

[**Robust Optimization**]

$$\text{(Original)} \quad \min \quad d^T \Omega d - \lambda d^T \alpha$$

Let set $U := \{\tilde{\alpha} \mid \tilde{\alpha}_i = \hat{\alpha}_i + \bar{\alpha}_i \gamma_i, \quad -1 \leq \gamma_i \leq 1, \quad \sum_i |\gamma_i| = \Gamma\}$.

$$\begin{aligned} \text{(robustness)} \quad & \min \quad d^T \Omega d - \lambda \min_{\tilde{\alpha} \in U} d^T \tilde{\alpha} \\ \Rightarrow \quad & \min_{\tilde{\alpha} \in U} d^T \tilde{\alpha} = \min \sum_i d^T (\hat{\alpha}_i + \bar{\alpha}_i \gamma_i) \\ \text{(Dual)} \Rightarrow \quad & \max \quad \pi + \sum_i \theta_i \\ & \text{s.t.} \quad \pi + \theta_i \leq \tilde{\alpha} d_i, \quad \forall i \in N \end{aligned}$$

$$\begin{aligned} \text{(ALL)} \quad & \min \quad d^T \Omega d + \lambda(\pi + \sum_i \theta_i) \\ & \text{s.t.} \quad (1) - (11) \\ & \quad \pi + \theta_i \leq \tilde{\alpha} d_i, \quad \forall i \in N \end{aligned}$$