Supplementary Document

This supplement starts with a table of notations. Then, it gives the proofs of all the lemmas and propositions, followed by an extension of the unreliable CM.

Table 1: Frequently Used Notations

	Subscript:
i	tier-2 supplier i=1,2
c/o	CM/OEM
	Superscript& Hat:
u^F	first best decisions in the centralized chain,
u	equilibrium outcomes under delegation,
$\hat{u}^i$	equilibrium outcomes under direct sourcing,
	System Parameters:
c_i	production cost of tier-2 supplier,
g_i	the density function of c_i
G_i	the distribution function of c_i
A_i	the working state of tier-2 supplier, 1/0=good/failure
α_i	the mean of A_i
p_{A_1,A_2}	the probability with tier-2 supplier i is A_i
k	CM's unit production cost
r	OEM's unit selling price
	Decisions:
q_i	the order quantity from tier-2 supplier i
	Functions:
π_j	player j's profit
	Notations for convenience
$\mathbf{c}$	(c_1, c_2)
$\mathbf{p}$	$(p_{11}, p_{10}, p_{01}, p_{00})$
$\mathbf{A}$	(A_1, A_2)
α	(α_1, α_2)
$\mathbf{q}$	$(q_1, q_2)'$
$S(\mathbf{Aq})$	$E_\xi[\min(\xi, \mathbf{Aq})]$
$R(\mathbf{q})$	$(r-k)E_{\mathbf{A}}S(\mathbf{Aq})$

A. Proofs of Formal Results

Proof of Proposition ??: According to Fudenberg and Tirole (1991, P257), a feasible direct sourcing mechanism can be fully characterized as follows: for all $i = 1, 2$,

$$\hat{\pi}_i(\mathbf{c}) = \hat{\pi}_i(c_{-i}, \overline{c}) + \int_{c_i}^{\overline{c}} \hat{q}_i(c_{-i}, x)dx,$$

for all c_{-i}, c_i;

2. $\hat{\pi}_i(\mathbf{c})$ is convex in c_i for all c_{-i}; that is, $\hat{q}_i(c_{-i}, c_i)$ is decreasing in c_i;
3. $\hat{\pi}_i(c_{-i}, \overline{c}) \geq 0$;
4. $$\hat{t}_i = \hat{m}_i + \alpha_i \hat{w}_i \hat{q}_i = \hat{\pi}_i(\mathbf{c}) + c_i \hat{q}_i(\mathbf{c}).$$

Note that if the production cost of a tier-2 supplier $i = 1, 2$ is $c_i = \overline{c}$, the OEM will set his profit to be 0, because otherwise, whenever this tier-2 supplier earns any positive profit, the OEM can decrease the transfer payment to increase the OEM's own profit without violating any constraint for tier-2 suppliers. Thus, $\hat{\pi}_i(c_{-i}, \overline{c}) = 0$ implies $\hat{\pi}_i(\mathbf{c}) = \int_{c_i}^{\overline{c}} \hat{q}_i(c_{-i}, x)dx$.

On the other hand, the CM's profit is 0 in this case of direct sourcing. Then, after substituting the profit of tier-2 suppliers, $\hat{\pi}_1$ and $\hat{\pi}_2$, into $\hat{\pi}_o$, the OEM's profit becomes

$$\begin{aligned}
\hat{\pi}_o &= \int_{\underline{c}}^{\bar{c}}\int_{\underline{c}}^{\bar{c}}[(r-k)E_{\mathbf{A}}S(\mathbf{A}\hat{q}(c_1,c_2)) - (c_1\hat{q}_1(c_1,c_2)+c_2\hat{q}_2(c_1,c_2)) - \sum_{i=1}^{2}\hat{\pi}_i]g_1(c_1)g_2(c_2)dc_1dc_2 \\
&= \int_{\underline{c}}^{\bar{c}}\int_{\underline{c}}^{\bar{c}}[R(\hat{q}(c_1,c_2)) - \sum_{i=1}^{2}(c_i\hat{q}_i(c_1,c_2)+\int_{c_i}^{\bar{c}}\hat{q}_i(c_{-i},x)dx)]g_1(c_1)g_2(c_2)dc_1dc_2 \\
&= \int_{\underline{c}}^{\bar{c}}\int_{\underline{c}}^{\bar{c}}[R(\mathbf{q}) - \sum_{i=1}^{n}(\nu_i(c_i))q_i(\mathbf{c})]g_1(c_1)g_2(c_2)dc_1dc_2,
\end{aligned}$$

where the last equality is from the integration by parts. Thus, (for given c_1 and c_2) the OEM's decision becomes equivalent to solving

$$\hat{q}(c)) := argmax_{\mathbf{q}}\{R(\mathbf{q}) - \sum_{i=1}^{n}(\nu_i(c_i))q_i(\mathbf{c})\},$$

the right-hand side of which is concave under *Assumption 1*.

As for the optimal solution of $\hat{q}(c_1,c_2)$, if $\hat{q}_1^*>0$ and $\hat{q}_2^*>0$, then both $\hat{q}_1^*$ and $\hat{q}_2^*$ should satisfy the first order condition (F.O.C), i.e., $dR(\hat{q}_1^*,\hat{q}_2^*)/d\hat{q}_i - \nu_i(c_i)=0$, because otherwise the OEM can change either $\hat{q}_1^*$ or $\hat{q}_2^*$ to improve her own profit. Therefore, for $i=1,2$

$$\hat{q}_i^*[dR(\hat{q}_1^*,\hat{q}_2^*)/d\hat{q}_i - \nu_i(c_i)] = 0.$$

On the other hand, if $\hat{q}_1^*=0$ and $\hat{q}_2^*>0$, then $\hat{q}_2^*$ should satisfy the first order condition (F.O.C), i.e., $dR(\hat{q}_1^*,\hat{q}_2^*)/d\hat{q}_2 - \nu_2(c_2)=0$, because otherwise the OEM can change $\hat{q}_2^*$ to improve her own profit. Therefore, for $i=1,2$

$$\hat{q}_i^*[dR(\hat{q}_1^*,\hat{q}_2^*)/d\hat{q}_i - \nu_i(c_i)] = 0.$$

Similarly, if $\hat{q}_1^*>0$ and $\hat{q}_2^*=0$, then $\hat{q}_1^*$ should satisfy the first order condition (F.O.C), i.e., $dR(\hat{q}_1^*,\hat{q}_2^*)/d\hat{q}_1 - \nu_1(c_1)=0$, because otherwise the OEM can change $\hat{q}_1^*$ to improve her own profit. Therefore, for $i=1,2$

$$\hat{q}_i^*[dR(\hat{q}_1^*,\hat{q}_2^*)/d\hat{q}_i - \nu_i(c_i)] = 0.$$

Finally, if $\hat{q}_1^*=\hat{q}_2^*=0$, then for $i=1,2$

$$\hat{q}_i^*[dR(\hat{q}_1^*,\hat{q}_2^*)/d\hat{q}_i - \nu_i(c_i)] = 0.$$

□

Proof of Proposition ??: (i) Given p_{10} and p_{01}, when there is dual sourcing,

$$\begin{aligned}
(r-k)[p_{11}\bar{F}(\hat{q}_1^*+\hat{q}_2^*)+p_{10}\bar{F}(\hat{q}_1^*)] &= \nu_1, \\
(r-k)[p_{11}\bar{F}(\hat{q}_1^*+\hat{q}_2^*)+p_{01}\bar{F}(\hat{q}_2^*)] &= \nu_2.
\end{aligned}$$

Then,

$$\begin{aligned}
\bar{F}(\hat{q}_1^*+\hat{q}_2^*) - p_{11}f(\hat{q}_1^*+\hat{q}_2^*)(\frac{d\hat{q}_1^*}{dp_{11}}+\frac{d\hat{q}_2^*}{dp_{11}}) - p_{10}f(\hat{q}_1^*)\frac{d\hat{q}_1^*}{dp_{11}} &= 0 \\
\bar{F}(\hat{q}_1^*+\hat{q}_2^*) - p_{11}f(\hat{q}_1^*+\hat{q}_2^*)(\frac{d\hat{q}_1^*}{dp_{11}}+\frac{d\hat{q}_2^*}{dp_{11}}) - p_{01}f(\hat{q}_2^*)\frac{d\hat{q}_2^*}{dp_{11}} &= 0.
\end{aligned}$$

So, $p_{10}f(\hat{q}_1^*)\frac{d\hat{q}_1^*}{dp_{11}} = p_{01}f(\hat{q}_2^*)\frac{d\hat{q}_2^*}{dp_{11}}$. Then, both $\frac{d\hat{q}_1^*}{dp_{11}}$ and $\frac{d\hat{q}_2^*}{dp_{11}}$ should have the same sign. As a consequence, it is easy to check $\frac{d\hat{q}_1^*}{dp_{11}} > 0$ and $\frac{d\hat{q}_2^*}{dp_{11}} > 0$.

(ii)

Let $\hat{q}_i^*(p_{11})$ denote the order quantity from tier-2 supplier i under p_{11}; then, for any $\epsilon > 0$,

$$\begin{aligned}&(p_{11}+\epsilon)\bar{F}(\hat{q}_1^*(p_{11}+\epsilon)+\hat{q}_2^*(p_{11}+\epsilon))\\&+(\alpha_1-(p_{11}+\epsilon))\bar{F}(\hat{q}_1^*(p_{11}+\epsilon)) = \nu_1/(r-k).\end{aligned} \tag{A-1}$$

Given α_1 and α_2, when there is dual sourcing,

$$\begin{aligned}(r-k)[p_{11}\bar{F}(\hat{q}_1^*+\hat{q}_2^*)+(\alpha_1-p_{11})\bar{F}(\hat{q}_1^*)] &= \nu_1,\\(r-k)[p_{11}\bar{F}(\hat{q}_1^*+\hat{q}_2^*)+(\alpha_2-p_{11})\bar{F}(\hat{q}_2^*)] &= \nu_2.\end{aligned}$$

Then,

$$\nu_1-(r-k)(\alpha_1-p_{11})\bar{F}(\hat{q}_1^*) = \nu_2-(r-k)(\alpha_2-p_{11})\bar{F}(\hat{q}_2^*),$$

which implies that when p_{11} increases, both $\frac{d\hat{q}_1^*}{dp_{11}}$ and $\frac{d\hat{q}_2^*}{dp_{11}}$ should have the same sign; otherwise, $\nu_1-(r-k)(\alpha_1-p_{11})\bar{F}(\hat{q}_1^*) = \nu_2-(r-k)(\alpha_2-p_{11})\bar{F}(\hat{q}_2^*)$ will no longer hold. That is, $[\hat{q}_1^*(p_{11}+\epsilon)-\hat{q}_1^*(p_{11})][\hat{q}_2^*(p_{11}+\epsilon)-\hat{q}_2^*(p_{11})] \geq 0$.

Clearly, if $\hat{q}_i^*(p_{11}+\epsilon) > \hat{q}_i^*(p_{11})$ for $i=1,2$, then

$$\begin{aligned}\nu_1/(r-k) &= p_{11}\bar{F}(\hat{q}_1^*(p_{11})+\hat{q}_2^*(p_{11}))+(\alpha_1-p_{11})\bar{F}(\hat{q}_1^*(p_{11}))\\&\geq p_{11}\bar{F}(\hat{q}_1^*(p_{11})+\hat{q}_2^*(p_{11}+\epsilon))+(\alpha_1-p_{11})\bar{F}(\hat{q}_1^*(p_{11}))\\&\geq p_{11}\bar{F}(\hat{q}_1^*(p_{11}+\epsilon)+\hat{q}_2^*(p_{11}+\epsilon))+(\alpha_1-p_{11})\bar{F}(\hat{q}_1^*(p_{11}+\epsilon))\\&> (p_{11}+\epsilon)\bar{F}(\hat{q}_1^*(p_{11}+\epsilon)+\hat{q}_2^*(p_{11}+\epsilon))+(\alpha_1-(p_{11}+\epsilon))\bar{F}(\hat{q}_1^*(p_{11}+\epsilon)),\end{aligned}$$

where the second inequality is because, given $\hat{q}_2^* \geq 0$, $p_{11}\bar{F}(x+\hat{q}_2^*)+(\alpha_1-p_{11})\bar{F}(x)$ decreases in x, while the last inequality occurs because $p_{11}\bar{F}(x_1+x_2)+(\alpha_1-p_{11})\bar{F}(x_1)$ decreases in p_{11}. Obviously, this is in contrast to (A-1). So, $\hat{q}_1^*(p_{11}+\epsilon) \leq \hat{q}_1^*(p_{11})$. Similarly, we can obtain $\hat{q}_2^*(p_{11}+\epsilon) \leq \hat{q}_2^*(p_{11})$. □

Proof of Proposition ??:

We define $\widetilde{g}_1(t)$ as the derivative of $\widetilde{G}(\alpha_1,t)$. In this proof, we omit the no-sourcing area under delegation, because when we follow the same steps as in the proof for direct sourcing, we can easily obtain this result for the no-sourcing area. For the remaining cases, because Lemma **??** implies that only one supplier is active under delegation, it suffices to consider the case of having an active supplier under delegation under $\alpha_1 \neq \alpha_2$ (The case of $\alpha_1 = \alpha_2$ can be found in the manuscript before presenting Proposition **??**).

As shown in the CM's optimal strategy in Lemma **??**, w affects which tier-2 supplier is active. This w is determined by the OEM, and Lemma **??** implies that only one supplier is active under delegation, so OEM actually determines which supplier is active. To simplify the analysis, we consider an equivalent question, in which the OEM decides which supplier is active, w is then determined accordingly. In this vein, we reformulating CM's profit as $\pi_c(c_1,c_2) = [(\alpha_1 w-c_1)y(c_1,c_2)+(\alpha_2 w-c_2)(1-y(c_1,c_2))]q$, where $y := y(c_1,c_2) = I_{\alpha_1 w-c_1\geq\alpha_2 w-c_2}$ is an indicator function, that is, $y(c_1,c_2)=1$ if $\alpha_1 w-c_1 \geq \alpha_2 w-c_2$, and $y(c_1,c_2)=0$ if $\alpha_1 w-c_1 < \alpha_2 w-c_2$.

According to Fudenberg and Tirole (1991, P257), a feasible mechanism should satisfy

$$\pi_c(\mathbf{c}) = \pi_c(c_{-i}, \bar{c}) + \int_{c_i}^{\bar{c}} \frac{d\pi_c(c_{-i}, c_i)}{dc_i} dt.$$

Note that when $c_1 = c_2 = \bar{c}$, the OEM will set the CM's profit to be 0, i.e., $\pi_c(\bar{c}, \bar{c}) = 0$. Because $\frac{d\pi_c}{dc_1} = -y(c_1, c_2)q$ and $\frac{d\pi_c}{dc_2} = -(1 - y(c_1, c_2))q$,

$$\begin{aligned}\pi_c(c_1, c_2) &= \pi_c(\bar{c}, \bar{c}) + \int_{c_1}^{\bar{c}} y(t, c_2)dt + \int_{c_2}^{\bar{c}} (1 - y(c_1, t))dt \\ &= [\int_{c_1}^{\bar{c}} y(t, c_2)dt + \int_{c_2}^{\bar{c}} (1 - y(c_1, t))dt]q\end{aligned}$$

Substituting it into OEM's profit, we have $\pi_o = \int_{c_1}^{\bar{c}} \int_{c_2}^{\bar{c}} [(y\alpha_1 + (1 - y)\alpha_2)rS(q) - yc_1q - (1 - y)c_2q - (\int_{c_1}^{\bar{c}} y(t, c_2)qdt + \int_{c_2}^{\bar{c}} (1 - y(c_1, t))qdt)]g_1(c_1)g_2(c_2)dc_1dc_2$

Checking the first derivative with respect to y, we obtain

$$y = \begin{cases} 1 & if \quad \alpha_1 rS(q) - \nu_1(c_1)q \geq \alpha_2 rS(q) - \nu_2(c_2)q \\ 0 & if \quad \alpha_1 rS(q) - \nu_1(c_1)q < \alpha_2 rS(q) - \nu_2(c_2)q. \end{cases}$$

Then, OEM's profit is $\pi_o = \int_{\underline{c}}^{\bar{c}} \int_{\underline{c}}^{\bar{c}_2(c_1)} [\alpha_2 rS(q) - \nu_2 q]g_1(c_1)g_2(c_2)dc_1dc_2 + \int_{\underline{c}}^{\bar{c}} \int_{\bar{c}_2(c_1)}^{\bar{c}} [\alpha_1 rS(q) - \nu_1 q]g_1(c_1)g_2(c_2)dc_1dc_2$. Given c_1, the maximization of the intergrand implies that q should be chosen to maximize each segment for either $c_2 \in [0, \bar{c}_2(c_1)]$ or $c_2 \in [\bar{c}_2(c_1), \bar{c}]$. Specifically, for $c_2 \in [0, \bar{c}_2(c_1)]$, the optimal quantity should be $q_1^* = 0$ and $q_2^* = Q_2(c_2)$, and CM's profit is $\pi_c = \int_0^{c_2} Q_2(x)dx$. However, for $c_2 \in [\bar{c}_2(c_1), \bar{c}]$, the optimal quantity is $q_2^* = 0$ and $q_1^* = Q_1(c_1)$, and the CM's profit is $\pi_c = \int_0^{c_1} Q_1(x)dx$.

Furthermore, given the optimal quantity, w can be chosen accordingly: $w \geq \frac{\bar{c}_2(c_1) - c_1}{\alpha_2 - \alpha_1}$ for $c_2 \in [0, \bar{c}_2(c_1)]$, while $w \leq \frac{\bar{c}_2(c_1) - c_1}{\alpha_2 - \alpha_1}$ for $c_2 \in [\bar{c}_2(c_1), \bar{c}]$. Given this w, m is adjusted to let $\pi_c = \int_{\underline{c}}^{c_1} Q_1(x)dx$. □

Proof of Proposition ??: (i) It follows simply from the partition of sourcing areas by using $c_i \leq \nu_i$ for $i = 1, 2$.

(ii) Comparing different areas, in the no-sourcing and the single-sourcing areas under direct sourcing, the OEM's profit is the same as that under delegation, whereas in the dual-sourcing area under direct sourcing, the OEM's profit is larger than that under delegation. In the single-sourcing or no-sourcing area, given α_1 and α_2, $\frac{d\hat{\pi}_o}{dp_{11}} = \frac{d\pi_o}{dp_{11}} = 0$. For the dual-sourcing area under direct sourcing,

$$\hat{\pi}_o = p_{11}rS(\hat{q}_1^* + \hat{q}_2^*) + (\alpha_1 - p_{11})rS(\hat{q}_1^*) + (\alpha_2 - p_{11})S(\hat{q}_2^*) - \nu_1\hat{q}_1^* - \nu_2\hat{q}_2^*,$$

Fixing α_1 and α_2, according to the envelope theorem, i.e., $d\hat{\pi}_o/d\hat{q}_1^* = 0$ and $d\hat{\pi}_o/d\hat{q}_2^* = 0$, we can easily show that $\frac{d\hat{\pi}_o}{dp_{11}} = r[S(\hat{q}_1^* + \hat{q}_2^*) - S(\hat{q}_1^*) - S(\hat{q}_2^*)] \leq 0$. However, under delegation, the fixed α_1 and α_2 imply that $\frac{d\pi_o}{dp_{11}} = 0$.

□

Proof of Lemma ??: First, note that if $p_{10} \geq c_1/w$, the CM will order q units from tier-2 supplier 1, because $p_{10}wq_1 - c \geq 0$ implies that it is profitable to order from tier-2 supplier

1, no matter how many units will be ordered from tier-2 supplier 2; Similarly, if $p_{01} \geq c_2/w$, tier-2 supplier 2 is active from which the CM orders q units.

Second, the case of $p_{10} < c_1/w$ and $p_{01} < c_2/w$, the decision of a deep-pocket CM is the same as that of the budget constrained CM. $\square$

Proof of Proposition ??: As shown in Lemma **??** above, when c_1 is sufficiently small, tier-2 supplier 1 will be active no matter whether tier-2 supplier 2 is active or not. Similarly, when c_2 is sufficiently small, tier-2 supplier 2 will be active no matter whether tier-2 supplier 1 is active or not. Thus, there exist two thresholds $\bar{c}_1^d(c_2)$ and $\bar{c}_2^d(c_1)$ such that both tier-2 suppliers will be active when $c_2 \in [\underline{c}, \bar{c}_2^d(c_1))$ and $c_1 \in [\underline{c}, \bar{c}_1^d(c_2))$, and at most one tier-2 supplier will be active if $c_2 > \bar{c}_2^d(c_1)$ or $c_1 > \bar{c}_1^d(c_2)$.

In the case of dual sourcing, the OEM will set $q(c_1, c_2) = argmax_q[(p_{10} + p_{01} + p_{11})S(q) - (v_1(c_1) + v_2(c_2))q]$ to maximize her own profit, so the wholesale price should satisfy $w(c_1, c_2) \leq (c_1/p_{10}) \wedge (c_2/p_{01})$ to ensure that both tier-2 suppliers will be active. As such, the CM's profit is $\pi_c = \int_{\underline{c}}^{c_1} \int_{\underline{c}}^{c_2} q(x_1, x_2) dx_1 dx_2$.

On the other hand, if $c_2 > \bar{c}_2^d(c_1)$ or $c_1 > \bar{c}_1^d(c_2)$, the equilibrium is similar to Proposition **??** above. $\square$

Proof of Proposition ??: When there is at most one tier-2 supplier is active, the proof of $\hat{\pi}_o \geq \pi_o$ is similar to the case of the budget constrained CM above. When there is "duplicate" dual sourcing, the deep-pocket CM will order $q_1 = q_2 = q$ units. This same order quantity setting can be treated as a special case of different order quantities $q_1 \neq q_2$ under direct sourcing above. Hence, $\hat{\pi}_o \geq \pi_o$.

$\square$

Proof of Proposition ??: The concavity of the CM's profit in q_1 and q_2 implies that the CM will set the order quantity according to F.O.C. Moreover, a feasible mechanism requires that $\pi_c' = \int_{c_1}^{\bar{c}} q_1(x, c_2) dx + \int_{c_2}^{\bar{c}} q_2(c_1, x) dx$, and $\phi[p_{11}(rS(q_1+q_2) + w(q_1+q_2)) + p_{10}(rS(q_1) + wq_1) + p_{01}(rS(q_2) + wq_2)] - c_1 q_1 - c_2 q_2 = \int_{c_1}^{\bar{c}} q_1(x) dx + \int_{c_2}^{\bar{c}} q_2(x) dx$. Substituting it into the OEM's profit, we obtain the OEM's profit as $\int_{\underline{c}}^{\bar{c}} \int_{\underline{c}}^{\bar{c}} \pi_o(c_1, c_2) dc_1 dc_2$, where

$$
\begin{aligned}
& \pi_o(c_1, c_2) \\
= \; & [p_{11}((1-\phi)rS(q_1(c_1,c_2) + q_2(c_1,c_2)) - w(q_1(c_1,c_2) + q_2(c_1,c_2))) \\
& + p_{10}((1-\phi)rS(q_1(c_1,c_2)) - wq_1(c_1,c_2)) + p_{01}((1-\phi)rS(q_2(c_1,c_2)) - wq_2(c_1,c_2))] \\
= \; & r[p_{11}S(q_1(c_1,c_2) + q_2(c_1,c_2)) + p_{10}S(q_1(c_1,c_2)) + p_{01}q_2(c_1,c_2))] \\
& - c_1 q_1(c_1,c_2) - c_2 q_2(c_1,c_2) - \int_{c_1}^{\bar{c}} q_1(x, c_2) dx - \int_{c_2}^{\bar{c}} q_2(c_1, x) dx.
\end{aligned}
$$

$$
\begin{aligned}
& \int_{\underline{c}}^{\bar{c}} \int_{\underline{c}}^{\bar{c}} \pi_o(c_1, c_2) dc_1 dc_2 \\
= \; & \int_{\underline{c}}^{\bar{c}} \int_{\underline{c}}^{\bar{c}} r[p_{11}S(q_1(c_1,c_2) + q_2(c_1,c_2)) + p_{10}S(q_1(c_1,c_2)) + p_{01}S(q_2(c_1,c_2))] \\
& - \nu_1 c_1 q_1(c_1,c_2) - \nu_2 c_2 q_2(c_1,c_2),
\end{aligned}
$$

where the last equality arises because we obtain the following through integration of the parts, we have

$$\int_{\underline{c}}^{\overline{c}} \int_{c_1}^{\overline{c}} q_1(x, c_2) dx g_1(c_1) dc_1 = \int_{\underline{c}}^{\overline{c}} q_1(c_1, c_2) G_1(c_1) dc_1,$$
$$\int_{\underline{c}}^{\overline{c}} \int_{c_2}^{\overline{c}} q_1(c_1, x) dx g_2(c_2) dc_2 = \int_{\underline{c}}^{\overline{c}} q_2(c_1, c_2) G_2(c_2) dc_2$$

Then, the first-order conditions of OEM's profit with respect to q_1 and q_2 imply that

$$q_1(c_1, c_2)[rp_{11}\bar{F}(q_1(c_1, c_2) + q_2(c_1, c_2)) + rp_{10}\bar{F}(q_1(c_1, c_2)) - \nu_1(c_1)] = 0,$$
$$q_2(c_1, c_2)[rp_{11}\bar{F}(q_1(c_1, c_2) + q_2(c_1, c_2)) + rp_{01}\bar{F}(q_2(c_1, c_2)) - \nu_2(c_2)] = 0,$$

which is the same as the procurement portfolio under direct sourcing characterized by (**??**), and the OEM's profit is therefore identical to that under direct sourcing. □

Proof of Proposition ??: It suffices to consider that when there is dual sourcing under direct sourcing, there exist wholesale prices w_b and w_l under which CM will adopt dual sourcing. Payment to the CM less the CM's procurement cost is his profit, or the information rent, which is collected on the basis of his private information on c_1 and c_2. Similar to the proof of Proposition **??**, a feasible mechanism requires that $\pi_c^{'} = \int_{c_1}^{\overline{c}} q_1(x)dx + \int_{c_2}^{\overline{c}} q_2(x)dx$. Substituting the CM's profit into the OEM's profit, we have the same formulation of the OEM's profit function as that under direct sourcing. □

Proof of Corollary ??: Here, we identify a pair of w_b and w_l which can achieve the procurement portfolio under direct sourcing. Given $\nu_1 \leq \nu_2$, (**??**) in Proposition **??** implies that $\hat{q}_1^* \geq \hat{q}_2^* > 0$ and $rp_{11}\bar{F}(\hat{q}_1^* + \hat{q}_2^*)/\nu_1 \leq 1$. If $q_b \in [\hat{q}_2^*, \hat{q}_1^*]$, then $t_c = p_{11}[w_b q_b + w_l(S(q_1 + q_2) - S(q_b))] + p_{10}[w_b q_b + w_l(S(q_1) - S(q_b))] + p_{01} w_b q_2$. It is optimal to set w_l and w_b according to F.O.C, or by satisfying $d\pi_c/dq_1 = w_l[p_{11}\bar{F}(\hat{q}_1^* + \hat{q}_2^*) + p_{10}\bar{F}(\hat{q}_1^*)] - c_1 = 0$, $d\pi_c/dq_2 = w_l p_{11}\bar{F}(\hat{q}_1^* + \hat{q}_2^*) + w_b p_{01} - c_2 = 0$. Therefore, $w_l = (r-k)c_1/\nu_1 < r - k$ and $w_b = [c_2 - (r-k)p_{11}c_1\bar{F}(\hat{q}_1^* + \hat{q}_2^*)/\nu_1]/p_{01} \geq (c_2 - c_1)/p_{01} \geq 0$. Other cases of no sourcing and single sourcing can be proven similarly. □

B. Extension: Unreliable CM

In the previous analysis, we assume that CM is reliable without disruption. Now, we assume that the CM disrupts with a probability $1-\alpha_c$, so with probability α_c the CM is in a good state to make assembly. When the CM disrupts, no product can be assembled for the OEM, so the OEM obtains zero revenue. Instead, when the CM is in a good state to make assembly, the OEM's revenue is $R(\mathbf{q}) = (r-k)E_{\mathbf{A}}S(\mathbf{A}\mathbf{q})$. Thus, the OEM's expected revenue is $\alpha_c R(\mathbf{q})$. As such, in all the remaining analysis in the manuscript, we can replace $R(\mathbf{q})$ with $\alpha_c R(\mathbf{q})$. This will lead to the same results as $\alpha_c = 1$.