$$\begin{aligned}\frac{dc}{dt} &= (ci + gng_p + gng_f - dnl - cox_a - cox_s)/cal_c \\ \frac{df}{dt} &= (fi + dnl - gng_f - fox_a - fox_s)/cal_f \\ \frac{dp}{dt} &= (pi - gng_p - pox_a - pox_s)/cal_p\end{aligned} \tag{1}$$

$$\begin{aligned}\frac{dc}{dt} &= (ci + gng_p + gng_f - dnl - g3p - cox)/cal_c \\ \frac{df}{dt} &= (3m_{ffa} * fi/m_{tg} + dnl - fox)/cal_f \\ \frac{dp}{dt} &= (pi - gng_p - pox)/cal_p\end{aligned} \tag{2}$$

$$rmr = mbc + mt + mc \tag{3}$$

$$mc = (1.0 - eff_{dnl}) \cdot dnl + (1.0 - eff_{gng}) \cdot (gng_f + gng_p) \tag{4}$$

$$gng_p = gng_{p,b}\left[\frac{p}{p_b} - \Gamma_c\left(\frac{\Delta ci}{ci_b}\right) + \Gamma_p\left(\frac{\Delta pi}{pi_b}\right)\right] \tag{5}$$

$$gng_f = fi\left(\frac{cal_c m_g}{cal_f m_{tg}}\right) + gng_{f,end,b} \cdot eff_{ci,d_f} \cdot eff_{obes,d_f} \tag{6}$$

$$dnl = \frac{ci(c/c_b)^{hill_{dnl}}}{(c/c_b)^{hill_{dnl}} + k_{dnl}^{hill_{dnl}}} \tag{7}$$

$$d_p = d_{p,b}\frac{p}{p_b} \tag{8}$$

$$d_f = d_{f,b} \cdot eff_{obes,d_f} \cdot eff_{ci,d_f} \tag{9}$$

$$d_c = d_{c,b} \cdot \frac{c}{c_b} \tag{10}$$

$$f_p = \frac{(n_{d_p} + max(0.0, eff_{pi,pox})) \cdot eff_{act,pox}}{z} \tag{11}$$

$$eff_{pi,pox} = w_{pi} \cdot (1.0 + s_{pi,ox} \cdot n_{\Delta pi}) \tag{12}$$

$$eff_{act,pox} = sa \cdot e^{-\ln(sa) \cdot act_{eng,bw}/act_{eng,bw,b}} \tag{13}$$

$$f_f = \frac{w_f \cdot eff_{ci,d_f} \cdot eff_{obes,d_f}}{z} \tag{14}$$

$$f_c = \frac{eff_{dg,cox} + max(0.0, eff_{ci,cox}) \cdot \frac{c}{0.1+c}}{z} \tag{15}$$

$$eff_{dg,cox} = w_g \cdot n_{d_c} \tag{16}$$

$$eff_{ci,cox} = w_{ci} \cdot (1.0 + s_{ci} \cdot n_{\Delta ci}) \tag{17}$$

$$tee = pae + rmr + tef \tag{18}$$

$$rmr = mbc + mt + mc \tag{19}$$

$$\begin{aligned} mei_b &= tee_b \\ &= pae_b + tef_b + rmr_b \\ &\implies \\ pae_b &= mei_b - (tef_b + rmr_b) \end{aligned} \tag{20}$$

$$act_{eng,bw,b} = \frac{pae_b}{bw_b} \tag{21}$$

$$\frac{dc}{dt} = 0, \frac{df}{dt} = 0, \frac{dp}{dt} = 0 \tag{22}$$

$$\begin{aligned} ci + gng_f + gng_p - cox_a - dnl - cox_s &= 0 \\ fi + dnl - gng_f - fox_a - fox_s &= 0 \\ pi - gng_p - pox_a - pox_s &= 0 \end{aligned} \tag{23}$$

$$cox_{s,0} = fox_{s,0} = pox_{s,0} = 0 \tag{24}$$

$$\begin{aligned} cox_{a,0} &= ci_0 + gng_{f,0} + gng_{p,0} - dnl_0 \\ fox_{a,0} &= fi_0 + dnl_0 - gng_{f,0} \\ pox_{a,0} &= pi_0 - gng_{p,0} \end{aligned} \tag{25}$$

$$f_p = \frac{prot\_term}{z} \tag{26}$$

$$prot\_term = n_{d_p} + max(eff_{pi,pox}, 0) \cdot eff_{act,pox} \tag{27}$$

$$n_{d_p} = \frac{d_p}{d_{p,b}} \tag{28}$$

$$eff_{pi,pox} = w_{pi} \cdot (1.0 + s_{pi,ox} \cdot n_{\Delta pi}) \tag{29}$$

$$n_{\Delta pi} = \frac{\Delta pi}{pi_b} \tag{30}$$

$$eff_{act,pox} = sa \cdot e^{-\ln(sa) \cdot n_{acteng_{bw}}} \tag{31}$$

$$n_{acteng_{bw}} = \frac{act_{eng,bw}}{act_{eng,bw,b}} \tag{32}$$

$$eff_{act,pox,0} = sa \cdot e^{-\ln(sa)} = 1 \tag{33}$$

$$f_{p,0} = \frac{1 + w_{pi}}{z_0} \tag{34}$$

$$f_f = \frac{fat\_term}{z} \tag{35}$$

$$fat\_term = w_f \cdot n_{d_f} \tag{36}$$

$$n_{d_f} = \frac{d_f}{d_{f,b}} \tag{37}$$

$$f_{f,0} = \frac{w_f}{z_0} \tag{38}$$

$$f_c = \frac{carb\_term}{z} \tag{39}$$

$$carb\_term = eff_{dg,cox} + max(0.0, eff_{ci,cox} \cdot (\frac{c}{0.1 + c})) \tag{40}$$

$$eff_{dg,cox} = w_g \cdot n_{d_c} \tag{41}$$

$$n_{d_c} = \frac{d_c}{d_{c,b}} \tag{42}$$

$$eff_{dg,cox} = w_g \tag{43}$$

$$eff_{ci,cox} = w_{ci} \cdot (1.0 + s_{ci} \cdot n_{\Delta ci}) \tag{44}$$

$$n_{\Delta ci} = \frac{\Delta ci}{ci_b} \tag{45}$$

$$eff_{ci,cox,0} = w_{ci} \tag{46}$$

$$carb\_term_0 = w_g + w_{ci} \tag{47}$$

$$f_{c,0} = \frac{w_g + w_{ci}}{z} \tag{48}$$

$$z = carb\_term + fat\_term + prot\_term \tag{49}$$

$$z_0 = (w_g + w_{ci}) + (1 + w_{pi}) + (w_f) \tag{50}$$

$$\begin{aligned}
cox_{a,0} &= f_{c,0} \cdot see_0 + gng_{p,0} + gng_{f,0} \\
fox_{a,0} &= f_{f,0} \cdot see_0 \\
pox_{a,0} &= f_{p,0} \cdot see_0 \\
cox_{a,0} &= ci_0 + gng_{f,0} + gng_{p,0} - dnl_0 \\
fox_{a,0} &= fi_0 + dnl_0 - gng_{f,0} \\
pox_{a,0} &= pi_0 - gng_{p,0} \\
&\Longrightarrow
\end{aligned} \tag{51}$$

$$\begin{aligned}
f_{c,0} \cdot see_0 + gng_{p,0} + gng_{f,0} &= ci_0 + gng_{f,0} + gng_{p,0} - dnl_0 \\
f_{f,0} \cdot see_0 &= fi_0 + dnl_0 - gng_{f,0} \\
f_{p,0} \cdot see_0 &= pi_0 - gng_{p,0} \\
&\Longrightarrow
\end{aligned} \tag{52}$$

$$\begin{aligned}
f_{c,0} \cdot see_0 &= ci_0 - dnl_0 \\
f_{f,0} \cdot see_0 &= fi_0 + dnl_0 - gng_{f,0} \\
f_{p,0} \cdot see_0 &= pi_0 - gng_{p,0} \\
&\Longrightarrow
\end{aligned} \tag{53}$$

$$
\begin{aligned}
f_{c,0} &= \frac{ci_0 - dnl_0}{see_0} \\
f_{f,0} &= \frac{fi_0 + dnl_0 - gng_{f,0}}{see_0} \\
f_{p,0} &= \frac{pi_0 - gng_{p,0}}{see_0}
\end{aligned}
\tag{54}
$$

$$
see = tee - gng_p - gng_f \tag{55}
$$

$$
\begin{aligned}
f_{c,0} &= \frac{ci_0 - dnl_0}{mei_b - gng_{f,0} - gng_{p,0}} \\
f_{f,0} &= \frac{fi_0 + dnl_0 - gng_{f,0}}{mei_b - gng_{f,0} - gng_{p,0}} \\
f_{p,0} &= \frac{pi_0 - gng_{p,0}}{mei_b - gng_{f,0} - gng_{p,0}}
\end{aligned}
\tag{56}
$$

$$
\begin{aligned}
k_c &= \frac{ci_0 - dnl_0}{mei_b - gng_{f,0} - gng_{p,0}} \\
k_f &= \frac{fi_0 + dnl_0 - gng_{f,0}}{mei_b - gng_{f,0} - gng_{p,0}} \\
k_p &= \frac{pi_0 - gng_{p,0}}{mei_b - gng_{f,0} - gng_{p,0}}
\end{aligned}
\tag{57}
$$

$$
\begin{aligned}
k_c &= \frac{w_g + w_{ci}}{(1 + w_{pi}) + (w_f) + (w_g + w_{ci})} \\
k_f &= \frac{w_f}{(1 + w_{pi}) + (w_f) + (w_g + w_{ci})} \\
k_p &= \frac{1 + w_{pi}}{(1 + w_{pi}) + (w_f) + (w_g + w_{ci})}
\end{aligned}
\tag{58}
$$

$$
\begin{aligned}
w_f &= (1.0 + w_{pi}) \cdot \frac{k_f}{k_p} \\
w_g &= \frac{k_c}{k_p} \cdot (1.0 + w_{pi}) - w_{ci}
\end{aligned}
\tag{59}
$$

$$bw = f + m_{lean} \tag{60}$$

$$m_{lean} = bm_b + ecw + m_{cell} \tag{61}$$

$$m_{cell} = ics + c + p + icw \tag{62}$$

$$icw = h_c \cdot c + h_p \cdot p + ciw \tag{63}$$

$$ecw_b = f_{tw,bw} \cdot f_{ecw,tw} \cdot bw_b \tag{64}$$

$$icw_b = f_{icw,ecw} \cdot ecw_b \tag{65}$$

$$m_{cell,b} = 1.0/f_{icw,cm} \cdot icw_b \tag{66}$$

$$m_{lean,b} = bm_b + ecw_b + m_{cell,b} \tag{67}$$

$$f_b = bw_b - m_{lean,b} \tag{68}$$

$$p_b = m_{cell,b} - icw_b - ics - c_b \tag{69}$$

$$
\begin{aligned}
icw &= h_c \cdot c + h_p \cdot p + ciw \\
icw_b &= f_{icw,ecw} \cdot ecw_b \\
\implies fiew \cdot ecw_b &= h_c \cdot c_b + h_p \cdot p_b + ciw \\
\implies ciw &= f_{icw,ecw} \cdot ecw_b - (h_c \cdot c_b + h_p \cdot p_b)
\end{aligned}
\tag{70}
$$