

$$M = \begin{pmatrix} p_1 q_1 & p_1(1 - q_1) & (1 - p_1)q_1 & (1 - p_1)(1 - q_1) \\ p_2 q_3 & p_2(1 - q_3) & (1 - p_2)q_3 & (1 - p_2)(1 - q_1) \\ p_3 q_2 & p_3(1 - q_2) & (1 - p_3)q_2 & (1 - p_3)(1 - q_2) \\ p_4 q_4 & p_4(1 - q_4) & (1 - p_4)q_4 & (1 - p_4)(1 - q_4) \end{pmatrix}$$

$$D = \det \begin{pmatrix} p_1 q_1 - 1 & p_1 - 1 & q_1 - 1 & 1 \\ p_2 q_3 & p_2 - 1 & q_3 & 1 \\ p_3 q_2 & p_3 & q_3 & 1 \\ p_4 q_4 & p_4 & q_4 & 1 \end{pmatrix}$$

If $p = q = (1, 1, 0, 0)$ then $D = 0$. What other vectors have this property?