Sourcing from Conflict Regions: Policies to Improve Transparency in International Supply Chains: Online Appendix

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I. Embargo Equilibrium

Maximizing utility

$$M = \left(\int_0^{\Omega_W} [x(\Theta_W^e)q(\omega)]^\rho \, d\omega \;\; + \int_0^{\Omega_E} [x(\Theta_E^e)q(\upsilon)]^\rho \, d\upsilon \right)^{1/\rho} \tag{A.1}$$

yields the following spending levels for varieties from NW (indexed by ω) and from NE (indexed by υ):

$$q(\omega)p(\omega) = 2\alpha\bar{L}\tilde{P}^{\sigma-1}\tilde{p}(\omega)^{1-\sigma} \qquad \text{and} \qquad q(\upsilon)p(\upsilon) = 2\alpha\bar{L}\tilde{P}^{\sigma-1}\tilde{p}(\upsilon)^{1-\sigma} \, , \tag{A.2}$$

with

$$\tilde{P} = \left(\int_0^{\Omega_W} \tilde{p}(\omega)^{1-\sigma} d\omega + \int_0^{\Omega_E} \tilde{p}(\upsilon)^{1-\sigma} d\upsilon \right)^{1/(1-\sigma)} \, , \quad \tilde{p}(\omega) = \frac{r_W^e}{\rho x(\Theta_W^e)} \quad \text{and} \quad \tilde{p}(\upsilon) = \frac{r_E^e}{\rho x(\Theta_E^e)}$$

as corresponding price index and profit maximizing prices.

From the zero profit condition and from (A.2) we can infer $\tilde{p}(\omega) = \tilde{p}(\upsilon)$, such that

$$r_E^e = r_W^e X^e \, . \tag{A.3}$$

Given that quality adjusted prices are equalized, we obtain for quantities from (A.2)

$$q_W^e = q_E^e X^e \, . \tag{A.4}$$

With an aggregate number of varieties $\Omega = \Omega_W + \Omega_E$, the price index can be written as

$$\tilde{P}^e = \frac{r_W^e}{\rho x(\Theta_W^e)} \Omega^{1/(1-\sigma)} \, . \tag{A.5}$$

The equilibrium aggregate number of varieties can be determined from the zero profit condition as

$$\Omega^e = \frac{2\alpha\bar{L}}{\sigma f} \; . \tag{A.6}$$

Inserting into (A.2) yields

$$\Omega^e q_W^e = \frac{2\alpha\bar{L}\rho}{r_W^e} \quad \text{and} \quad \Omega^e q_E^e = \frac{2\alpha\bar{L}\rho}{r_E^e} \; . \tag{A.7}$$

Using $\Omega_W^e q_W^e = \bar{R}_W + \phi\bar{R}_E$, $\Omega_E^e q_E^e = (1-\phi)\bar{R}_E$ and (A.4) yields (A.8) for the number of varieties in both countries and for equilibrium resource prices.

$$\begin{aligned} \Omega_W^e &= \frac{\bar{R}_W + \phi\bar{R}_E}{\bar{R}_W + \tilde{\phi}^e\bar{R}_E}\Omega^e \; , & \Omega_E^e &= \frac{(1-\phi)X^e\bar{R}_E}{\bar{R}_W + \tilde{\phi}^e\bar{R}_E}\Omega^e \; , \\ r_W^e &= \frac{2\alpha\bar{L}\rho}{\bar{R}_W + \tilde{\phi}^e\bar{R}_E} \quad \text{and} & r_E^e &= \frac{2\alpha\bar{L}\rho X^e}{\bar{R}_W + \tilde{\phi}^e\bar{R}_E} \; . \end{aligned} \tag{A.8}$$

For the comparative static effects of an increase in ϕ, we first differentiate (12):

$$\begin{aligned} \frac{\partial\Theta_W^e}{\partial S^e} &= \frac{\phi\bar{R}_E}{\bar{R}_W + \phi\bar{R}_E} \; , & \frac{\partial\Theta_W^e}{\partial\phi} &= -\frac{(1-S^e)\bar{R}_W\bar{R}_E}{\left[\bar{R}_W + \phi\bar{R}_E\right]^2} \; , \\ \frac{\partial\Theta_E^e}{\partial S^e} &= 1 \; , \quad \text{and} & \frac{\partial\Theta_E^e}{\partial\phi} &= 0 \; . \end{aligned} \tag{A.9}$$

Employing the specification $x(\Theta) = 1 - \mu(1-\Theta)$ yields for the relative evaluation term

$$X^e = \frac{1-\mu(1-\Theta_E^e)}{1-\mu(1-\Theta_W^e)} \tag{A.10}$$

and using (A.9)

$$\begin{aligned} \frac{\partial X^e}{\partial S^e} &= \frac{\mu\bar{R}_W}{x(\Theta_W^e)^2\left[\bar{R}_W + \phi\bar{R}_E\right]} > 0 \; , \\ \frac{\partial X^e}{\partial\phi} &= \frac{\mu(1-S^e)\bar{R}_E\bar{R}_W x(\Theta_E^e)}{x(\Theta_W^e)^2\left[\bar{R}_W + \phi\bar{R}_E\right]^2} > 0 \; , \quad \text{and} \\ \frac{\partial X^e}{\partial\mu} &= -\frac{(1-S^e)\bar{R}_W}{x(\Theta_W^e)^2\left[\bar{R}_W + \phi\bar{R}_E\right]} < 0 \; . \end{aligned} \tag{A.11}$$

From totally differentiating equation (14), we obtain

$$\begin{aligned} \frac{dS^e}{d\phi} &= -\frac{\partial\hat{r}_E^e/\partial\phi}{8\gamma + \partial\hat{r}_E^e/\partial S^e} < 0 \; , & \frac{d\hat{r}_E^e}{d\phi} &= \frac{8\gamma\partial\hat{r}_E^e/\partial\phi}{8\gamma + \partial\hat{r}_E^e/\partial S^e} > 0 \; , \\ \frac{dS^e}{d\gamma} &= \frac{\hat{r}_E^e}{\gamma\left(8\gamma + \partial\hat{r}_E^e/\partial S^e\right)} > 0 \; , & \frac{d\hat{r}_E^e}{d\gamma} &= \frac{\hat{r}_E^e\partial\hat{r}_E^e/\partial S^e}{\gamma\left(8\gamma + \partial\hat{r}_E^e/\partial S^e\right)} > 0 \; , \\ \frac{dS^e}{d\mu} &= -\frac{\partial\hat{r}_E^e/\partial\mu}{8\gamma + \partial\hat{r}_E^e/\partial S^e} > 0 \; , \quad \text{and} & \frac{d\hat{r}_E^e}{d\mu} &= \frac{8\gamma\partial\hat{r}_E^e/\partial\mu}{8\gamma + \partial\hat{r}_E^e/\partial S^e} < 0 \; . \end{aligned} \tag{A.12}$$

since from (13), the definition of $\hat{r}_E^e$ and (A.12) we have

$$\frac{\partial \hat{r}_E^e}{\partial S^e} = \frac{2\alpha \bar{L}\rho \bar{R}_W (1-\phi)\partial X^e/\partial S^e}{\left[\bar{R}_W + \tilde{\phi}^e \bar{R}_E\right]^2} > 0 \,, \quad \text{and}$$
$$\frac{\partial \hat{r}_E^e}{\partial \phi} = \frac{2\alpha \bar{L}\rho \bar{R}_W \left[1 - X^e + (1-\phi)\partial X^e/\partial \phi\right]}{\left[\bar{R}_W + \tilde{\phi}^e \bar{R}_E\right]^2} > 0 \,, \quad \text{and}$$
$$\frac{\partial \hat{r}_E^e}{\partial \mu} = \frac{2\alpha \bar{L}\rho \bar{R}_W (1-\phi)\partial X^e/\partial \mu}{\left[\bar{R}_W + \tilde{\phi}^e \bar{R}_E\right]^2} < 0 \,. \tag{A.13}$$

II. Certification Equilibrium

As for the embargo equilibrium, we can derive equations similar to (A.2)–(A.7) for the certification setting, with Θ_W^c and Θ_E^c from (16) replacing Θ_W^e and Θ_E^e, and with $X^c = x(0)/x(\Theta_W^c)$. The market clearing conditions $\Omega_W^c q_W^c = \bar{R}_W + \left[gS^c + (1-S^c)\phi\right]\bar{R}_E$ and $\Omega_E^c q_E^c = (1-S^c)(1-\phi)\bar{R}_E$ determine the equilibrium number of varieties as

$$\Omega_W^c = \frac{\bar{R}_W + \left[gS^c + (1-S^c)\phi\right]\bar{R}_E}{\bar{R}_W + \left[gS^c + (1-S^c)\tilde{\phi}^c\right]\bar{R}_E}\Omega^c \,,$$
$$\Omega_E^c = \frac{X^c(1-S^c)(1-\phi)\bar{R}_E}{\bar{R}_W + \left[gS^c + (1-S^c)\tilde{\phi}^c\right]\bar{R}_E}\Omega^c \,, \tag{A.14}$$

and

$$\Omega^c = \frac{2\alpha\bar{L}}{\sigma f} \,.$$

For the equilibrium resource prices, we obtain

$$r_W^c = \frac{2\alpha\bar{L}\rho}{\bar{R}_W + \left[gS^c + (1-S^c)\tilde{\phi}^c\right]\bar{R}_E} \quad \text{and} \quad r_E^c = r_W^c X^c \,. \tag{A.15}$$

The price for resources from legal mines $\hat{r}_L^c = g r_W^c$ with certification exceeds the price $\hat{r}_E^e$ with the embargo, if and only if

$$\frac{g}{\bar{R}_W + \left[gS^c + (1-S^c)\tilde{\phi}^c\right]\bar{R}_E} > \frac{\tilde{\phi}^e}{\bar{R}_W + \tilde{\phi}^e\bar{R}_E} \,, \quad \text{or}$$
$$\left(g - \tilde{\phi}^e\right)\bar{R}_W > \tilde{\phi}^e\left(g - \tilde{\phi}^c\right)\left(S^c - 1\right)\bar{R}_E \,, \tag{A.16}$$

which is satisfied for $g > \tilde{\phi}^e$.

For the influence of S^c on $\hat{r}_I^c$ we have

$$\frac{\partial \hat{r}_I^c}{\partial S^c} = \frac{2\alpha\bar{L}\rho\left[(\bar{R}_W + gS^c\bar{R}_E)\frac{\partial\tilde{\phi}^c}{\partial S^c} - (g-\tilde{\phi}^c)\tilde{\phi}^c\bar{R}_E\right]}{\{R_W + \left[gS^c + (1-S^c)\tilde{\phi}^c\right]\bar{R}_E\}^2} \,. \tag{A.17}$$

Sufficient for $\partial \hat{r}_I^c / \partial S^c < 0$ is $d\partial\tilde{\phi}^c/\partial S^c < 0$, which, in turn is satisfied if $\partial X^c/\partial S^c < 0$. The term X^c can be written as follows:

$$X^c = \frac{(1-\mu)\{\bar{R}_W + [gS^c + (1-S^c)\phi]\,\bar{R}_E\}}{\bar{R}_W + [gS^c + (1-S^c)(1-\mu)\phi]\,\bar{R}_E} \, . \tag{A.18}$$

This yields

$$\begin{aligned}\frac{\partial X^c}{\partial S^c} =& \frac{(1-\mu)(g-\phi)\bar{R}_E\{\bar{R}_W + [gS^c + (1-S^c)(1-\mu)\phi]\,\bar{R}_E\}}{\{\bar{R}_W + [gS^c + (1-S^c)(1-\mu)\phi]\,\bar{R}_E\}^2} \\ &- \frac{(1-\mu)\,[g-(1-\mu)\phi]\,\bar{R}_E\{\bar{R}_W + [gS^c + (1-S^c)\phi]\,\bar{R}_E\}}{\{\bar{R}_W + [gS^c + (1-S^c)(1-\mu)\phi]\,\bar{R}_E\}^2} \\ =& - \frac{(1-\mu)\mu\phi\bar{R}_E\,(\bar{R}_W + g\bar{R}_E)}{\{\bar{R}_W + [gS^c + (1-S^c)(1-\mu)\phi]\,\bar{R}_E\}^2} < 0 \, . \end{aligned} \tag{A.19}$$

III. Welfare Effects

Embargo: For consumer welfare, $\tilde{P}^e < \tilde{P}^p$ if $r_W^e/x(\Theta_W^e) < r^p/x(\Theta^p)$ or $(\bar{R}_W + \tilde{\phi}^e\bar{R}_E)x(\Theta_W^e) > \bar{R}x(\Theta^p)$. Rearranging and inserting for $x(\Theta)$ yields the condition $\bar{R}\,[\Theta_W^e - \Theta^p] > (1-\phi)\bar{R}_E\,[\Theta_W^e - \Theta_E^e]$. Inserting for Θ reveals after some manipulations that this inequality is equivalent to $S^e > S^p$, which is satisfied.

For income in SW, comparing (9) with (13) reveals that $r_W^e > r^p$ since $\bar{R}_W + \tilde{\phi}^e\bar{R}_E < \bar{R}$.

Certification: For a comparison of consumer welfare under the embargo and under certification, note that $r_W^c/x(\Theta_W^c) < r_W^e/x(\Theta_W^e)$ is equivalent to

$$\begin{aligned}\left[\bar{R}_W + \left(gS^c + (1-S^c)\tilde{\phi}^c\right)\bar{R}_E\right] x(\Theta_W^c) &> \left[\bar{R}_W + \tilde{\phi}^e\bar{R}_E\right] x(\Theta_W^e) \quad \text{or} \\ [\bar{R} + (1-\phi)(X^c-1)(1-S^c)\bar{R}_E + (g-1)S^c\bar{R}_E]\,x(\Theta_W^c) &> [\bar{R} + (1-\phi)(X^e-1)\bar{R}_E]\,x(\Theta_W^e)\end{aligned}$$

Inserting for $x(\Theta)$ yields

$$[\bar{R} - (1-\phi)(1-S^c)\bar{R}_E]\,\mu\Theta_W^c + (g-1)S^c\bar{R}_E x(\Theta_W^c) > \bar{R}\mu\Theta_W^e + (1-\phi)\mu\,(\Theta_E^e - \Theta_W^e)\,\bar{R}_E \, .$$

For $g \to 1$ and after inserting for Θ_W^c, the l.h.s. of this inequality becomes $\bar{R}_W + S^c\bar{R}_E$. For the r.h.s., inserting for Θ_W^e and Θ_E^e yields $\bar{R}_W + S^e\bar{R}_E$. Thus, the above inequality is satisfied for $S^c > S^e$ if $g \to 1$.

For income in SW, equations (9) and (17) imply that $r_W^c > r^p$ if $\bar{R}_W + [gS^c + (1-S^c)\phi]\,\bar{R}_E < \bar{R}$ or $(g-\phi)S^c < 1-\phi$, which is satisfied.

Welfare in SE is equal to resource rents in SE minus costs of rent seeking, i.e.,

$$V_{SE} = \left[\hat{r}_L - \pi(\hat{r}_L - \hat{r}_I)\tilde{F} - (a+b)\,\tilde{F} - 0.5\gamma\tilde{F}^2\right]\bar{R}_E \, . \tag{A.20}$$

Inserting and rearranging yields

$$V_{SE}^p = \left[1 - \frac{5r^p}{32\gamma}\right] r^p \bar{R}_E \ ,$$

$$V_{SE}^e = \left[1 - \frac{5\hat{r}_E^e}{32\gamma}\right] \hat{r}_E^e \bar{R}_E \ , \quad \text{and}$$

$$V_{SE}^c = \left[1 - \frac{(\tilde{\phi}^c)^3 \left[4g^2 + 2g\tilde{\phi}^c - (\tilde{\phi}^c)^2\right] \hat{r}_I^c}{2\gamma g(g+\tilde{\phi}^c)^4}\right] \hat{r}_L^c \bar{R}_E \ . \tag{A.21}$$

For $r_L^c > r_E^e$ and $r_I^c < r_E^e$, sufficient for $V_{SE}^c > V_{SE}^e$ is

$$\frac{(\tilde{\phi}^c)^3 \left[4g^2 + 2g\tilde{\phi}^c - (\tilde{\phi}^c)^2\right]}{2\gamma g(g+\tilde{\phi}^c)^4} < \frac{5}{32\gamma} \ , \quad \text{or}$$

$$5\left[g^4 - (\tilde{\phi}^c)^4\right] + 25g^3\tilde{\phi}^c + 55g^2(\tilde{\phi}^c)^2 + 11(g - \tilde{\phi}^c)(\tilde{\phi}^c)^3 > 0 \ ,$$

which is satisfied.

Aggregate income in SW and SE with certification is given by

$$\begin{aligned} V_{SW}^c + V_{SE}^c &= r_W^c \bar{R}_W + \left[1 - \frac{(\tilde{\phi}^c)^3 \left[4g^2 + 2g\tilde{\phi}^c - (\tilde{\phi}^c)^2\right] \hat{r}_I^c}{2\gamma g(g+\tilde{\phi}^c)^4}\right] \hat{r}_L^c \bar{R}_E \\ &= \left[\bar{R}_W + g\bar{R}_E\right] r_W^c - \frac{(\tilde{\phi}^c)^2 \left[4g^2 + 2g\tilde{\phi}^c - (\tilde{\phi}^c)^2\right]}{2\gamma(g+\tilde{\phi}^c)^4} \left(\hat{r}_I^c\right)^2 \bar{R}_E \\ &= 2\alpha\bar{L}\rho - (1 - S^c)(\tilde{\phi}^c - g) r_W^c \bar{R}_E - \frac{(\tilde{\phi}^c)^2 \left[4g^2 + 2g\tilde{\phi}^c - (\tilde{\phi}^c)^2\right]}{2\gamma(g+\tilde{\phi}^c)^4} \left(\hat{r}_I^c\right)^2 \bar{R}_E \end{aligned}$$

Inserting for S^c and rearranging yields

$$V_{SW}^c + V_{SE}^c = 2\alpha\bar{L}\rho - \frac{\left(\tilde{\phi}^c\right)^4 + 2g^2\left(\tilde{\phi}^c\right)^2 + 2g\left(\tilde{\phi}^c\right)^3}{2\gamma\left(g+\tilde{\phi}^c\right)^4} \left(\hat{r}_I^c\right)^2 \bar{R}_E \tag{A.22}$$

Aggregate income in SW and SE with the embargo is given by

$$V_{SW}^e + V_{SE}^e = 2\alpha\bar{L}\rho - \frac{5\left(\hat{r}_E^e\right)^2}{32\gamma} \bar{R}_E \ . \tag{A.23}$$

Since $\hat{r}_I^c < \hat{r}_E^e$, sufficient for $V_{SW}^c + V_{SE}^c > V_{SW}^e + V_{SE}^e$ is

$$\frac{\left(\tilde{\phi}^c\right)^4 + 2g^2\left(\tilde{\phi}^c\right)^2 + 2g\left(\tilde{\phi}^c\right)^3}{2\gamma\left(g+\tilde{\phi}^c\right)^4} < \frac{5}{32\gamma} \quad \text{or}$$

$$5g^3 + 25g^2\tilde{\phi}^c + 23g\left(\tilde{\phi}^c\right)^2 + 11\left(\tilde{\phi}^c\right)^3 > 0 \ ,$$

which is satisfied.