capital.

$$\begin{aligned} p_n &= w + rwn \\ p_{n-1} &= w + rw\,(n-1) + p_n \\ p_{n-2} &= w + rw\,(n-2) + p_{n-1} \\ &\vdots \\ p_1 &= w + rw + p_2 \end{aligned} \tag{16}$$

By recursive substitution,

$$\begin{aligned} p_n &= w\,(1 + rn) \\ p_{n-1} &= 2w\,(1 + rn) - wr \\ p_{n-2} &= 3w\,(1 + rn) - wr\,(1 + 2) \\ &\vdots \\ p_1 &= nw\,(1 + rn) - wr\,(1 + 2 + \cdots + (n-1)) \end{aligned} \tag{17}$$

Therefore total sales are

$$\sum_{k=1}^{n} p_k = w\,(1 + rn)\left(\sum_{k=1}^{n} k\right) - wr \sum_{k=1}^{n-1} k\,(n-k) \tag{18}$$

Using the algebraic identity:

$$\textstyle\sum_{k=1}^{n-1} k\,(n-k) = \frac{1}{6} n\,(n-1)\,(n+1)$$

total sales in the chain are

$$\sum_{k=1}^{n} p_k = \frac{1}{2} nw\,(nr+1)\,(n+1) - \frac{1}{6} nrw\,(n-1)\,(n+1) \tag{19}$$

Total value added in the chain is

$$\begin{aligned} p_1 &= nw\,(1 + rn) - wr \sum_{k=1}^{n-1} k \\ &= nw\,(nr+1) - \frac{1}{2} nrw\,(n-1) \end{aligned} \tag{20}$$