Business Commonality, Standardization and Product Cycles

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February 28, 2022

Appendix: Setting up a Multinational Corporation

We now extend the analysis by turning to production in the South via setting up a multinational corporation instead of arm's length contracting. We focus on incentives and abstain from set up costs. Similarly, we abstained from transaction cost considerations under arm's length contracting. To get a benchmark for the South, initially we assume that all tasks are undertaken in the South, and the North simply maintains the R&D stage and the headquarters. We assume that if production is offshored by setting up a multinational corporation, then, each worker engaged in a given task, θ, in the South obtains

$$x_i^S(\theta) = a^S + e_i^S(\theta) + \eta + \xi_i^S, \tag{1}$$

that is, now there is commonality with the high-tech stage (i.e., η enters the production function in the South).[1] The northern branch exports managerial expertise in implementing relative performance evaluation contracts that can provide stronger incentives. To ease the exposition, we assume that common uncertainty σ_η^2 is sufficiently large so that the Southern branch also uses a tournament $w_i^S(\theta) = b^S(\theta) + \beta^S(\theta)[x_i^S(\theta) - \overline{x}^S]$, where $[b^S(\theta), \beta^S(\theta)]$ are the contractual parameters to be determined by the firm. We still adhere to alternative assumption (iia), and we make the additional assumption that $n\delta\tau(\theta) \geq 1$, $\forall\theta > 0$. Note that assumption (iii) implies that $\sigma_\eta^2 > (1/(n-1))\,\varsigma_\xi^2$ is sufficient to ensure that tournaments are used both in the North and in the South.[2]

[1] For concreteness, we assume that the southern branch of a multinational corporation faces the exact same common shock η that the northern branch faces. In reality, the southern branch will face common shocks that are correlated to the common shocks faced by the northern branch. We conjecture that the results are quantitatively similar.

[2] In other words, $\sigma_\eta^2 > (1/(n-1))\,\sigma_\xi^2$ and $\sigma_\eta^2 > (1/(n-1))\,\varsigma_\xi^2$.

The payment scheme now takes the form

$$\begin{aligned} w_i(\theta) &= w_i^S(\theta) = b^S(\theta) + \beta^S(\theta)[x_i^S(\theta) - \overline{x}^S(\theta)] \\ &= b^S(\theta) + \beta^S(\theta)\left[x_i^S(\theta) - \frac{\sum_{i=1}^{n\delta\tau(\theta)} x_i^S(\theta)}{n\delta\tau(\theta)}\right] \\ &= b^S(\theta) + \beta^S(\theta)\left[a^S + e_i^S(\theta) + \eta + \xi_i^S - \frac{\sum_{i=1}^{n\delta\tau(\theta)} \left(a^S + e_i^S(\theta) + \eta + \xi_i^S\right)}{n\delta\tau(\theta)}\right] \\ &= b^S(\theta) + \beta^S(\theta)\left[\frac{n\delta\tau(\theta)-1}{n\delta\tau(\theta)} e_i^S(\theta) - \frac{1}{n\delta\tau(\theta)}\sum_{j\neq i} e_j^S(\theta) + \frac{n\delta\tau(\theta)-1}{n\delta\tau(\theta)}\xi_i^S - \frac{1}{n\delta\tau(\theta)}\sum_{j\neq i}\xi_j^S\right]. \end{aligned} \tag{2}$$

First, the firm calculates each worker's expected utility:

$$EU_i^S = -\exp\left\{-r\left[\begin{array}{c} b^S(\theta) + \beta^S(\theta)\frac{n\delta\tau(\theta)-1}{n\delta\tau(\theta)} e_i^S(\theta) - \beta^S(\theta)\frac{1}{n\delta\tau(\theta)}\sum_{j\neq i} e_j^S(\theta) - \\ -\frac{\left(e_i^S(\theta)\right)^2}{2a} - \frac{n\delta\tau(\theta)-1}{n\delta\tau(\theta)}\frac{r\left(\beta^S(\theta)\right)^2 \varsigma_\xi^2}{2} \end{array}\right]\right\}. \tag{3}$$

To ensure the compatibility of the contract with worker incentives to perform, the firm calculates the effort level that maximizes (3). First order conditions yield

$$e_i^S(\theta) = \frac{n\delta\tau(\theta)-1}{n\delta\tau(\theta)} a^S \beta^S(\theta). \tag{4}$$

Given (4), and similar to the all North case in Section 3b above, the worker's individual rationality constraint then implies

$$EU_i^S = -1 \iff$$

$$\iff b^S(\theta) = \frac{1}{2}\frac{n\delta\tau(\theta)-1}{n\delta\tau(\theta)}\left(\frac{n\delta\tau(\theta)-1}{n\delta\tau(\theta)} a^S + r\varsigma_\xi^2\right)\left(\beta^S(\theta)\right)^2 \tag{5}$$

Then, the firm selects $\beta^S(\theta)$ that maximizes expected total profit

$$\begin{aligned}
ET\Pi^S &= Ey^S - E\int_0^1 \sum_{i=1}^{n\delta\tau(\theta)} w_i^S(\theta)d\theta = Ey^S - \int_0^1 \sum_{i=1}^{n\delta\tau(\theta)} Ew_i^S(\theta)d\theta \qquad (6)\\
&= n\delta a^S \int_0^1 \tau(\theta)d\theta + \int_0^1 \sum_{i=1}^{n\delta\tau(\theta)} e_i^S(\theta)d\theta + n\delta\mu \int_0^1 \tau(\theta)d\theta - \\
&\quad - \int_0^1 \sum_{i=1}^{n\delta\tau(\theta)} E\left[b^S(\theta) + \beta^S(\theta)\left[\begin{array}{c} \frac{n\delta\tau(\theta)-1}{n\delta\tau(\theta)} e_i^S(\theta) - \frac{1}{n\delta\tau(\theta)}\sum_{j\neq i} e_j^S(\theta) + \frac{n\delta\tau(\theta)-1}{n\delta\tau(\theta)}\xi_i^S - \\ - \frac{1}{n\delta\tau(\theta)}\sum_{j\neq i}\xi_j^S \end{array}\right]\right] d\theta \\
&= n\delta a^S \int_0^1 \tau(\theta)d\theta + a^S \int_0^1 \left(n\delta\tau(\theta) - 1\right)\beta^S(\theta)d\theta + n\delta\mu \int_0^1 \tau(\theta)d\theta - \\
&\quad - \frac{1}{2}\int_0^1 \left[\left(n\delta\tau(\theta) - 1\right)\left(\frac{n\delta\tau(\theta) - 1}{n\delta\tau(\theta)}a^S + r\varsigma_\xi^2\right)\left(\beta^S(\theta)\right)^2\right] d\theta.
\end{aligned}$$

Maximizing (6) with respect to $\beta^S(\theta)$ yields:

$$(n\delta\tau(\theta) - 1)a^S - (n\delta\tau(\theta) - 1)\left(\frac{n\delta\tau(\theta) - 1}{n\delta\tau(\theta)}a^S + r\varsigma_\xi^2\right)\beta^S(\theta) = 0,\ \forall\theta,$$

therefore,

$$\beta^S(\theta) = \frac{a^S}{\frac{n\delta\tau(\theta)-1}{n\delta\tau(\theta)}a^S + r\varsigma_\xi^2},\ \forall\theta. \qquad (7)$$

Given this, $b^S(\theta)$ can be written as

$$b^S(\theta) = \frac{1}{2}\frac{\left(a^S\right)^2}{a^S + \frac{n\delta\tau(\theta)}{n\delta\tau(\theta)-1}r\varsigma_\xi^2},\ \forall\theta. \qquad (8)$$

Hence, the firm's expected profit under tournaments when production takes place in the South is

$$\begin{aligned}
ET\Pi^S &= n\delta a^S \int_0^1 \tau(\theta)d\theta + \int_0^1 \left(n\delta\tau(\theta) - 1\right)\frac{\left(a^S\right)^2}{\frac{n\delta\tau(\theta)-1}{n\delta\tau(\theta)}a^S + r\varsigma_\xi^2}d\theta + \qquad (9)\\
&\quad n\delta\mu\int_0^1 \tau(\theta)d\theta - \frac{1}{2}\int_0^1 \left(n\delta\tau(\theta) - 1\right)\frac{\left(a^S\right)^2}{\frac{n\delta\tau(\theta)-1}{n\delta\tau(\theta)}a^S + r\varsigma_\xi^2}d\theta \\
&= n\delta\left(a^S + \mu\right)\int_0^1 \tau(\theta)d\theta + n\delta\frac{1}{2}\int_0^1 \frac{\left(a^S\right)^2}{a^S + \frac{n\delta\tau(\theta)}{(n\delta\tau(\theta)-1)}r\varsigma_\xi^2}\tau(\theta)d\theta.
\end{aligned}$$

Given the analysis above, if production could be fragmented, the firm's expected profit under a multinational corporation and tournaments in the North and in the South would be equal to

$$n(1-\theta^*)(a+\mu)+n(1-\theta^*)\frac{1}{2}\frac{a^2}{a+\frac{n}{n-1}r\sigma_\xi^2}+n\delta\left(a^S+\mu\right)\int_0^{\theta^*}\tau(\theta)d\theta+ \tag{10}$$
$$+n\delta\frac{1}{2}\int_0^{\theta^*}\frac{\left(a^S\right)^2}{a^S+\frac{n\delta\tau(\theta)}{(n\delta\tau(\theta)-1)}r\varsigma_\xi^2}\tau(\theta)d\theta.$$

Maximizing this profit with respect to θ^* yields

$$-n(a+\mu)-n\frac{1}{2}\frac{a^2}{a+\frac{n}{n-1}r\sigma_\xi^2}+n\delta\left(a^S+\mu\right)\tau(\theta^*)+n\delta\frac{1}{2}\frac{d}{d\theta^*}\left[\int_0^{\theta^*}\frac{\left(a^S\right)^2}{a^S+\frac{n\delta\tau(\theta)}{(n\delta\tau(\theta)-1)}r\varsigma_\xi^2}\tau(\theta)d\theta\right]=0. \tag{11}$$

By using *Leibniz's integral rule*, it follows that

$$\begin{aligned}
&\frac{d}{d\theta^*}\left[\int_0^{\theta^*}\frac{\left(a^S\right)^2}{a^S+\frac{n\delta\tau(\theta}{(n\delta\tau(\theta)-1)}r\varsigma_\xi^2}\tau(\theta)d\theta\right]\\
=\;&\frac{\left(a^S\right)^2}{a^S+\frac{n\delta\tau(\theta^*)}{(n\delta\tau(\theta^*)-1)}r\varsigma_\xi^2}\tau(\theta^*)\frac{d\theta^*}{d\theta^*}-\frac{\left(a^S\right)^2}{a^S+\frac{n\delta\tau(0)}{(n\delta\tau(0)-1)}r\varsigma_\xi^2}\tau(0)\frac{d0}{d\theta^*}+\int_0^{\theta^*}\frac{d}{d\theta^*}\left[\frac{\left(a^S\right)^2}{a^S+\frac{n\delta\tau(\theta)}{(n\delta\tau(\theta)-1)}r\varsigma_\xi^2}\tau(\theta)\right]d\theta\\
=\;&\frac{\left(a^S\right)^2}{a^S+\frac{n\delta\tau(\theta^*)}{(n\delta\tau(\theta^*)-1)}r\varsigma_\xi^2}\tau(\theta^*)-0+0\\
=\;&\frac{\left(a^S\right)^2}{a^S+\frac{n\delta\tau(\theta^*)}{(n\delta\tau(\theta^*)-1)}r\varsigma_\xi^2}\tau(\theta^*).
\end{aligned}$$

Hence, (11) becomes

$$-n(a+\mu)-n\frac{1}{2}\frac{a^2}{a+\frac{n}{n-1}r\sigma_\xi^2}+n\delta\left(a^S+\mu\right)\tau(\theta^*)+n\delta\frac{1}{2}\frac{\left(a^S\right)^2}{a^S+\frac{n\delta\tau(\theta^*)}{(n\delta\tau(\theta^*)-1)}r\varsigma_\xi^2}\tau(\theta^*)=0.$$

For illustrative purposes, by assuming again that $\tau(\theta)=\frac{1}{\theta}$, with $\theta>0$, the condition is rewritten as

$$-(a+\mu)-\frac{1}{2}\frac{a^2}{a+\frac{n}{n-1}r\sigma_\xi^2}+\delta(a^S+\mu)\frac{1}{\theta^*}+\frac{1}{2}\delta\frac{\left(a^S\right)^2\frac{1}{\theta^*}}{a^S+\frac{n\delta\frac{1}{\theta^*}}{\left(n\delta\frac{1}{\theta^*}-1\right)}r\varsigma_\xi^2}=0,\;\forall\theta^*>0. \tag{12}$$

Let $\Theta^*=\frac{1}{\theta^*}$. The condition then yields

$$\frac{(a^S+\mu)\Theta^* 2\left[a^S\left(n\delta\Theta^*-1\right)+n\delta\Theta^* r\varsigma_\xi^2\right]+\left(a^S\right)^2\Theta^*\left(n\delta\Theta^*-1\right)}{2\left[a^S\left(n\delta\Theta^*-1\right)+n\delta\Theta^* r\varsigma_\xi^2\right]}-$$
$$-\frac{1}{\delta}\left[(a+\mu)+\frac{1}{2}\frac{a^2}{a+\frac{n}{n-1}r\sigma_\xi^2}\right] = 0,\ \forall\Theta^*>0.$$

Now let $A\equiv\frac{1}{\delta}\left[(a+\mu)+\frac{1}{2}\frac{a^2}{a+\frac{n}{n-1}r\sigma_\xi^2}\right]$. Hence, the condition becomes

$$\left[3\left(a^S\right)^2 n\delta+2\mu a^S n\delta+2a^S n\delta r\varsigma_\xi^2+2\mu n\delta r\varsigma_\xi^2\right]\left(\Theta^*\right)^2-$$
$$-\left[3\left(a^S\right)^2+2\mu a^S+A2a^S n\delta+A2n\delta r\varsigma_\xi^2\right]\Theta^*+A2a^S = 0.$$

The solution to the quadratic then satisfies

$$\Theta^*=\frac{1}{\theta^*}=\frac{\left[3\left(a^S\right)^2+2\mu a^S+A2a^S n\delta+A2n\delta r\varsigma_\xi^2\right]\pm\sqrt{\Delta}}{2\left[3\left(a^S\right)^2 n\delta+2\mu a^S n\delta+2a^S n\delta r\varsigma_\xi^2+2\mu n\delta r\varsigma_\xi^2\right]}, \tag{13}$$

where

$$\Delta = \left[3\left(a^S\right)^2+2\mu a^S+A2a^S n\delta+A2n\delta r\varsigma_\xi^2\right]^2-$$
$$-4\left[3\left(a^S\right)^2 n\delta+2\mu a^S n\delta+2a^S n\delta r\varsigma_\xi^2+2\mu n\delta r\varsigma_\xi^2\right]A2a^S.$$

A comparison of θ^* yields more offshoring (i.e., a higher θ^*) under tournaments in the North and piece rates in the South via arm's length contracting, than under tournaments in the North and the South and a multinational corporation, when

$$\frac{a^S+\frac{1}{2}\frac{(a^S)^2}{a^S+r\varsigma_\xi^2}-\widehat{U}}{\mu+a+\frac{1}{2}\frac{a^2}{a+\frac{n}{n-1}r\sigma_\xi^2}}>\frac{2n\left[3\left(a^S\right)^2+2\mu a^S+2a^S r\varsigma_\xi^2+2\mu r\varsigma_\xi^2\right]}{\left[3\left(a^S\right)^2+2\mu a^S+A2a^S n\delta+A2n\delta r\varsigma_\xi^2\right]\pm\sqrt{\Delta}}.$$

Obviously the condition is quite complicated and it is not clear what the impact of expected commonality μ, abilities a and a^S, and idiosyncratic shocks σ_ξ^2 and ς_ξ^2 is. But one thing is clear. If the reservation utility in the South is sufficiently negative (i.e., $-\widehat{U}$ is sufficiently large), you would offshore more under tournaments in the North and piece rates in the South via arm's length contracting, rather than under tournaments in the North and the South and a multinational corporation, to benefit from the reduced costs in the South. Otherwise, we conjecture that you offshore more under tournaments in the North and the

South and a multinational corporation, rather than under tournaments in the North and piece rates in the South via arm's length contracting. Setting up a multinational corporation allows you to strengthen business commonality in production; it also allows the export of managerial practices and, in particular, know-how related to the implementation of more sophisticated incentive contracts such as relative performance evaluation tournaments, which provide stronger incentives.