$$Y_{RK} = \left(1 - \frac{\pi^2}{2}\right) Y_{NK} \qquad (1)$$

$$Y_{RL} = \left(1 + \gamma(\pi - \pi^e) - \frac{\pi^2}{2}\right) Y_{NL} \qquad (2)$$

$$\pi_L^* = \gamma\left(1 - \frac{\partial \pi^e}{\partial \pi}\right) \qquad (3)$$

$$\pi_G = P\pi_L \qquad (4)$$

$$\pi_D = \varphi \pi_G + \pi_B \qquad (5)$$

$$\pi = \alpha \pi_D + \pi_W \qquad (6)$$

$$\pi = \alpha(\varphi P \pi_L + \pi_B) + \pi_W \qquad (7)$$

$$U_G = -(\pi - \pi_G)^2 \qquad (8)$$

$$\frac{\partial U_G}{\partial \alpha} = -2(\pi - \pi_G)\frac{\partial(\pi - \pi_G)}{\partial \alpha} \qquad (9)$$

$$\pi - \pi_G = \alpha \varphi P \gamma\left(1 - \frac{\partial \pi^e}{\partial \pi}\right) \qquad (10)$$
$$+ \alpha \pi_B - P\gamma\left(1 - \frac{\partial \pi^e}{\partial \pi}\right)$$
$$+ \pi_W$$

$$\frac{\partial(\pi - \pi_G)}{\partial \alpha} = \varphi P \gamma\left(1 - \frac{\partial \pi^e}{\partial \pi}\right) \qquad (11)$$
$$- P\gamma \frac{\partial \pi^e}{\partial \pi \partial \alpha}(\alpha \varphi - 1)$$
$$+ \pi_B$$

$$\alpha^* = \frac{\left(1 - \frac{\partial \pi^e}{\partial \pi}\right)}{\frac{\partial \pi^e}{\partial \pi \partial \alpha}} + \frac{1}{\varphi} + \frac{\pi_B}{\varphi P \gamma \frac{\partial \pi^e}{\partial \pi \partial \alpha}} \qquad (12)$$

$$\frac{\partial \alpha^*}{\partial P} = -\frac{\frac{\partial \pi^e}{\partial \pi \partial P}}{\frac{\partial \pi^e}{\partial \pi \partial \alpha}} - \frac{\pi_B}{\varphi P^2 \gamma \frac{\partial \pi^e}{\partial \pi \partial \alpha}} \qquad (13)$$