Managing Trade: Evidence from China and the US*

Nick Bloom
Stanford University

Kalina Manova
University College London

John Van Reenen
MIT

Stephen Teng Sun
Peking University

Zhihong Yu
University of Nottingham

January 2018

Abstract

This appendix provides formal proofs for the baseline model in the paper and presents three theoretical extensions for endogenous choice of management practices, multiple components of firm ability, and endogenous choice of input and output quality.

1 Proofs for Baseline Model

1.1 Set Up

Product demand. The representative consumer in country j has CES utility

$$U_j = \left[\int_{i\in\Omega_j} (q_{ji}x_{ji})^{\alpha} di\right]^{\frac{1}{\alpha}} \tag{1.1}$$

*We thank Rui Zhang and Xincheng Qiu of Peking University for his excellent research assistance for this appendix.

where q_{ji} and x_{ji} are quality and quantity consumed by country j of variety i, and Ω_j is the set of goods available to j. The elasticity of substitution across products is $\sigma = 1/(1-\alpha) > 1$ with $0 < \alpha < 1$. If total expenditure in country j is R_j, j's demand for variety i is

$$x_{ji} = R_j P_j^{\sigma-1} q_{ji}^{\sigma-1} p_{ji}^{-\sigma}. \tag{1.2}$$

Proof. The utility maximization problem is

$$\max_{\{x_{ji}\}} U_j = \left[\int_{i\in\Omega_j} (q_{ji}x_{ji})^{\alpha} di\right]^{\frac{1}{\alpha}} \quad \text{s.t.} \quad \int_{i\in\Omega_j} (p_{ji}x_{ji})\, di = R_j. \tag{1.3}$$

where p_{ji} is the price of variety i in country j. Define the Lagrangian function as

$$L = \left[\int_{i\in\Omega_j} (q_{ji}x_{ji})^{\alpha} di\right]^{\frac{1}{\alpha}} + \lambda\left(R_j - \int_{i\in\Omega_j} (p_{ji}x_{ji})\, di\right). \tag{1.4}$$

The first order condition implies:

$$\frac{\partial L}{\partial x_{ji}} = \left[\int_{i\in\Omega_j} (q_{ji}x_{ji})^{\alpha} di\right]^{\frac{1-\alpha}{\alpha}} (q_{ji}x_{ji})^{\alpha-1} q_{ji} - \lambda p_{ji} = 0, \tag{1.5}$$

$$\implies x_{ji} = \frac{\left(\lambda \frac{p_{ji}}{q_{ji}}\right)^{\frac{1}{\alpha-1}} \left[\int_{i\in\Omega_j} (q_{ji}x_{ji})^{\alpha} di\right]^{\frac{1}{\alpha}}}{q_{ji}}. \tag{1.6}$$

Substituting for x_{ji} in the budget constraint and rearranging yields

$$\lambda = \left\{\frac{\left[\int_{i\in\Omega_j} (q_{ji}x_{ji})^{\alpha} di\right]^{\frac{1}{\alpha}} \int_{i\in\Omega_j} \left(\frac{p_{ji}}{q_{ji}}\right)^{1-\sigma} di}{R_j}\right\}^{1-\alpha} \quad \text{and} \tag{1.7}$$

$$x_{ji} = R_j P_j^{\sigma-1} q_{ji}^{\sigma-1} p_{ji}^{-\sigma}, \tag{1.8}$$

where we have used $\sigma = 1/(1-\alpha)$ and defined $P_j \equiv \left[\int_{i\in\Omega_j} \left(\frac{p_{ji}}{q_{ji}}\right)^{1-\sigma} di\right]^{\frac{1}{1-\sigma}}$ as a quality-adjusted ideal price index. ■

1.2 Profit Maximization

Optimal firm behavior. Individual producers separately maximize profits for each destination-product market by solving

$$\begin{aligned} \max_{p_{ji},x_{ji}} \pi_{ji} &= p_{ji}x_{ji} - \tau_j x_{ji} (\varphi\lambda_i)^{\theta-\delta} - f_{pj} \\ \text{s.t. } x_{ji} &= R_j P_j^{\sigma-1} q_{ji}^{\sigma-1} p_{ji}^{-\sigma}. \end{aligned} \tag{1.9}$$

Product quality is exogenously determined by the quality production function as $q_{ji} = q_i = (\varphi\lambda_i)^{\theta}$. A producer with management competence φ and product expertise λ_i will therefore charge a constant mark-up $\frac{1}{\alpha}$ over marginal cost and have the following price, quantity, quality, quality-adjusted price, revenues and profits for product i in market j:

$$
\begin{aligned}
p_{ji}(\varphi,\lambda_i) &= \frac{\tau_j(\varphi\lambda_i)^{\theta-\delta}}{\alpha}, \qquad x_{ji}(\varphi,\lambda_i) = R_j P_j^{\sigma-1}\left(\frac{\alpha}{\tau_j}\right)^{\sigma}(\varphi\lambda_i)^{\delta\sigma-\theta}, && (1.10)\\
q_i(\varphi,\lambda_i) &= (\varphi\lambda_i)^{\theta}, \qquad p_{ji}(\varphi,\lambda_i)/q_i(\varphi,\lambda_i) = \frac{\tau_j(\varphi\lambda_i)^{-\delta}}{\alpha}, && (1.11)\\
r_{ji}(\varphi,\lambda_i) &= R_j\left(\frac{P_j\alpha}{\tau_j}\right)^{\sigma-1}(\varphi\lambda_i)^{\delta(\sigma-1)}, \qquad \pi_{ji}(\varphi,\lambda_i) = \frac{r_{ji}(\varphi,\lambda_i)}{\sigma} - f_{pj}. && (1.12)
\end{aligned}
$$

Proof. Define the Lagrangian function as

$$
L = p_{ji}x_{ji} - \tau_j x_{ji}(\varphi\lambda_i)^{\theta-\delta} - f_{pj} + \mu\left(R_j P_j^{\sigma-1}(\varphi\lambda_i)^{\theta(\sigma-1)}p_{ji}^{-\sigma} - x_{ji}\right). \qquad (1.13)
$$

The first order conditions are:

$$
\begin{aligned}
\frac{\partial L}{\partial x_{ji}} &= p_{ji} - \tau_j(\varphi\lambda_i)^{\theta-\delta} - \mu = 0, && (1.14)\\
\frac{\partial L}{\partial p_{ji}} &= x_{ji} - \sigma\mu R_j P_j^{\sigma-1}(\varphi\lambda_i)^{\theta(\sigma-1)}p_{ji}^{-\sigma-1} = 0, && (1.15)\\
\frac{\partial L}{\partial \mu} &= R_j P_j^{\sigma-1}(\varphi\lambda_i)^{\theta(\sigma-1)}p_{ji}^{-\sigma} - x_{ji} = 0. && (1.16)
\end{aligned}
$$

Plugging the second condition into the third one, one obtains $p_{ji} = \sigma\mu$. Substituting into the first condition, it follows that $\mu = \tau_j(\varphi\lambda_i)^{\theta-\delta}/(\sigma-1)$. Using simple algebra and $\sigma = 1/(1-\alpha)$ delivers the following expressions for the outcomes of interest:

$$
\begin{aligned}
p_{ji}(\varphi,\lambda_i) &= \sigma\mu = \sigma\frac{\tau_j(\varphi\lambda_i)^{\theta-\delta}}{\sigma-1} = \frac{\tau_j(\varphi\lambda_i)^{\theta-\delta}}{\alpha}, && (1.17)\\
x_{ji}(\varphi,\lambda_i) &= R_j P_j^{\sigma-1}(\varphi\lambda_i)^{\theta(\sigma-1)}p_{ji}^{-\sigma} = R_j P_j^{\sigma-1}\left(\frac{\alpha}{\tau_j}\right)^{\sigma}(\varphi\lambda_i)^{\delta\sigma-\theta}, && (1.18)\\
\frac{p_{ji}(\varphi,\lambda_i)}{q_i(\varphi,\lambda_i)} &= \frac{\tau_j(\varphi\lambda_i)^{-\delta}}{\alpha}, && (1.19)\\
r_{ji}(\varphi,\lambda_i) &= p_{ji}x_{ji} = R_j\left(\frac{P_j\alpha}{\tau_j}\right)^{\sigma-1}(\varphi\lambda_i)^{\delta(\sigma-1)}, && (1.20)\\
\pi_{ji}(\varphi,\lambda_i) &= p_{ji}x_{ji} - \tau_j x_{ji}(\varphi\lambda_i)^{\theta-\delta} - f_{pj} = (1-\alpha)r_{ji} - f_{pj} = \frac{r_{ji}(\varphi,\lambda_i)}{\sigma} - f_{pj}. && (1.21)
\end{aligned}
$$

■

1.3 Selection into Products and Markets

Product expertise cut-off for production. Since profits $\pi_d(\varphi, \lambda_i)$ increase with product expertise λ_i, there is a zero-profit expertise level $\lambda^*(\varphi)$ for each management ability draw φ below which the firm will not produce i for the domestic market. This cut-off is defined by the zero-profit condition $\pi_d(\varphi, \lambda^*(\varphi)) = 0$ and is decreasing in φ, i.e. $\frac{d\lambda^*(\varphi)}{d\varphi} < 0$.

Proof. The definition of the product expertise cut-off $\lambda^*(\varphi)$ delivers a closed-form solution for it:

$$\pi_d(\varphi, \lambda^*(\varphi)) = 0 \Leftrightarrow r_d(\varphi, \lambda^*(\varphi)) = R_d(P_d\alpha)^{\sigma-1}(\varphi\lambda^*(\varphi))^{\delta(\sigma-1)} = \sigma f_p \tag{1.22}$$

$$\Longrightarrow \lambda^*(\varphi) = \frac{1}{\varphi}\left[\frac{\sigma f_p}{R_d(P_d\alpha)^{\sigma-1}}\right]^{\frac{1}{\delta(\sigma-1)}}. \tag{1.23}$$

Therefore $\frac{d\lambda^*(\varphi)}{d\varphi} < 0$. ■

Product expertise cut-off for exporting. Similarly, export profits $\pi_{ji}(\varphi, \lambda_i)$ increase with product expertise λ_i, such that there is a cut-off expertise level $\lambda_j^*(\varphi)$ for each management ability draw φ below which the firm will not export product i to country j. This cut-off is defined by the zero-profit condition $\pi_{ji}\left(\varphi, \lambda_j^*(\varphi)\right) = 0$ and is decreasing in φ, i.e. $\frac{d\lambda_j^*(\varphi)}{d\varphi} < 0$.

Proof. The definition of the export product expertise cut-off $\lambda_j^*(\varphi)$ delivers a closed-form solution for it:

$$\pi_{ji}\left(\varphi, \lambda_j^*(\varphi)\right) = 0 \Leftrightarrow r_{ji}\left(\varphi, \lambda_j^*(\varphi)\right) = R_j\left(\frac{P_j\alpha}{\tau_j}\right)^{\sigma-1}\left(\varphi\lambda_j^*(\varphi)\right)^{\delta(\sigma-1)} = \sigma f_{pj} \tag{1.24}$$

$$\Longrightarrow \lambda_j^*(\varphi) = \frac{1}{\varphi}\left[\frac{\sigma f_{pj}}{R_j\left(\frac{P_j\alpha}{\tau_j}\right)^{\sigma-1}}\right]^{\frac{1}{\delta(\sigma-1)}}. \tag{1.25}$$

Therefore $\frac{d\lambda_j^*(\varphi)}{d\varphi} < 0$. ■

Management ability cut-off for exporting. The export profits in country j of a firm with management competence φ are:

$$\pi_j(\varphi) = \int_{\lambda_j^*(\varphi)}^{\infty} \pi_{ji}(\varphi, \lambda)\, z(\lambda)\, d\lambda - f_{hj}. \tag{1.26}$$

Since export profits $\pi_j(\varphi)$ increase with management ability φ, only firms with management level above a cut-off φ_j^* will service destination j. This cut-off is defined by the zero-profit condition $\pi_j\left(\varphi_j^*\right) = 0$.

Proof. According to Leibniz's rule,

$$\frac{d\pi_j(\varphi)}{d\varphi} = \int_{\lambda_j^*(\varphi)}^{\infty} \frac{\partial \pi_{ji}(\varphi,\lambda)}{\partial \varphi} z(\lambda)\, d\lambda - \pi_{ji}\left(\varphi, \lambda_j^*(\varphi)\right) z\left(\lambda_j^*(\varphi)\right) \frac{d\lambda_j^*(\varphi)}{d\varphi}. \tag{1.27}$$

Since $r_{ji}(\varphi,\lambda_i) = R_j \left(\frac{P_j\alpha}{\tau_j}\right)^{\sigma-1} (\varphi\lambda_i)^{\delta(\sigma-1)}$ and $\pi_{ji}(\varphi,\lambda_i) = \frac{r_{ji}(\varphi,\lambda_i)}{\sigma} - f_{pj}$, it follows that

$$\frac{\partial \pi_{ji}(\varphi,\lambda)}{\partial \varphi} = \frac{1}{\sigma}\frac{\partial r_{ji}(\varphi,\lambda)}{\partial \varphi} = \frac{\delta(\sigma-1)}{\sigma} R_j \left(\frac{P_j\alpha}{\tau_j}\right)^{\sigma-1} (\varphi\lambda)^{\delta(\sigma-1)-1}\lambda > 0 \tag{1.28}$$

because $\delta > 0$ and $\sigma > 1$. We have already proved that $\frac{d\lambda_j^*(\varphi)}{d\varphi} < 0$. Therefore $\frac{d\pi_j(\varphi)}{d\varphi} > 0$, such that export profits in country j increase with management ability and only firms above a zero-profit management cut-off will export to j. ■

Management ability cut-off for production. Firm φ's global profits are given by

$$\pi(\varphi) = \pi_d(\varphi) + \sum\nolimits_j \pi_j(\varphi) = \int_{\lambda^*(\varphi)}^{\infty} \pi_d(\varphi,\lambda) z(\lambda)\, d\lambda + \sum\nolimits_j \left(\int_{\lambda_j^*(\varphi)}^{\infty} \pi_{ji}(\varphi,\lambda) z(\lambda)\, d\lambda - f_{hj} \right) - f_h \tag{1.29}$$

Since global profits $\pi(\varphi)$ increase with management ability φ, firms with management below a minimum level φ^* will be unable to break even and exit immediately upon learning their attributes. This cut-off is defined by the zero-profit condition $\pi(\varphi^*) = 0$.

Proof. According to Leibniz's rule,

$$\frac{d\pi(\varphi)}{d\varphi} = \int_{\lambda^*(\varphi)}^{\infty} \frac{\partial \pi_d(\varphi,\lambda)}{\partial \varphi} z(\lambda)\, d\lambda - \pi_d(\varphi, \lambda^*(\varphi))\, z(\lambda^*(\varphi)) \frac{d\lambda^*(\varphi)}{d\varphi} + \sum\nolimits_j \frac{d\pi_j(\varphi)}{d\varphi}. \tag{1.30}$$

Since $r_d(\varphi,\lambda_i) = R_d (P_d\alpha)^{\sigma-1} (\varphi\lambda_i)^{\delta(\sigma-1)}$ and $\pi_d(\varphi,\lambda_i) = \frac{r_d(\varphi,\lambda_i)}{\sigma} - f_p$, it follows that

$$\frac{\partial \pi_d(\varphi,\lambda)}{\partial \varphi} = \frac{1}{\sigma}\frac{\partial r_d(\varphi,\lambda)}{\partial \varphi} = \frac{\delta(\sigma-1)}{\sigma} R_d (P_d\alpha)^{\sigma-1} (\varphi\lambda)^{\delta(\sigma-1)-1}\lambda > 0 \tag{1.31}$$

because $\delta > 0$ and $\sigma > 1$. We have already proved that $\frac{d\lambda^*(\varphi)}{d\varphi} < 0$ and $\frac{d\pi_j(\varphi)}{d\varphi} > 0$. Therefore $\frac{d\pi(\varphi)}{d\varphi} > 0$, such that global profits increase with management ability and only firms above a zero-profit management cut-off will commence production. ■

1.4 Empirical Predictions

Proposition 1. *Better managed firms are more likely to export.*

Proof. This proposition follows from the result that total export profits $\pi_X(\varphi) = \sum_j \pi_j(\varphi)$ increase with management ability φ. On the intensive margin, we have already established that bilateral export profits increase with management competence, $\frac{\partial \pi_j(\varphi)}{\partial \varphi} > 0$. On the extensive margin, only firms with ability $\varphi \geq \varphi_j^*$ will sell to destination j. For destinations $j = \{1, 2, ..., J\}$, denote

$$\varphi_X^* = \min\{\varphi_1^*, \varphi_2^*, ..., \varphi_J^*\} \tag{1.32}$$

Since firms with higher φ are more likely to have both $\varphi \geq \varphi_j^*$ for any j and $\varphi \geq \varphi_X^*$ overall, they have a higher propensity to export to any given destination j, as well as a higher propensity to be exporters, i.e. to export to at least one destination. The proof to the next proposition is closely related and provides detailed derivations for these claims. ■

Proposition 2. *Better managed firms export more products to more destination markets and earn higher export revenues and profits.*

Proof. First, denote the number of destinations a firm enters as $n(\varphi) = \sum_j I\left(\varphi \geq \varphi_j^*\right)$, where

$$I\left(\varphi \geq \varphi_j^*\right) = \begin{cases} 1, & \varphi \geq \varphi_j^* \\ 0, & \varphi < \varphi_j^* \end{cases} \tag{1.33}$$

A higher φ means that a larger number of destinations j satisfy $\varphi \geq \varphi_j^*$ because $\frac{\partial I\left(\varphi \geq \varphi_j^*\right)}{\partial \varphi} > 0$. Therefore $n(\varphi)$ is increasing in φ and better managed exporters enter more markets, i.e. $\frac{\partial n(\varphi)}{\partial \varphi} > 0$.

Second, for any given market j, we have already shown that bilateral export revenues and profits increase with management ability, $\frac{dr_j(\varphi)}{d\varphi} > 0$ and $\frac{d\pi_j(\varphi)}{d\varphi} > 0$. From the product expertise cut-off condition for exporting, we know that $\frac{d\lambda_j^*(\varphi)}{d\varphi} < 0$. This implies that a higher φ is associated with a bigger measure of products $N_j(\varphi) = 1 - Z\left(\lambda_j^*(\varphi)\right)$ exported to destination j:

$$\frac{dN_j(\varphi)}{d\varphi} = -\frac{dZ\left(\lambda_j^*(\varphi)\right)}{d\varphi} = -\frac{dZ\left(\lambda_j^*(\varphi)\right)}{d\lambda_j^*}\frac{d\lambda_j^*(\varphi)}{d\varphi} > 0. \tag{1.34}$$

Third, total export sales $r_X(\varphi)$, profits $\pi_X(\varphi)$ and number of products $N_X(\varphi)$ are:

$$r_X(\varphi) = \sum\nolimits_j r_j(\varphi) I\left(\varphi \geq \varphi_j^*\right), \quad \pi_X(\varphi) = \sum\nolimits_j \pi_j(\varphi) I\left(\varphi \geq \varphi_j^*\right), \quad N_X(\varphi) = 1 - Z\left(\lambda_X^*(\varphi)\right) \tag{1.35}$$

where $\lambda_X^*(\varphi) = \min\{\lambda_1^*(\varphi), \lambda_2^*(\varphi), ..., \lambda_J^*(\varphi)\}$ denotes the minimum product expertise cut-off for exporting $\lambda_j^*(\varphi)$ across countries j for a firm with given φ. Note that firms export a nested set of products i to different markets, which follows a strict pecking order based on λ_i.

Since $\frac{dr_j(\varphi)}{d\varphi} > 0$, $\frac{d\pi_j(\varphi)}{d\varphi} > 0$, $\frac{\partial I\left(\varphi \geq \varphi_j^*\right)}{\partial \varphi} > 0$ and $\frac{dN_j(\varphi)}{d\varphi} > 0$, it directly follows that:

$$\frac{dr_X(\varphi)}{d\varphi} = \sum_j \left[\frac{dr_j(\varphi)}{d\varphi} I\left(\varphi \geq \varphi_j^*\right) + \frac{dI\left(\varphi \geq \varphi_j^*\right)}{d\varphi} r_j(\varphi)\right] > 0, \tag{1.36}$$

$$\frac{d\pi_X(\varphi)}{d\varphi} = \sum_j \left[\frac{d\pi_j(\varphi)}{d\varphi} I\left(\varphi \geq \varphi_j^*\right) + \frac{dI\left(\varphi \geq \varphi_j^*\right)}{d\varphi} \pi_j(\varphi)\right] > 0, \tag{1.37}$$

$$\frac{dN_X(\varphi)}{d\varphi} = -\frac{dZ\left(\lambda_X^*(\varphi)\right)}{d\lambda_X^*} \frac{d\lambda_X^*(\varphi)}{d\varphi} > 0. \tag{1.38}$$

■

Proposition 3. *Better managed firms offer higher-quality products if $\theta > 0$, but quality is invariant across firms if $\theta = 0$. Better managed firms set lower quality-adjusted prices if $\delta > 0$, but quality-adjusted prices are invariant across firms if $\delta = 0$. Better managed firms charge higher prices if $\theta > \delta$ and lower prices if $\delta > \theta$, but prices are invariant across firms if $\theta = \delta$.*

Proof. This proposition can be established directly from the solution to the firm's profit-maximization problem above. Taking the partial derivative of firm's price, quality and quality-adjusted price with respect to management ability, we have:

$$p_{ji}(\varphi, \lambda_i) = \frac{\tau_j (\varphi \lambda_i)^{\theta - \delta}}{\alpha} \Longrightarrow \frac{\partial p_{ji}}{\partial \varphi} = \frac{(\theta - \delta)}{\alpha} \tau_j (\varphi \lambda_i)^{\theta - \delta - 1} \lambda_i \tag{1.39}$$

$$q_{ji}(\varphi, \lambda_i) = (\varphi \lambda_i)^{\theta} \Longrightarrow \frac{\partial q_{ji}}{\partial \varphi} = \theta (\varphi \lambda_i)^{\theta - 1} \lambda_i \tag{1.40}$$

$$\frac{p_{ji}(\varphi, \lambda_i)}{q_{ji}(\varphi, \lambda_i)} = \frac{\tau_j (\varphi \lambda_i)^{-\delta}}{\alpha} \Longrightarrow \frac{\partial (p_{ji}/q_{ji})}{\partial \varphi} = -\frac{\delta}{\alpha} \tau_j (\varphi \lambda_i)^{-\delta - 1} \lambda_i \tag{1.41}$$

Recall that $\theta \geq 0$ and $\delta \geq 0$. It immediately follows that $\frac{\partial q_{ji}}{\partial \varphi} > 0$ if and only if $\theta > 0$ and $\frac{\partial(p_{ji}/q_{ji})}{\partial \varphi} < 0$ if and only if $\delta > 0$. Since the sign of $\frac{\partial p_{ji}}{\partial \varphi}$ depends on $(\theta - \delta)$, $\frac{\partial p_{ji}}{\partial \varphi} > 0$ if $\theta > \delta$, $\frac{\partial p_{ji}}{\partial \varphi} < 0$ if $\delta > \theta$, and $\frac{\partial p_{ji}}{\partial \varphi} = 0$ if $\theta = \delta$. ■

Proposition 4. *Better managed firms use more expensive inputs of higher quality and/or more expensive assembly of higher complexity if $\theta > 0$, but input quality and assembly complexity are invariant across firms if $\theta = 0$.*

Proof. From Proposition 3, we know that better managed firms produce goods of higher quality if and only if $\theta > 0$. While we do not explicitly model firms' endogenous choice of product quality in the baseline framework, we assume that producing goods of higher quality entails higher marginal production costs. The implicit micro-foundation for this quality production function is that manufacturing higher-quality products requires more expensive inputs of higher quality and/or more costly assembly technologies. See also Section 2.3 in this Appendix. ■

2 Model Extensions

2.1 Extension 1: Endogenous Management

Our baseline model assumes that management competence is an exogenous draw at the firm level. We now establish that Propositions 1-4 would continue to hold if an exogenous firm primitive endogenously determines the firm's choice of management practice, as long as implementing more effective management practices improves firm performance but is sufficiently more costly. Intuitively, adopting more sophisticated management practices can enhance existing firm capabilities and thereby stimulate market entry and firm revenues. Good management and intrinsic firm attributes may also be complementary, such that effective firm productivity may be supermodular in these two components. At the same time, superior management strategies arguably require higher sunk costs of adoption (e.g. hiring a manager, re-designing production facilities, training staff to use new data monitoring, etc.) and higher fixed costs of production (e.g. collecting data, analyzing peformance, communicating results to staff, etc.). As a result of such economies of scale, exogenously better firms that expect to be more competitive in the market and generate higher sales would endogenously choose better management practices, thereby further improving their performance. Propositions 1-4 would then hold both for the exogenous firm primitive and for the endogenous management quality. In particular, the Propositions would state causal effects for the firm primitive and conditional correlations for management, where the latter would constitute one mechanism through which the former operates.

To illustrate this insight tractably and transparently, we make minimal functional form assumptions for the impact of management choice on firm ability and for the cost of management adoption. The same insight would however apply more generally, as long as the benefit to management upgrading increases faster with management competence than the cost of management upgrading.

We assume that firm entrepreneurs receive an exogenous talent draw ϕ and choose to use management practice m at a convex fixed cost of f_m, where $df_m/dm > 0$ and $d^2f_m/dm^2 > 0$. Firm ability $\varphi = \phi m(\phi)$ depends on the combination of talented entrepreneurs and management effectiveness. Given product expertise draws λ_i, firms can produce one unit of product i with quality $q_i = [\varphi\lambda_i]^{\theta} = [\phi m(\phi)\lambda_i]^{\theta}$ at a marginal cost of $[\varphi\lambda_i]^{\theta-\delta} = [\phi m(\phi)\lambda_i]^{\theta-\delta}$. In this environment, the proof below establishes that Propositions 1-4 continue to hold as conditional correlations for the endgenous management level in two steps: We first show that Propositions 1-4 apply for effective firm ability $\varphi = \phi m(\phi)$. We then demonstrate that effective firm ability and management are monotonically related, $d\varphi/dm > 0$. Together, these two results directly imply that Propositions 1-4 must also hold for management $m(\phi)$.

Proof. Step One

This extension of the model closely follows the solution concept in Sections 1.3 and 1.4 of this Appendix. Since the fixed cost of management adoption is independent of the firm's product scope, market penetration, and production scale, the firms' profit maximization problem can be solved in steps. The choice of management practice will be determined in the last of these steps. All preceding steps will remain in essense the same as in the baseline model, such that all key equations can be obtained simply by replacing φ with $\phi m(\phi)$.

First, note that entrepreneurial talent ϕ and management competence m always enter multiplicatively as firm ability $\varphi = \phi m(\phi)$ and fix product quality at $q_i = [\varphi\lambda_i]^{\theta} = [\phi m(\phi)\lambda_i]^{\theta}$. The firm will therefore begin by choosing the profit-maximizing price and quantity in each potential destination-product market, conditional on entry there. The optimal price, quantity, quality-adjusted price, revenues and profits for product i in country j will be given by equations (1.17). In particular, domestic profits $\pi_{di}(\phi, m, \lambda)$ from product i and export profits $\pi_{ji}(\phi, m, \lambda_i)$ from product i in country j will be given by the expressions below and increasing in management competence as before:

$$\pi_{di}(\phi, m, \lambda_i) = \frac{1}{\sigma} R_d (P_d \alpha)^{\sigma-1} (\phi m \lambda_i)^{\delta(\sigma-1)} - f_p \Longrightarrow \frac{\partial \pi_{di}(\phi, m, \lambda)}{\partial m} > 0 \tag{2.1}$$

$$\pi_{ji}(\phi, m, \lambda_i) = \frac{1}{\sigma} R_j \left(\frac{P_j \alpha}{\tau_j}\right)^{\sigma-1} (\phi m \lambda_i)^{\delta(\sigma-1)} - f_{pj} \Longrightarrow \frac{\partial \pi_{ji}(\phi, m, \lambda)}{\partial m} > 0 \tag{2.2}$$

Second, the firm will decide which products to produce and which products to export to destination j based on product expertise cut-offs for production and for exporting, $\lambda^*(\phi, m)$ and $\lambda_j^*(\phi, m)$. As before, these cut-offs are given by zero-profit conditions and defined by equations (1.23) and (1.25). However, these are no longer closed-form solutions that depend only on the exogenous firm attribute φ and model parameters, since firm ability $\varphi = \phi m(\phi)$ is now endogenous. Note also that these product expertise cut-offs are decreasing in both entrepreneurial talent and management capacity:

$$\lambda^*(\phi, m) = \frac{1}{\phi m} \left[\frac{\sigma f_p}{R_d (P_d \alpha)^{\sigma-1}}\right]^{\frac{1}{\delta(\sigma-1)}}, \frac{\partial \lambda^*(\phi, m)}{\partial m} = -\frac{\lambda^*}{m} < 0,\ \frac{\partial \lambda^*(\phi, m)}{\partial \phi} = -\frac{\lambda^*}{\phi} < 0 \tag{2.3}$$

$$\lambda_j^*(\phi, m) = \frac{1}{\phi m} \left[\frac{\sigma f_{pj}}{R_j \left(\frac{P_j \alpha}{\tau_j}\right)^{\sigma-1}}\right]^{\frac{1}{\delta(\sigma-1)}}, \frac{\partial \lambda_j^*(\phi, m)}{\partial m} = -\frac{\lambda_j^*}{m} < 0,\ \frac{\partial \lambda_j^*(\phi, m)}{\partial \phi} = -\frac{\lambda_j^*}{\phi} < 0 \tag{2.4}$$

Third, the firm will choose which export markets j to enter. This decision will be guided by firm ability cut-offs for exporting, φ_j^*, which are pinned down by the zero-profit condition $\pi_j\left(\varphi_j^*\right) = 0$ as earlier.

Together, the results above imply that Propositions 1-4 hold for effective firm ability $\varphi = \phi m(\phi)$.

Step Two

Given *Step One* above, Propositions 1-4 will atutomatically hold for management competence m if effective firm ability $\varphi = \phi m(\phi)$ is increasing in m. We now prove this monotonicity.

In the final stage of the firm's problem, the entrepreneur will decide whether to begin production upon learning his talent draw. It is at this point that the firm will also choose its optimal management practice m and thereby effective ability φ, in order to maximize global profits from domestic sales and any exports abroad. This profit maximization problem closely resembles equation (1.29) in the baseline model:

$$\max_m \pi(\phi, m) = \int_{\lambda^*(\phi,m)}^{\infty} \pi_{di}(\phi, m, \lambda) z(\lambda) d\lambda + \sum_j \left(\int_{\lambda_j^*(\phi,m)}^{\infty} \pi_{ji}(\phi, m, \lambda) z(\lambda) d\lambda - f_{hj} \right) - f_h - f_m. \tag{2.5}$$

The first order condition with respect to management practices m implies that:

$$\begin{aligned}
\frac{\partial \pi(\phi, m)}{\partial m} &= \left(\int_{\lambda^*(\phi,m)}^{\infty} \frac{\partial \pi_{di}(\phi, m, \lambda)}{\partial m} z(\lambda) d\lambda - \pi_{di}(\phi, m, \lambda^*) z(\lambda^*) \frac{\partial \lambda^*(\phi, m)}{\partial m} \right) + \\
&+ \sum_j \left(\int_{\lambda_j^*(\phi,m)}^{\infty} \frac{\partial \pi_{ji}(\phi, m, \lambda)}{\partial m} z(\lambda) d\lambda - \pi_{ji}\left(\phi, m, \lambda_j^*\right) z\left(\lambda_j^*\right) \frac{\partial \lambda_j^*(\phi, m)}{\partial m} \right) - \frac{\partial f_m}{\partial m} = \\
&= \int_{\lambda^*(\phi,m)}^{\infty} A_d \delta(\sigma - 1) \frac{(\phi m \lambda)^{\delta(\sigma-1)}}{m} z(\lambda) d\lambda + \\
&+ \sum_j \left(\int_{\lambda_j^*(\phi,m)}^{\infty} A_j \delta(\sigma - 1) \frac{(\phi m \lambda)^{\delta(\sigma-1)}}{m} z(\lambda) d\lambda \right) - \frac{\partial f_m}{m} \\
&= 0.
\end{aligned} \tag{2.6}$$

Note that by the definition of the zero-profit product expertise cut-offs $\lambda^*(\phi, m)$ and $\lambda_j^*(\phi, m)$, the terms involving $\pi_{di}(\phi, m, \lambda^*) = \pi_{ji}\left(\phi, m, \lambda_j^*\right) = 0$ drop out. For ease of notation, the exogenous terms characterizing aggregate expenditure, aggregate price indices, and bilateral trade costs have been collected in $A_d \triangleq \frac{1}{\sigma} R_d (P_d \alpha)^{\sigma-1}$ and $A_j \triangleq \frac{1}{\sigma} R_j \left(\frac{P_j \alpha}{\tau_j}\right)^{\sigma-1}$.

Using this first order condition, one can solve for the firm's optimal management competence level m as an implicit function of ϕ defined as $F(\phi, m)$:

$$\begin{aligned}
F(\phi, m) \equiv & \int_{\lambda^*(\phi,m)}^{\infty} A_d \delta(\sigma - 1) \frac{(\phi m \lambda)^{\delta(\sigma-1)}}{m} z(\lambda) d\lambda + \\
&+ \sum_j \left(\int_{\lambda_j^*(\phi,m)}^{\infty} A_j \delta(\sigma - 1) \frac{(\phi m \lambda)^{\delta(\sigma-1)}}{m} z(\lambda) d\lambda \right) - \frac{\partial f_m}{m} \\
&\triangleq F_d(\phi, m) + \sum_j F_j(\phi, m) - \frac{\partial f_m}{m}.
\end{aligned} \tag{2.7}$$

We want to prove that $\varphi = \phi m(\phi)$ is increasing in m. We therefore need to show that:

$$\frac{d(\phi m(\phi))}{dm} = \frac{d\phi}{dm} m + \phi = \phi \left(\frac{d\phi}{dm} \frac{m}{\phi} + 1 \right) > 0. \tag{2.8}$$

From the Implicit Function Theorem, it follows that:

$$\frac{d\phi}{dm} = -\frac{\partial F / \partial m}{\partial F / \partial \phi}. \tag{2.9}$$

Therefore, all we need is to prove that:

$$\frac{\partial F/\partial m}{\partial F/\partial \phi} < \frac{\phi}{m}. \tag{2.10}$$

We first show that the denominator $\partial F/\partial \phi$ is positive. Note that

$$\frac{\partial F}{\partial \phi} = F_{1d}(\phi, m) + \sum_j F_{1j}(\phi, m), \tag{2.11}$$

where for each country k in the set comprising the home economy d and all potential export destinations j, $k \in \{d\} \cup \{1, 2, \ldots, J\}$, $F_{1k}(\phi, m)$ is given by:

$$F_{1k}(\phi, m) = A_k \delta(\sigma-1)(\phi m)^{\delta(\sigma-1)-1}\left[\delta(\sigma-1)\int_{\lambda_k^*(\phi,m)}^{\infty} \lambda^{\delta(\sigma-1)} z(\lambda)\, d\lambda - \phi(\lambda_k^*)^{\delta(\sigma-1)} z(\lambda_k^*)\frac{\partial \lambda_k^*(\phi, m)}{\partial \phi}\right]. \tag{2.12}$$

Since $\partial \lambda_k^*(\phi, m)/\partial \phi < 0$ as shown above, it follows that $\partial F/\partial \phi > 0$.

We next examine the numerator $\partial F/\partial m$:

$$\frac{\partial F}{\partial m} = F_{2d}(\phi, m) + \sum_j F_{2j}(\phi, m) - \frac{d^2 f_m}{dm^2}, \tag{2.13}$$

where for each country k, $F_{2k}(\phi, m)$ is given by:

$$F_{2k}(\phi, m) = A_k \delta(\sigma-1)(\phi m)^{\delta(\sigma-1)}\frac{1}{m}\left[\frac{\delta(\sigma-1)-1}{m}\int_{\lambda_k^*}^{\infty} \lambda^{\delta(\sigma-1)} z(\lambda)\, d\lambda - (\lambda_k^*)^{\delta(\sigma-1)} z(\lambda_k^*)\frac{\partial \lambda_k^*}{\partial m}\right]. \tag{2.14}$$

Since $\partial F/\partial \phi > 0$ and $d^2 f_m/dm^2 > 0$, we therefore know that:

$$\frac{\partial F/\partial m}{\partial F/\partial \phi} < \frac{F_{2d}(\phi, m) + \sum_j F_{2j}(\phi, m)}{F_{1d}(\phi, m) + \sum_j F_{1j}(\phi, m)}. \tag{2.15}$$

Recalling that $\partial \lambda_k^*/\partial \phi = -\lambda_k^*/\phi$ and $\partial \lambda_k^*/\partial m = -\lambda_k^*/m$ for all $k \in \{d\} \cup \{1, 2, \ldots, J\}$, one can show that $F_{2k}(\phi, m)/F_{1k}(\phi, m) < \phi/m$:

$$\frac{F_{2k}(\phi, m)}{F_{1k}(\phi, m)} = \frac{A_k \delta(\sigma-1)(\phi m)^{\delta(\sigma-1)}\frac{1}{m}\left[\frac{\delta(\sigma-1)-1}{m}\int_{\lambda_k^*}^{\infty} \lambda^{\delta(\sigma-1)} z(\lambda)\, d\lambda - (\lambda_k^*)^{\delta(\sigma-1)} z(\lambda_k^*)\frac{\partial \lambda_k^*}{\partial m}\right]}{A_k \delta(\sigma-1)(\phi m)^{\delta(\sigma-1)-1}\left[\delta(\sigma-1)\int_{\lambda_k^*}^{\infty} \lambda^{\delta(\sigma-1)} z(\lambda)\, d\lambda - \phi(\lambda_k^*)^{\delta(\sigma-1)} z(\lambda_k^*)\frac{\partial \lambda_k^*}{\partial \phi}\right]} \tag{2.16}$$

$$= \frac{\phi\left[\frac{\delta(\sigma-1)-1}{m}\int_{\lambda_k^*}^{\infty} \lambda^{\delta(\sigma-1)} z(\lambda)\, d\lambda + (\lambda_k^*)^{\delta(\sigma-1)} z(\lambda_k^*)\frac{\lambda_k^*}{m}\right]}{\left[\delta(\sigma-1)\int_{\lambda_k^*}^{\infty} \lambda^{\delta(\sigma-1)} z(\lambda)\, d\lambda + \phi(\lambda_k^*)^{\delta(\sigma-1)} z(\lambda_k^*)\frac{\lambda_k^*}{\phi}\right]}$$

$$= \frac{\phi}{m} \cdot \frac{(\delta(\sigma-1)-1)\int_{\lambda_k^*}^{\infty} \lambda^{\delta(\sigma-1)} z(\lambda)\, d\lambda + (\lambda_k^*)^{\delta(\sigma-1)} z(\lambda_k^*)\lambda_k^*}{\delta(\sigma-1)\int_{\lambda_k^*}^{\infty} \lambda^{\delta(\sigma-1)} z(\lambda)\, d\lambda + (\lambda_k^*)^{\delta(\sigma-1)} z(\lambda_k^*)\lambda_k^*}$$

$$< \frac{\phi}{m}.$$

Therefore,

$$\frac{\partial F/\partial m}{\partial F/\partial \phi} < \frac{F_{2d}(\phi, m) + \sum_j F_{2j}(\phi, m)}{F_{1d}(\phi, m) + \sum_j F_{1j}(\phi, m)} < \frac{\phi}{m}. \tag{2.17}$$

We have thus proven that effective firm ability $\varphi = \phi m(\phi)$ is increasing in management competence m. Since all comparative statics for φ hold as in the baseline model, it follows that all propositions also hold as conditional correlations for management quality m even when firms endogenously choose their management practices. ■

2.2 Extension 2: Multiple Ability Components

The theoretical predictions of our baseline model would continue to hold if management is one of multiple draws that jointly determine firm ability φ. For example, firm ability $\varphi = m \cdot \phi$ may depend on the entrepreneur's intrinsic talent ϕ and the manager's competence for implementing effective management practices m. If entrepreneurs and managers do not match perfectly assortatively due to labor market frictions, then $|corr(m, \phi)| \neq 1$. While all firm outcomes would now be pinned down by φ instead of m alone, management competence would have the same effects as in our baseline model *ceteris paribus*. Propositions 1-4 would now hold for φ unconditionally, for ϕ conditional on m, and for m conditional on ϕ. The last result is the conditional relationship that remains relevant for our empirical analysis.

2.3 Extension 3: Endogenous Quality

For expositional simplicity, we do not model firms's choice of product quality in the baseline model, and adopt instead a reduced-form quality production function. Endogenizing firms' choice of input and output quality in a richer framework would however preserve our theoretical predictions. What is sufficient for this to occur is that output quality - and by extension firm profits - is supermodular in firm ability and either the quality of inputs or the complexity of the assembly process. We illustrate this point here by incorporating endogenous quality choice as in Kugler and Verhoogen (2012) into our baseline framework. The same key insights would emerge with alternative microfoundations for the quality production function.

We assume that there is complementarity between firm ability and input quality in the production of output quality. In particular, using an input of quality c_{ji}, the firm can produce one unit of product i with output quality

$$q_{ji} = \left[\frac{1}{2}\left((\varphi\lambda_i)^b\right)^\rho + \frac{1}{2}\left(c_{ji}^2\right)^\rho\right]^{\frac{1}{\rho}} \tag{2.18}$$

at a marginal cost of c_{ji}. In this setting, the parameter b can be interpreted as the scope for quality differentiation, while the parameter ρ governs the degree of complementarity between input quality c_{ji} and firm-specific management φ (as well as firm-product specific expertise λ_i). The quadratic specification for c_{ji} is not crucial but adopted for tractability.

Given this quality production function, more capable firms will optimally use higher-quality inputs in order to produce higher-quality goods.

Proof. Now the firm's maximization problem becomes

$$\max_{p_{ji},x_{ji},c_{ji}} \pi(\varphi,\lambda_i) = p_{ji}x_{ji} - \tau_j x_{ji}c_{ji} - f_{pj}$$

$$\text{s.t. } x_{ji} = R_j P_j^{\sigma-1} q_{ji}^{\sigma-1} p_{ji}^{-\sigma}$$

Substituting the constraint into the objective function, this is equivalent to solving

$$\max_{p_{ji},c_{ji}} \pi_{ji}(\varphi,\lambda_i) = R_j P_j^{\sigma-1} \left[\frac{1}{2}(\varphi\lambda_i)^{b\rho} + \frac{1}{2}c_{ji}^{2\rho}\right]^{\frac{\sigma-1}{\rho}} p_{ji}^{-\sigma}(p_{ji} - \tau_j c_{ji}) - f_{pj}$$

The first order conditions with respect to p_{ji} and c_{ji} yield the following equations respectively:

$$p_{ji} = \frac{\sigma}{\sigma-1}\tau_j c_{ji} \tag{2.19}$$

$$(\sigma-1)\, c_{ji}^{2\rho-1}(p_{ji} - \tau_j c_{ji}) = \tau_j \left[\frac{1}{2}(\varphi\lambda_i)^{b\rho} + \frac{1}{2}c_{ji}^{2\rho}\right] \tag{2.20}$$

Substituting equation (2.19) into equation (2.20) and using equation (2.18) delivers the following endogenous input quality c_{ji} and output quality q_{ji} as a function of firm management ability φ and product expertise λ_i:

$$c_{ji} = c_i = (\varphi\lambda_i)^{\frac{b}{2}}, \quad q_{ji} = q_i = (\varphi\lambda_i)^b. \tag{2.21}$$

This expression immediately implies that better managed firms will endogenously choose to source higher-quality inputs in order to produce higher-quality goods, i.e. $\frac{\partial c_i(\varphi,\lambda_i)}{\partial\varphi} > 0$ and $\frac{\partial q_i(\varphi,\lambda_i)}{\partial\varphi} > 0$. While we have allowed firms to freely vary input and output quality across markets j, the quality production function we have considered guarantees that firms optimally select a single quality level for each product i in their portfolio. Intuitively, better managed firms would endogenously produce higher-quality goods for any given market under alternative formulations that allow for quality customization across markets.

Finally, note that when $\theta = b$ and $\delta = \frac{b}{2}$, the solution in equation (2.21) corresponds exactly to the reduced-form formulation of the quality production function in our baseline model: Firms then produce one unit of product i with quality $q_i = (\varphi\lambda_i)^\theta$ at a marginal cost of $c_i = (\varphi\lambda_i)^{\theta-\delta}$. ■