M1,t} - q^{arb}_{e,M2,t} \le (1-\psi^{9}_{e,t}) \cdot M^{9}; \; \psi^{9}_{e,t} \in [0,1]$$

$$q_{e,m,t} \ge 0 \perp \mu^{10}_{e,m,t} \ge 0 \iff \mu^{10}_{e,m,t} \ge \psi^{10}_{e,m,t} \cdot M^{10}; \; q_{e,m,t} \le (1-\psi^{10}_{e,m,t}) \cdot M^{10}; \; \psi^{10}_{e,m,t} \in [0,1]$$

$$\bar{q}_{e,t} \ge 0 \perp \mu^{11}_{e,t} \ge 0 : \forall e \in \mathcal{E} \setminus \{i\}, t \iff \mu^{11}_{e,t} \ge \psi^{11}_{e,t} \cdot M^{11}; \; \bar{q}_{e,t} \le (1-\psi^{11}_{e,t}) M^{11}; \; \psi^{11}_{e,t} \in [0,1]$$

$$q^{del}_{e,m,t} \ge 0 \perp \mu^{12}_{e,m,t} \ge 0 \iff \mu^{12}_{e,m,t} \ge \psi^{12}_{e,m,t} \cdot M^{12}; \; q^{del}_{e,m,t} \le (1-\psi^{12}_{e,m,t}) M^{12}; \; \psi^{12}_{e,m,t} \in [0,1]$$

$$q^{arb}_{e,m,t} \ge 0 \perp \mu^{13}_{e,m,t} \ge 0 \iff \mu^{13}_{e,m,t} \ge \psi^{13}_{e,m,t} \cdot M^{13}; \; q^{arb}_{e,m,t} \le (1-\psi^{13}_{e,m,t}) M^{13}; \; \psi^{13}_{e,m,t} \in [0,1]$$