Middlemen: good for resources and fishermen?

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Online Appendix

Proof of propositions

Proof of Proposition 1

To find the effect on the ex-vessel price of the final market price, we differentiate equation (10) which yields:

$$\frac{\partial P}{\partial P_n} = \frac{1}{1+\frac{\mu}{\varepsilon}} \, . \tag{A1}$$

We now consider how the ex-vessel price changes when market power appears. This is done by differentiating equation (A1) with respect to the degree of market power. This gives:

$$\frac{\partial\left(\frac{\partial P}{\partial P_n}\right)}{\partial \mu} = -\frac{1}{\varepsilon\left(1+\frac{\mu}{\varepsilon}\right)^2}. \tag{A2}$$

With $\mu = 0$, equation (A1) yields $\frac{\partial P}{\partial P_n} = 1$.

With $0 < \mu \leq 1$, a middleman with market power will tend to offer a price at which $P_n - c > P$. From this follows $\left(1 + \frac{\mu}{\varepsilon}\right) > 1 \rightarrow \frac{\mu}{\varepsilon} > 0 \rightarrow \varepsilon > 0$. This results in $\frac{\partial P}{\partial P_n} > 0$, and $\frac{\partial\left(\frac{\partial P}{\partial P_n}\right)}{\partial \mu} > 0$.

Thus, equation (A1) is always positive and equation (A2) is always negative; that is, satisfying Proposition 1.1.

With $\mu = 0$, equation (A1) gives $\frac{\partial P}{\partial P_n} = 1$; with $0 < \mu \leq 1$, equation (A1) we find $\frac{\partial P}{\partial P_n} < 1$.

Hence, Proposition 1.2 is proved.

A middleman with market power, $0 < \mu \leq 1$, will tend to offer a price at which $P_n - c > P$. From this it follows that $\varepsilon > 0 \rightarrow X > \frac{K}{e}$ or $X > X_{MSY}$ or $P < P_{MSY}$. If middlemen are competitive, $\mu = 0$, then $P_n - c = P$ with $\forall \varepsilon$. This condition is thus satisfied even if $\varepsilon < 0$ or $P > P_{MSY}$. Proposition 1.3 is proved.

Proof of Proposition 2

To see how fish stocks will be affected by opening up for trade, we use equation (5) and differentiate the fish stock with respect to the ex-vessel price:

$$\frac{dX}{dP} = -\frac{q^2X^2}{\gamma r\left(ln\frac{K}{X}+1\right)} < 0. \tag{A3}$$

Next, we multiply equation (A3) with equation (A1) in order to achieve the differential of fish stock with respect to the final market price. This yields:

$$\frac{\partial X}{\partial P_n} = \frac{\partial X}{\partial P} \cdot \frac{\partial P}{\partial P_n} = -\frac{q^2X^2}{\gamma r\left(ln\frac{K}{X}+1\right)} \cdot \frac{1}{1+\frac{\mu}{\varepsilon}} < 0. \tag{A4}$$

The effect of the degree of market power at the intermediary level on the fish stock is then found as:

$$\frac{\partial\left(\frac{\partial X}{\partial P_n}\right)}{\partial \mu} = \frac{-q^2X^2}{\gamma r\left(ln\frac{K}{X}+1\right)} \cdot \frac{-1}{\varepsilon\left(1+\frac{\mu}{\varepsilon}\right)^2} = \frac{q^2X^2}{\gamma r\left(ln\frac{K}{X}+1\right)\varepsilon\left(1+\frac{\mu}{\varepsilon}\right)^2} > 0.$$

Hence, Proposition 2.1 is proved.

To prove Proposition 2.2, we consider the effects on the stock of an increase in the final market price with market failures, $\left.\frac{\partial X}{\partial P_n}\right|_{0<\mu\leq 1}$, and without market failures, $\left.\frac{\partial X}{\partial P_n}\right|_{\mu=0}$, at the intermediary level:

$$\left.\frac{\partial X}{\partial P_n}\right|_{\mu=0} = -\frac{q^2X^2}{\gamma r\left(ln\frac{K}{X}+1\right)}$$

$$\left.\frac{\partial X}{\partial P_n}\right|_{0<\mu\leq 1} = -\frac{q^2X^2}{\gamma r\left(ln\frac{K}{X}+1\right)} \cdot \frac{1}{1+\frac{\mu}{\varepsilon}}$$

$$\rightarrow \left.\frac{\partial X}{\partial P_n}\right|_{\mu=0} < \left.\frac{\partial X}{\partial P_n}\right|_{0<\mu\leq 1} .$$

Proposition 2.2 is proved.

When $1 \geq \mu > 0 \rightarrow P < P_{MSY} \rightarrow E < E_{MSY} \rightarrow X > X_{MSY}$; when $\mu = 0 \rightarrow P > P_{MSY} \rightarrow E > E_{MSY} \rightarrow X < X_{MSY}$. Proposition 2.3 is proved.

Proof of Proposition 3

To prove Proposition 3.1, we first differentiate π_f with respect to X in equation (11) to identify how the fishermen's rent changes in response to the stock:

$$\frac{\partial \pi_f}{\partial X} = \frac{\gamma r^2}{q^2} ln \frac{K}{X}\left(-\frac{1}{X}\right) < 0 \,. \tag{A5}$$

Multiplying equation (A4) by equation (A5), the effect on fishermen's rent of the final market price is obtained:

$$\frac{\partial \pi_f}{\partial P_n} = \frac{\partial \pi_f}{\partial X} \cdot \frac{\partial X}{\partial P_n}$$

$$\frac{\partial \pi_f}{\partial P_n} = \frac{\gamma r^2}{q^2} ln \frac{K}{X}\left(-\frac{1}{X}\right) \cdot \left(-\frac{q^2 X^2}{\gamma r\left(ln\frac{K}{X}+1\right)} \frac{1}{1+\frac{\mu}{\varepsilon}}\right) = \frac{1}{1+\frac{\mu}{\varepsilon}} \frac{rXln\frac{K}{X}}{\left(ln\frac{K}{X}+1\right)} > 0 \,. \tag{A6}$$

Secondly, we consider how profit of the middlemen will be affected by opening up for trade. Differentiating π_m with respect to X by using equation (12) yields then:

$$\frac{\partial \pi_m}{\partial X} = 2\frac{\mu}{\varepsilon}\frac{\gamma r^2}{q^2} ln \frac{K}{X}\left(-\frac{1}{X}\right) < 0 \,. \tag{A7}$$

The effect on profit of the middlemen as a result of final market price changes is found by multiplying equation (A7) by equation (A4):

$$\frac{\partial \pi_m}{\partial P_n} = \frac{\partial \pi_m}{\partial X} \cdot \frac{\partial X}{\partial P_n}$$

$$\frac{\partial \pi_m}{\partial P_n} = 2\frac{\mu}{\varepsilon}\frac{\gamma r^2}{q^2} ln \frac{K}{X}\left(-\frac{1}{X}\right) \cdot \left(-\frac{q^2 X^2}{\gamma r\left(ln\frac{K}{X}+1\right)} \frac{1}{1+\frac{\mu}{\varepsilon}}\right) = 2\frac{\mu}{\varepsilon}\frac{1}{1+\frac{\mu}{\varepsilon}} \frac{rXln\frac{K}{X}}{\left(ln\frac{K}{X}+1\right)} > 0 \text{ with } \forall \varepsilon > 0 \,. \tag{A8}$$

The total rent effect is then:

$$\frac{\partial \pi}{\partial P_n} = \frac{\partial \pi_m}{\partial P_n} + \frac{\partial \pi_f}{\partial P_n} = 2\frac{\mu}{\varepsilon}\frac{1}{1+\frac{\mu}{\varepsilon}} \frac{rXln\frac{K}{X}}{\left(ln\frac{K}{X}+1\right)} + \frac{1}{1+\frac{\mu}{\varepsilon}} \frac{rXln\frac{K}{X}}{\left(ln\frac{K}{X}+1\right)} \tag{A9}$$

$$= \frac{2\frac{\mu}{\varepsilon}+1}{\frac{\mu}{\varepsilon}+1} \frac{rXln\frac{K}{X}}{\left(ln\frac{K}{X}+1\right)} > 0 \text{ with } \forall \varepsilon > 0 \,.$$

Propositions 3.1 and 3.2 are proved.

To show that the total rent of the supply chain is influenced by the degree of market power among middlemen, we differentiate equations (A6), (A8) and (A9) once more with respect to

μ:

$$\frac{\partial\left(\frac{\partial\pi_f}{\partial P_n}\right)}{\partial\mu} = -\frac{1}{\varepsilon\left(1+\frac{\mu}{\varepsilon}\right)^2}\frac{rXln\frac{K}{X}}{\left(ln\frac{K}{X}+1\right)}$$

$$\frac{\partial\left(\frac{\partial\pi_m}{\partial P_n}\right)}{\partial\mu} = \frac{2}{\varepsilon\left(1+\frac{\mu}{\varepsilon}\right)^2}\frac{rXln\frac{K}{X}}{\left(ln\frac{K}{X}+1\right)}$$

$$\frac{\partial\left(\frac{\partial\pi}{\partial P_n}\right)}{\partial\mu} = \frac{\partial\left(\frac{\partial\pi_f}{\partial P_n}\right)}{\partial\mu} + \frac{\partial\left(\frac{\partial\pi_m}{\partial P_n}\right)}{\partial\mu} = \frac{1}{\varepsilon\left(1+\frac{\mu}{\varepsilon}\right)^2}\frac{rXln\frac{K}{X}}{\left(ln\frac{K}{X}+1\right)}$$

$$\varepsilon > 0 \rightarrow \frac{\partial\left(\frac{\partial\pi_f}{\partial P_n}\right)}{\partial\mu} < 0 \text{ but } \frac{\partial\left(\frac{\partial\pi_m}{\partial P_n}\right)}{\partial\mu} > 0 \text{ and } \frac{\partial\left(\frac{\partial\pi}{\partial P_n}\right)}{\partial\mu} > 0$$

$$\left.\frac{\partial\pi}{\partial P_n}\right|_{\mu=0} = \frac{rXln\frac{K}{X}}{\left(ln\frac{K}{X}+1\right)}$$

$$\left.\frac{\partial\pi}{\partial P_n}\right|_{0<\mu\leq 1} = \frac{2\frac{\mu}{\varepsilon}+1}{\frac{\mu}{\varepsilon}+1}\frac{rXln\frac{K}{X}}{\left(ln\frac{K}{X}+1\right)} > \frac{rXln\frac{K}{X}}{\left(ln\frac{K}{X}+1\right)} = \left.\frac{\partial\pi}{\partial P_n}\right|_{\mu=0} \text{ since } \frac{2\frac{\mu}{\varepsilon}+1}{\frac{\mu}{\varepsilon}+1} > 1 \,.$$

Thus Proposition 3.3 is proved.