Step-1

Suppose A, b, and c be such that each entry in them is positive. Let us show that in this case, both the primal and dual are feasible.

Let

$$A = \begin{bmatrix} a & b \\ c & d \end{bmatrix}$$
$$b = \begin{bmatrix} b_1 \\ b_2 \end{bmatrix}$$
$$c = \begin{bmatrix} c_1 \\ c_2 \end{bmatrix}$$

Step-2

Consider $Ax \geq b$. This gives the following:

$$\begin{bmatrix} a & b \\ c & d \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} \geq \begin{bmatrix} b_1 \\ b_2 \end{bmatrix}$$
$$\begin{bmatrix} ax_1 + bx_2 \\ cx_1 + dx_2 \end{bmatrix} \geq \begin{bmatrix} b_1 \\ b_2 \end{bmatrix}$$

All a, b, c, and d are positive, therefore, as x_1 and x_2 are increased, the quantities $ax_1 + bx_2$ and $cx_1 + dx_2$ can be made greater than b_1 and b_2. In particular, let $x_1 = \frac{b_1 + b_2}{2p}$ and $x_2 = \frac{b_1 + b_2}{2p}$, where $p = \min\{a,b,c,d\}$. Then it is clear that $ax_1 + bx_2 > b_1$ and $cx_1 + dx_2 \geq b_2$.

Step-3

Consider $yA \leq c$. This gives the following:

$$[y_1, y_2]\begin{bmatrix} a & b \\ c & d \end{bmatrix} \leq [c_1, c_2]$$
$$[ay_1 + cy_2, by_1 + dy_2] \leq [c_1, c_2]$$

All a, b, c, and d are positive, therefore, as y_1 and y_2 are decreased, the quantities $ay_1 + cy_2$ and $by_1 + dy_2$ can be made lesser than c_1 and c_2. In particular, let $y_1 = \frac{c_1 + c_2}{2r}$ and $y_2 = \frac{c_1 + c_2}{2r}$, where $r = \max\{a,b,c,d\}$, then clearly $ay_1 + cy_2 \leq c_1$ and $by_1 + dy_2 \leq c_2$.

Step-4

Therefore, in either case, we have shown that when all the entries of A, b, and c are positive, the primal and dual are feasible.