The datasets used and/or analyzed during the current study available from the corresponding author on reasonable request.

$$E_{y1} = xzw[\mathrm{Am}_2 + q(\alpha v_2 - c_2)\beta - \lambda(1-s)(\mathrm{u}_2 + \mathrm{h}_2) + D_2] + (1-x)zw[q(\alpha v_2 - c_2)\beta - \lambda(1-s)(\mathrm{u}_2 + \mathrm{h}_2) + D_2] + x(1-z)w[q(\alpha v_2 - c_2)\beta - \lambda(1-s)(\mathrm{u}_2 + \mathrm{h}_2) + D_2] + xz(1-w)[\mathrm{Am}_2 + q(\alpha v_2 - c_2)\beta - \lambda(\mathrm{u}_2 + \mathrm{h}_2) + D_2] + (1-x)(1-z)w[q(\alpha v_2 - c_2)\beta - \lambda(1-s)(\mathrm{u}_2 + \mathrm{h}_2) + D_2] + (1-x)z(1-w)[q(\alpha v_2 - c_2)\beta - \lambda(\mathrm{u}_2 + \mathrm{h}_2) + D_2] + x(1-z)(1-w)[q(\alpha v_2 - c_2)\beta - \lambda(\mathrm{u}_2 + \mathrm{h}_2) + D_2] + (1-x)(1-z)(1-w)[q(\alpha v_2 - c_2)\beta - \lambda(\mathrm{u}_2 + \mathrm{h}_2) + D_2]$$

$$E_{y2} = xzw(p_2 - f_2) + (1-x)zw(p_2 - f_2) + x(1-z)w(p_2 - f_2) + xz(1-w)p_2 + (1-x)(1-z)w(-f_2) + (1-x)z(1-w)p_2 + x(1-z)(1-w)p_2 + (1-x)(1-z)(1-w) \times 0$$

$$\overline{E_y} = yE_{y1} + (1-y)E_{y2}$$

$$E_{z1} = xyw[\mathrm{Am}_3 + \mathrm{q}(\alpha v_3 - c_3)\beta - \lambda(1-\mathrm{s})(\mathrm{u}_3 + \mathrm{h}_3) + D_3] + (1-x)yw[\mathrm{q}(\alpha v_3 - c_3)\beta - \lambda(1-\mathrm{s})(\mathrm{u}_3 + \mathrm{h}_3) + D_3] + x(1-y)w[\mathrm{q}(\alpha v_3 - c_3)\beta - \lambda(1-\mathrm{s})(\mathrm{u}_3 + \mathrm{h}_3) + D_3] + xy(1-w)[\mathrm{Am}_3 + \mathrm{q}(\alpha v_3 - c_3)\beta - \lambda(\mathrm{u}_3 + \mathrm{h}_3) + D_3] + (1-x)(1-y)w[\mathrm{q}(\alpha v_3 - c_3)\beta - \lambda(1-\mathrm{s})(\mathrm{u}_3 + \mathrm{h}_3) + D_3] + (1-x)y(1-w)[\mathrm{q}(\alpha v_3 - c_3)\beta - \lambda(\mathrm{u}_3 + \mathrm{h}_3) + D_3] + x(1-y)(1-w)[\mathrm{q}(\alpha v_3 - c_3)\beta - \lambda(\mathrm{u}_3 + \mathrm{h}_3) + D_3] + (1-x)(1-y)(1-w)[\mathrm{q}(\alpha v_3 - c_3)\beta - \lambda(\mathrm{u}_3 + \mathrm{h}_3) + D_3]$$

$$E_{z2} = xyw(p_3 - f_3) + (1-x)yw(p_3 - f_3) + x(1-y)w(p_3 - f_3) + xy(1-w)p_3 + (1-x)(1-y)w(-f_3) + (1-x)y(1-w)p_3 + x(1-y)(1-w)p_3 + (1-x)(1-y)(1-w) \times 0$$

$$\overline{E_z} = zE_{z1} + (1-z)E_{z2}$$

$$E_{w1} = xyz[(1+\alpha\beta)(\mathrm{B}_2 + \mathrm{B}_3) - c_4 - \mathrm{s}\lambda(\mathrm{u}_2 + \mathrm{u}_3 + \mathrm{h}_2 + \mathrm{h}_3) + D_4] + (1-x)yz[(1+\alpha\beta)(\mathrm{B}_2 + \mathrm{B}_3) - c_4 - \mathrm{s}\lambda(\mathrm{u}_2 + \mathrm{u}_3 + \mathrm{h}_2 + \mathrm{h}_3) + D_4] + x(1-y)z[(1+\alpha\beta)\mathrm{B}_3 - c_4 - \mathrm{s}\lambda(\mathrm{u}_3 + \mathrm{h}_3) + f_2 + D_4] + xy(1-z)[(1+\alpha\beta)\mathrm{B}_2 - c_4 - \mathrm{s}\lambda(\mathrm{u}_2 + \mathrm{h}_2) + f_3 + D_4] + (1-x)(1-y)z[(1+\alpha\beta)\mathrm{B}_3 - c_4 - \mathrm{s}\lambda(\mathrm{u}_3 + \mathrm{h}_3) + f_2 + D_4] + (1-x)y(1-z)[(1+\alpha\beta)\mathrm{B}_2 - c_4 - \mathrm{s}\lambda(\mathrm{u}_2 + \mathrm{h}_2) + f_3 + D_4] + x(1-y)(1-z)(f_2 + f_3 - c_4) + (1-x)(1-y)(1-z)(f_2 + f_3 - c_4)$$

$$E_{w2} = xyz \times 0 + (1-x)yz \times 0 + x(1-y)z \times 0 + xy(1-z) \times 0 + (1-x)(1-y)z \times 0 + (1-x)y(1-z) \times 0 + x(1-y)(1-z) \times 0 + (1-x)(1-y)(1-z) \times 0$$

$$\overline{E_w} = wE_{w1} + (1-w)E_{w2}$$

Jacobian matrix:

$$J = \begin{bmatrix} \frac{\partial F(x)}{\partial x} & \frac{\partial F(x)}{\partial y} & \frac{\partial F(x)}{\partial z} & \frac{\partial F(x)}{\partial w} \\ \frac{\partial F(y)}{\partial x} & \frac{\partial F(y)}{\partial y} & \frac{\partial F(y)}{\partial z} & \frac{\partial F(y)}{\partial w} \\ \frac{\partial F(z)}{\partial x} & \frac{\partial F(z)}{\partial y} & \frac{\partial F(z)}{\partial z} & \frac{\partial F(z)}{\partial w} \\ \frac{\partial F(w)}{\partial x} & \frac{\partial F(w)}{\partial y} & \frac{\partial F(w)}{\partial z} & \frac{\partial F(w)}{\partial w} \end{bmatrix}$$

$$= \begin{bmatrix} \sigma_1 & -x[\mathrm{Am}_1 z - (f_1 - p_1)(z-1)](x-1) & -x\left(\mathrm{Am}_1 y - (f_1 - p_1)(y\right. \\ -y\left(\mathrm{Am}_2 z + p_2 (z-1)\right)(y-1) & \sigma_2 & -y\left(\mathrm{Am}_2 x + p_2 (x-1\right. \\ -z(z-1)(p_3 y - p_3 + A m_3 y) & -z(z-1)(p_3 x - p_3 + A m_3 x) & \sigma_3 \\ 0 & -z(z-1)(f_3 + h_3 \lambda s + \lambda s u_3) & w(w-1)(f_3 - D_4 - B_3 + D_4 y - B \end{bmatrix}$$

$$\sigma_1 = -(2x-1)[\, D_1 - \lambda(h_1 + u_1) + (f_1 - p_1)(y+z) + yz(Am_1 - f_1 + p_1) + \beta q(\alpha v_1 - c_1)]$$

$$\sigma_2 = -(2y-1)[D_2 + \beta q(\alpha v_2 - c_2) + f_2 w + \lambda(h_2 + u_2)(sw-1) - p_2 x - p_2 z + xz(Am_2 + p_2)]$$

$$\sigma_3 = -(2z-1)[\, D_3 + \beta q(\alpha v_3 - c_3) + f_3 w + \lambda(h_3 + u_3)(sw-1) - p_3(x+y) + xy(p_3 + Am_3)]$$

$$\sigma_4 = (2w-1)\{c_4 - f_2 - f_3 + [f_2 - D_4 + \lambda s(h_2 + u_2) - B_2(1+\alpha\beta)]y + [f_3 - D_4 + \lambda s(h_3 + u_3) - B_3(1+\alpha\beta)]z + D_4 yz\}$$

Eigenvalue solving process

E1: (0,0,0,0)

$\sigma 1 = D1 - \lambda(h1 + u1) + \beta q(\alpha v1 - c1) > 0$

$\sigma 2 = D2 - \lambda(h2 + u2) + \beta q(\alpha v2 - c2) > 0$

$\sigma 3 = D3 - \lambda(h3 + u3) + \beta q(\alpha v3 - c3) > 0$

$\sigma 4 = f2 - c4 + f3$ Unstable

E2: (0,0,0,1)

$\sigma 1 = D1 - \lambda(h1 + u1) + \beta q(\alpha v1 - c1) > 0$

$\sigma 2 = D2 + f2 + \beta q(\alpha v2 - c2) - \lambda(h2 + u2)(1-s) > 0$

$\sigma 3 = D3 + f3 + \beta q(\alpha v3 - c3) - \lambda(h3 + u3)(1-s) > 0$

$\sigma 4 = c4 - f2 - f3$ Unstable

E3: (0,0,1,0)

$\sigma 1 = D1 - \lambda(h1 + u1) + \beta q(\alpha v1 - c1) + f1 - p1 > 0$

$\sigma 2 = D2 - \lambda(h2 + u2) + \beta q(\alpha v2 - c2) - p2$ Unstable

$\sigma 3 = - [D3 — \lambda(h3 + u3) + \beta q(\alpha v3 - c3)] < 0$

$\sigma 4 = B3(\alpha\beta + 1) - c4 - \lambda s(h3 + u3) + D4 + f2$ Unstable

E4: (0,1,0,0)

$\sigma 1 = D1 - \lambda(h1 + u1) + \beta q(\alpha v1 - c1) + f1 - p1 > 0$

$\sigma 2 = -[D2 — \lambda(h2 + u2) + \beta q(\alpha v2 - c2)] < 0$

$\sigma 3 = D3 - \lambda(h3 + u3) + \beta q(\alpha v3 - c3)) - p3$ Unstable

$\sigma 4 = B2(\alpha\beta + 1) - c4 - \lambda s(h2 + u2) + D4 + f3$ Unstable

E5: (1,0,0,0)

$\sigma 1 = - [D1 - \lambda(h1 + u1) + \beta q(\alpha v1 - c1)] < 0$

$\sigma 2 = D2 - \lambda(h2 + u2) + \beta q(\alpha v2 - c2) - p2$ Unstable

$\sigma 3 = D3 - \lambda(h3 + u3) + \beta q(\alpha v3 - c3) - p3$ Unstable

$\sigma 4 = f2 - c4 + f3$ Unstable

E6: (1,0,0,1)

$\sigma 1 = - [D1 - \lambda(h1 + u1) + \beta q(\alpha v1 - c1)] < 0$

$\sigma 2 = D2 + \beta q(\alpha v2 - c2) - \lambda(h2 + u2)(1- s) + f2 - p2$ Unstable

$\sigma 3 = D3 + \beta q(\alpha v3 - c3) - \lambda(h3 + u3)(1- s) + f3 - p3$ Unstable

$\sigma 4 = c4 - f2 - f3$ Unstable

E7: (1,0,1,0)

$\sigma 1 = -[D1 - \lambda(h1 + u1) + \beta q(\alpha v1 - c1)] + p1 - f1 < 0$

$\sigma 2 = D2 - \lambda(h2 + u2) + \beta q(\alpha v2 - c2) + Am2 - p2$ Unstable

$\sigma 3 = - [D3 — \lambda(h3 + u3) + \beta q(\alpha v3 - c3)] + p3$ Unstable

$\sigma 4 = B3(\alpha\beta + 1) - c4 - \lambda s(h3 + u3) + D4 + f2$ Unstable

E8: (1,1,0,0)

σ1 = -[D1 -λ(h1 + u1)+βq(αv1 - c1)]+p1-f1<0
σ2 = - [D2 - λ(h2 + u2) + βq(αv2 - c2)]+p2 Unstable
σ3 = D3 - λ(h3 + u3) +βq(αv3 - c3))+Am3- p3 Unstable
σ4 = B2($\alpha\beta$ + 1) - c4- λs(h2 + u2) + D4 + f3 Unstable

E9: (0,1,1,0)
σ1 =D1 - λ(h1 + u1) +βq(αv1 - c1)+Am1+ f1 - p1>0
σ2 = - [D2 - λ(h2 + u2) + βq(αv2 - c2)]+p2 Unstable
σ3 = - D3 + λ(h3 + u3) + βq(c3 - αv3)+p3 Unstable
σ4 =(B2+B3)($\alpha\beta$+ 1)- λs(h2 + u2+ h3 + u3)+ D4 - c4>0

E10: (0,1,0,1)
σ1 = D1 - λ(h1 + u1) +βq(αv1 - c1) + f1 - p1>0
σ2 = - [D2-λ(h2 + u2)(1-s)+ βq(αv2 - c2)] - f2<0
σ3 = D3 + βq(c3 - αv3)-λ(h3 + u3)(1-s) + f3 - p3>0
σ4 = -B2($\alpha\beta$+1)+λs(h2 + u2)+c4 - D4 - f3 Unstable

E11: (0,0,1,1)
σ1 = D1 - λ(h1 + u1) +βq(αv1 - c1) + f1 - p1>0
σ2 = D2-λ(h2 + u2)(1-s)+ βq(αv2 - c2) + f2 - p2>0
σ3 = - [D3+ βq(c3 - αv3)-λ(h3 + u3)(1-s)] - f3<0
σ4 =- B3($\alpha\beta$ + 1) + λs(h3 + u3)+c4-D4-f2 Unstable

E12: (1,0,1,1)
σ1 = - [D1-λ(h1 + u1)+βq(αv1 - c1)]+p1 - f1<0
σ2 = D2 - λ(h2 + u2) + βq(αv2 - c2)+ f2 + Am2>0
σ3 = - [D3 + βq(c3 - αv3)+λ(h3 + u3)(1-s)]+p3 - f3<0
σ4 =- B3($\alpha\beta$ + 1) + λs(h3 + u3)+c4-D4-f2 Unstable

E13: (1,1,0,1)
σ1 = - [D1-λ(h1 + u1)+βq(αv1 - c1)]+p1 - f1<0
σ2 = - [D2 + βq(αv2 - c2)-λ(h2 + u2)(1-s)]+p2 - f2<0
σ3 = D3 + βq(c3 - αv3) - λ(h3 + u3) + Am3>0
σ4 = - B2($\alpha\beta$ + 1)+λs(h2 + u2)+c4-D4-f3 Unstable

E14: (1,1,1,0)
σ1 = -[D1-λ(h1 + u1)+βq(αv1 - c1)]+p1 - f1- Am1<0
σ2 = - [D2 + βq(αv2 - c2)-λ(h2 + u2)]+p2 - Am2 Unstable
σ3 = - [D3-λ(h3 + u3) + βq(αv3-c3)]+p3- Am3 Unstable
σ4 = - (B2 + B3)(1 + $\alpha\beta$) + λs(h2 + u2 + h3 + u3) +c4 - 2D4<0
(同 E9σ4)

E15: (0,1,1,1)
σ1 = D1 - λ(h1 + u1) +βq(αv1 - c1)+Am1+ f1 - p1>0

σ2 = - [D2 + βq(αv2 - c2)-λ(h2 + u2)(1-s)]+p2-f2<0
σ3 = - [D3 + βq(αv3 - c3)-λ(h3 + u3)(1-s)]+p3-f3<0
σ4 =-(B2 + B3)(1 + $\alpha\beta$)+λs(h2+u2+h3+u3)-c4-D4+f2+f3 Unstable

E16: (1,1,1,1)
σ1 = - D1 + λ(h1 + u1) + βq(c1 - αv1)+p1- f1 - Am1<0
σ2 = - D2 +λ(h2 + u2)(1-s) + βq(c2 - αv2) +p2- f2 - Am2<0
σ3 = - D3+λ(h3 + u3)(1-s)+ βq(c3 - αv3) + p3- f3 - Am3<0
σ4 =- (B2 + B3)(1 + $\alpha\beta$) + λs(h2 + u2 + h3 + u3) +c4 - 2D4 <0