Let $\alpha = \lim x_n$.

Then

$$\begin{aligned}\alpha &= \lim x_n \\ &= \lim \tfrac{1}{2}\left(x_{n-1} + \frac{c}{x_{n-1}}\right) \\ &= \tfrac{1}{2} \lim \left(x_{n-1} + \frac{c}{x_{n-1}}\right) \\ &= \tfrac{1}{2} \lim x_{n-1} + \tfrac{1}{2} \lim \frac{c}{x_{n-1}} \\ &= \tfrac{1}{2}\alpha + \tfrac{1}{2}\frac{c}{\alpha}, \text{ provided } \alpha \neq 0.\end{aligned}$$

Then

$$\alpha = \tfrac{1}{2}\left(\alpha + \frac{c}{\alpha}\right)$$

$$2\alpha = \alpha + \frac{c}{\alpha}$$

$$2\alpha - \alpha = \frac{c}{\alpha}$$

$$\alpha = \frac{c}{\alpha}$$

$$\alpha^2 = c$$

$$\alpha = \sqrt{c}$$

$$\lim x_n = \sqrt{c}.$$

Provided $\alpha \neq 0$ shown below.

Let $c \geq 1$ and $x_0 = 1$, and $x_n = \frac{1}{2}\left(x_{n-1} + \frac{c}{x_{n-1}}\right)$.

Then $1 \leq x_0 \leq c$.

Claim: If $1 \leq x_k \leq c$
$1 \leq x_{k+1} \leq c$, for all $k \in \mathbb{N}$.

No bigger than c, $x_{k+1} = \frac{1}{2}\left(x_k + \frac{c}{x_k}\right) \leq \frac{1}{2}(c + c) = c.$

Also, no less than 1, $x_{k+1} = \frac{1}{2}\left(x_k + \frac{c}{x_k}\right) \geq \frac{1}{2}(1+1) = 1.$

So $1 \leq x_n \leq c$ for all $n \in \mathbb{N}$.

In particular,
$\alpha = \lim_{n\to\infty} x_n > 0.$