

$$E((\theta - E(\theta)) \cdot (\theta - E(\theta))^T)$$

$$= E(\theta\theta^T - \theta\theta^{*T} - \theta^{*}\theta^T + \theta\theta^{*T})$$

$$= E(\theta\theta^T - \theta\theta^{*T} - \theta^{*}\theta^T + \theta\theta^{*T})$$

$$= E((X^T X)^{-1} X^T y \cdot y^T X (X^T X)^{-1})$$

$$\theta^* \theta^{*T} + \theta \epsilon (X^{-1})^T + X^{-1} \epsilon \theta^{*T} + X^{-1} \epsilon \epsilon^T (X^{-1})^T$$

$$- \theta^* \theta^{*T} - X^{-1} \epsilon \theta^{*T}$$

$$- \theta^* \theta^{*T} - \theta^* \epsilon^T (X^{-1})^T$$

$$+ \theta^* \theta^{*T}$$

$$\Rightarrow E(X^{-1} \epsilon \epsilon^T (X^{-1})^T)$$

$$= (X^T X)^{-1} E(\epsilon \epsilon^T) = (X^T X)^{-1} \sigma^2$$

$$= E(\theta^*) = \theta^*$$

$$= E(\theta^*) + E(X^{-1} \epsilon)$$

$$E(\theta) = E(X^T X)^{-1} X^T (X \theta + \epsilon)$$

$$= (X^T X)^{-1} X^T (X \theta + \epsilon)$$

$$\theta = \theta^* + X^{-1} \epsilon$$

$$\theta^T = \theta^{*T} + \epsilon^T (X^{-1})^T$$

$$E(\theta\theta^T) = E(\theta\theta^{*T} + \theta\epsilon^T (X^{-1})^T + \theta^{*}\epsilon^T (X^{-1})^T + \theta^{*}\theta^{*T} + \epsilon\epsilon^T (X^{-1})^T (X^{-1})$$

$$Var(\theta) = E((\theta - E(\theta))(\theta - E(\theta))^T) = E((\theta - E(\theta))(\theta - E(\theta))^T)$$

$$E(\epsilon) = 0$$

$$E(\epsilon^2)$$

$$E(\epsilon \epsilon^T)$$

ϵ is given from normal