

$$\begin{aligned}
\boldsymbol{\Sigma} &= cov \begin{pmatrix} \mathbf{w}_{i,1} \\ \mathbf{v}_{i,1} \\ \mathbf{w}_{i,2} \\ \mathbf{v}_{i,2} \end{pmatrix} \\
&= \begin{pmatrix} \boldsymbol{\Sigma}_{11} & \boldsymbol{\Sigma}_{12} & \boldsymbol{\Sigma}_{13} & \boldsymbol{\Sigma}_{14} \\ \hline & \boldsymbol{\Sigma}_{22} & \boldsymbol{\Sigma}_{23} & \boldsymbol{\Sigma}_{24} \\ \hline & & \boldsymbol{\Sigma}_{33} & \boldsymbol{\Sigma}_{34} \\ \hline & & & \boldsymbol{\Sigma}_{44} \end{pmatrix} \\
&= \begin{pmatrix} \boldsymbol{\Phi} + \boldsymbol{\Omega}_{11} & \boldsymbol{\Phi}\boldsymbol{\beta}^\top + \boldsymbol{\Omega}_{12} & \boldsymbol{\Phi} & \boldsymbol{\Phi}\boldsymbol{\beta}^\top \\ \hline & \boldsymbol{\beta}\boldsymbol{\Phi}\boldsymbol{\beta}^\top + \boldsymbol{\Psi} + \boldsymbol{\Omega}_{22} & \boldsymbol{\beta}\boldsymbol{\Phi} & \boldsymbol{\beta}\boldsymbol{\Phi}\boldsymbol{\beta}^\top + \boldsymbol{\Psi} \\ \hline & & \boldsymbol{\Phi} + \boldsymbol{\Omega}_{33} & \boldsymbol{\Phi}\boldsymbol{\beta}^\top + \boldsymbol{\Omega}_{34} \\ \hline & & & \boldsymbol{\beta}\boldsymbol{\Phi}\boldsymbol{\beta}^\top + \boldsymbol{\Psi} + \boldsymbol{\Omega}_{44} \end{pmatrix}
\end{aligned}$$