1. 左扰动 $R(t) = \exp(\phi_0^\wedge t)$

$$
\begin{aligned}
\frac{\partial Rp}{\partial R} &= \lim_{\varphi \to 0} \frac{\exp(\varphi^\wedge)\exp(\phi^\wedge)p - \exp(\phi^\wedge)p}{\varphi} \\
&\approx \lim_{\varphi \to 0} \frac{(1+\varphi^\wedge)\exp(\phi^\wedge)p - \exp(\phi^\wedge)p}{\varphi} \\
&= \lim_{\varphi \to 0} \frac{\varphi^\wedge Rp}{\varphi} \\
&= \lim_{\varphi \to 0} \frac{-(Rp)^\wedge \varphi}{\varphi} \\
&= -(Rp)^\wedge
\end{aligned}
$$

右扰动

$$
\begin{aligned}
\frac{\partial (Rp)}{\partial \varphi} &= \lim_{\varphi \to 0} \frac{\exp(\phi^\wedge)\exp(\varphi^\wedge)p - \exp(\phi^\wedge)p}{\varphi} \\
&\approx \lim_{\varphi \to 0} \frac{\exp(\phi^\wedge)(1+\varphi^\wedge)p - \exp(\phi^\wedge)p}{\varphi} \\
&= \lim_{\varphi \to 0} \frac{\exp(\phi^\wedge)\varphi^\wedge p}{\varphi} \\
&= \lim_{\varphi \to 0} \frac{-\exp(\phi^\wedge)p^\wedge \varphi}{\varphi} \\
&= -Rp^\wedge
\end{aligned}
$$

2. (8) 左扰动

$$\frac{\partial \ln(R_1R_2)^\vee}{\partial R_1} = \frac{\partial \ln[\exp(\phi_1^\wedge)\exp(\phi_2^\wedge)]^\vee}{\partial R_1}$$

$$\approx \frac{\partial[J_l(\phi_2)^{-1}\phi_1+\phi_2]}{\partial \phi_1}$$

$$= J_l(\phi_2)^{-1}$$

，其中 $J_l = J = \frac{\sin\phi_2}{\phi_2}\underline{\underline{I}} + (1-\frac{\sin\phi_2}{\phi_2})aa^T + \frac{1-\cos\phi_2}{\phi_2}a^\wedge$

(9) 右扰动

$$\frac{\partial \ln(R_1R_2)^\vee}{\partial R_2} \approx \frac{\partial[J_r(\phi_1)^{-1}\phi_2+\phi_1]}{\partial \phi_2}$$

$$= J_r(\phi_1)^{-1}$$

$$= J_l(-\phi_1)^{-1}$$