Endogenous Product and Organizational Cycles: the Role of Product Quality*

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Abstract

In this paper we show that product quality could provide an important explanation for a firm's decisions regarding organizational structures during the product cycle. Specifically, the emergence of multinationals during the product cycle may depend not only on product quality and how it is achieved, but also on whether or not there is an increasing/decreasing return to quality.

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1 Introduction

In the spirit of Vernon's (1966) original notion of the product cycle, Pol Antràs (2005) provides an intriguing model that generates both endogenous product and organizational cycles with two equilibrium paths. The first path is one in which the transfer of production to the South first takes place within the boundaries of the Northern firm (e.g. a wholly owned foreign affiliate - becoming multinational) and then at arm's length (e.g. licensing or subcontracting).[1] The second path is an equilibrium in which the transfer of production to the South goes straight to an arm's length arrangement without passing through the multinational stage. Although the model provides a mathematical condition that separates the two equilibrium paths, it is silent on the type of scenario that could lead to the choice of one equilibrium path over the other.

In this paper we investigate how product quality could play an important role in the Northern firms' decisions regarding which path to choose. We show that the multinational stage could occur if the products are of a high quality; however, the reverse could also happen, depending on the different types of costs incurred to achieve that high product quality. We show that if product quality is achieved via the intensity of the headquarter service, multinationals may emerge in the product cycle for high-quality products. If product quality is achieved by incurring fixed or variable costs, multinationals could emerge for either high- or low-quality products, depending on whether or not there is an increasing or decreasing return to quality.

The rest of the paper is organized as follows. Section 2 describes the basic framework in Antràs (2005). Section 3 investigates three different quality-cost specifications and their associated product cycles. Section 4 contains our conclusions.

2 The Basic Set-up and the Central Result of Antràs (2005)

Suppose there are two countries in the world: the North and the South. Consumer preferences in the North are such that the unique producer of a single good y faces the following isoelastic demand function:

$$y = \lambda p^{-1/(1-\alpha)}, \qquad o < \alpha < 1 \tag{1}$$

[1] Antràs' (2005) seminal work on incomplete contracts and product organizational cycles has spawned new interest in literature on product cycles (e.g. see Basco (2013) and Van Biesebroeck and Zhang (2014), among others).

where p is the price of the good and λ is a parameter taken as given by the producer.

Final production of good y takes place in the North and is given by the following Cobb-Douglas function:

$$y = \left(\frac{x_h}{1-z}\right)^{1-z} \left(\frac{x_l}{z}\right)^{z}, \qquad 0 \leq z \leq 1 \tag{2}$$

where x_h is the high-tech input and x_l is the low-tech input. Both inputs are produced by labour only. However, the high-tech input can only be produced by the parent firm in the North (e.g. research centre or headquarters) and the unit labour requirement is one. Conversely, the low-tech input (i.e. goods production) can be carried out by a manufacturing plant in either country and the unit labour requirement is unity in both countries. The wage rates, w^N in the North and w^S in the South, are fixed and $w^N > w^S$.[2]

The investment in labour needed to produce x_h and x_l is relationship specific. It is incurred upon entry and is useless outside the relationship. The two parties will bargain over the surplus of the relationship after the inputs have been produced via a symmetric Nash bargaining game. Since *ex ante* there are many potential identical manufacturers of the low-tech input, the research centre will demand a lump-sum transfer T from the chosen manufacturer to make the latter break even. The parent firm in the North has the following three choices.

(*i*) *Manufacturing via Northern production* (*i.e. by an independent plant in the North*) – In this case, the required standard of input x_l can be assured because the two parties can *ex ante* write an enforceable contract that is contingent on x_l meeting the required standard. Thus, there will be no possibility of an incomplete contract, and the outcome will be efficient. Since from (1-2) the revenue is $R = \lambda^{(1-\alpha)} \left(x_h/(1-z)\right)^{\alpha(1-z)} \left(x_l/z\right)^{\alpha z}$, choosing x_h and x_l to maximize $R - w^N x_h - w^N x_l$ allows us to obtain the research centre's *ex ante* profits under *Northern production:*

$$\pi^N(z) = (1-\alpha)\,\lambda \left(\frac{w^N}{\alpha}\right)^{-\alpha/(1-\alpha)} \tag{3}$$

(*ii*) *Manufacturing via subcontracting* (*i.e. by an independent plant in the South*) – Since the manufacturer is located in the South, the two parties cannot write an enforceable contract that

[2] As mentioned in Antràs (2005), these assumptions can be justified in a simple general-equilibrium model by assuming that wages are determined by the productivity of labour in producing the numeraire good C_o in these countries, and that the labour supply is large enough so that C_o is produced in both countries.

is contingent on x_l meeting the required standard. If they fail to agree during bargaining, both parties are left with nothing. This is an example of incomplete contracts in international production sharing. Under the symmetric Nash bargaining, the research centre chooses x_h to maximize $R/2 - w^N x_h$ and the manufacturer sets x_l to maximize $R/2 - w^S x_l$. Combining the first-order conditions of these two programs, and using T to make the manufacturer break even, we obtain the research centre's *ex ante* profits under *subcontracting*:

$$\pi_M^S(z) = \left(1 - \frac{1}{2}\alpha\right)\lambda\left(\frac{2\left(w^N\right)^{(1-z)}\left(w^S\right)^z}{\alpha}\right)^{-\left(\frac{\alpha}{1-\alpha}\right)} \tag{4}$$

(*iii*) *Manufacturing via multinational/foreign direct investment* (i.e. *by a vertically integrated plant located in the South*) – In this case, if the two parties fail to reach an agreement during bargaining, the research centre can fire the manager of the manufacturing plant. The manager will be left with nothing, but the research centre will be left with a fraction of the output, δy, which translates into sale revenues of $\delta^\alpha R$. Symmetric bargaining leaves each party with its default option plus one-half of the quasi-rents: $(1-\delta^\alpha)R$. The research centre, therefore, chooses x_h to maximize $\delta^\alpha R + (1-\delta^\alpha)R/2 - w^N x_h$, and the manufacturer sets x_l to maximize $(1-\delta^\alpha)R/2 - w^S x_l$. Solving the two corresponding first-order conditions, and using T to make the manufacturer break even, we obtain the research centre's *ex ante* profits:

$$\pi^M(z) = \left(1 - \frac{1}{2}\alpha\left[1 + \delta^\alpha\left(1-2z\right)\right]\right)\lambda\left(\frac{2\left(w^N\right)^{(1-z)}\left(w^S\right)^z}{\alpha(1+\delta^\alpha)^{(1-z)}(1-\delta^\alpha)^z}\right)^{-\frac{\alpha}{1-\alpha}} \tag{5}$$

When faced with the choice between (*i*) and (*ii*) only, a comparison of (3) and (4) indicates that the low-tech input will be produced by an independent plant in the South if $A(z) \leq \omega \equiv w^N/w^S$, where

$$A(z) \equiv \left[\frac{1-\alpha}{\left(1-\frac{1}{2}\alpha\right)\left(\frac{1}{2}\right)^{\alpha/(1-\alpha)}}\right]^{(1-\alpha)/\alpha z} \tag{6}$$

With the assumption of $\omega > A(1) > 1$, it is straightforward to show that for $z < \overline{z} \equiv A^{-1}(\omega)$ (*resp.* $z > \overline{z}$), the low-tech input is produced under Northern production (*resp.* subcontracting).

Similarly, when faced with the choice between (*i*) and (*iii*) only, a comparison of (3) and (5) indicates that the low-tech input will be produced by a vertically integrated plant in the South if $A_M(z) \leq \omega \equiv w^N/w^S$, where

$$A_M(z) \equiv \left[\frac{1-\alpha}{1-\frac{1}{2}\alpha(1+\delta^\alpha(1-2z))}\right]^{\frac{(1-\alpha)}{\alpha z}} \left[\frac{2}{(1+\delta^\alpha)^{(1-z)}(1-\delta^\alpha)^z}\right]^{\frac{1}{z}} \tag{7}$$

With the assumption of $\delta^\alpha \leq 1/2$, as in Antràs (2005), it is straightforward to show that the low-tech input is produced under Northern production (*resp.* multinational/FDI) for $z < \overline{z}_{MN} \equiv A_M^{-1}(\omega)$ (*resp.* $z > \overline{z}_{MN}$).

When faced with the choice between (*ii*) and (*iii*) only, a comparison of (4) and (5) indicates that $\pi_M^S(z) > \pi^S(z)$ (or, equivalently, $A_M(z) < A(z)$) for $0 < z < \overline{z}_{MS}$, and $\pi_M^S(z) < \pi^S(z)$ for $\overline{z}_{MS} < z \leq 1$, where $\overline{z}_{MS} \in (0,1)$ and $A_M(\overline{z}_{MS}) = A(\overline{z}_{MS})$.

Finally, when faced with all three choices, except for the zero-probability case of $\overline{z} = \overline{z}_{MS} = \overline{z}_{MN}$, in general we have the following two cases:[3]

Case (a): $\overline{z}_{MS} < \min\{\overline{z}, \overline{z}_{MN}\}$ – In this case, the low-tech input is produced in the North for $z < \overline{z}$, and in the South via subcontracting for $z > \overline{z}$.

Case (b): $\overline{z}_{MS} > \max\{\overline{z}, \overline{z}_{MN}\}$ – In this case, the low-tech input is produced in the North for $z < \overline{z}_{MN}$, in the South by a vertically integrated plant for $\overline{z}_{MN} < z < \overline{z}_{MS}$, and in the South via subcontracting for $z > \overline{z}_{MS}$.

Following Vernon's original product cycle hypothesis that a good becomes more and more standardized as it matures throughout its life cycle, Antràs assumes that the share of high-tech input (or the headquarter intensity) is inversely related to its maturity. Specifically, it is assumed that the output elasticity of the low-tech input increases through time t:

$$z = h(t), \quad h'(t) > 0, h(0) = 0, \text{and} \lim_{t\to\infty} h(t) = 1 \tag{8}$$

Thus, as shown in Antràs (2005), a simple dynamic model will display the following product and organizational cycles (see Figures (a) and (b)). In Figure/Case (a), when the good is relatively new (i.e. $t < \bar{t} \equiv h^{-1}(\overline{z})$), the manufacturing stage of production takes place in the North. When the good becomes relatively mature (i.e. $t > \bar{t}$), manufacturing is moved to the South via subcontracting. In this case, a multinational will not occur. In Figure/Case (b), the following product cycle emerges. When the good is relatively new (i.e. $t < \bar{t}_{MN} \equiv h^{-1}(\overline{z}_{MN})$), the

[3]See Lemma 3 and Figure 4 in Antràs (2005). Notice that, as shown in Antràs (2005), curve $A(z)$ intersects curve $A_M(z)$ from the top left as z increases.

manufacturing stage of production takes place in the North. For an intermediate maturity of the good, $\bar{t}_{MN} < t < \bar{t}_{MS} \equiv h^{-1}(\bar{z}_{MS})$, manufacturing is moved to the South, but within the firm's boundaries (i.e. becoming multinational). When the good becomes even more standardized, $t > \bar{t}_{MS}$, production is shifted to an unaffiliated party in the South (i.e. subcontracting).

This is the central result of Antràs (2005, pp. 1065: Proposition 2). The model nicely generates both endogenous product and organizational cycles. However, the model is silent on what scenario could lead to Case (a) or Case (b).

In the rest of our analysis, we investigate how product quality could play an important role in determining the path more likely to be chosen by the Northern firm.

3 Product Quality and the Product Cycle

Suppose a representative consumer has the following utility function:

$$U = y_0 + \left[\int_0^1 [\varepsilon(i) y_\varepsilon(i)]^\alpha di\right]^{\frac{1}{\alpha}}, \qquad o < \alpha < 1 \tag{9}$$

where y_0 is consumption of a homogeneous good and the second part of (9) is aggregate consumption of a continuum of differentiated products, $y_\varepsilon(i)$, $i \in [0,1]$. Parameter $\varepsilon(i) \in (0,1)$ is the strength of the representative consumer's taste for product i, or product i's quality index.

The demand for firm i's product, corresponding to (9), has the following isoelastic function:

$$y_\varepsilon(i) = [\varepsilon(i)]^{\alpha/(1-\alpha)} \lambda [p_\varepsilon(i)]^{-1/(1-\alpha)} \tag{10}$$

where $\lambda = \left[\int_0^1 [\varepsilon(i) y_\varepsilon(i)]^\alpha di\right]^{\frac{1}{\alpha}}$ is taken as given by each individual firm. We drop index i, because of this partial equilibrium and single-product framework (as in Antràs (2005)), and use the following demand function going forward:

$$y_\varepsilon = (\varepsilon)^{\alpha/(1-\alpha)} \lambda (p_\varepsilon)^{-1/(1-\alpha)}, \qquad 0 < \alpha < 1 \tag{11}$$

To produce output y_ε, the firm has to incur certain costs.[4] However, we will show that the types of costs associated with the quality of the product are important for understanding how product quality could play an important role in determining the path more likely to be chosen by the Northern firm for the evolving organizational structures in the product cycle. The following are three such specifications.

[4]We take ε as given. It is beyond the scope of this Comment to discuss how the firm might want to choose an optimal level of ε for its product.

3.1 Product Quality and Fixed Cost

It is a common assumption in the industrial organization literature that higher quality often requires a higher level of fixed costs (e.g. Shaked and Sutton, 1983; Motta, 1993; Sutton, 2007). Following Hallak and Sivadasan (2013), we assume that a firm's fixed costs, measured in units of Northern labour, are related to product quality and organizational forms in production. Specifically, we assume

$$F^j(\varepsilon) = \varepsilon^\kappa f^j \ , \ \ \kappa > 0, \, j = N, S, M \tag{12}$$

where f^j is a constant corresponding to each organizational form. Following the literature, we assume $f^M > f^S > f^N$.[5]

With the same derivation procedures as in Section 2, we obtain the profits corresponding to the three choices facing the parent firm in the North (as in (3-5)):

$$\pi_1^N(z) = (1-\alpha)\,\lambda\varepsilon^{\frac{\alpha}{1-\alpha}}\left(\frac{w^N}{\alpha}\right)^{-\frac{\alpha}{1-\alpha}} - w^N\varepsilon^\kappa f^N \tag{13}$$

$$\pi_{M1}^S(z) = \left(1-\frac{1}{2}\alpha\right)\lambda\varepsilon^{\frac{\alpha}{1-\alpha}}\left(\frac{2\left(w^N\right)^{(1-z)}\left(w^S\right)^z}{\alpha}\right)^{-\frac{\alpha}{1-\alpha}} - w^N\varepsilon^\kappa f^S \tag{14}$$

$$\pi_1^M(z) = \left(1-\frac{1}{2}\alpha\left[1+\delta^\alpha\left(1-2z\right)\right]\right)\lambda\varepsilon^{\frac{\alpha}{1-\alpha}}\left(\frac{2\left(w^N\right)^{(1-z)}\left(w^S\right)^z}{\alpha(1+\delta^\alpha)^{(1-z)}(1-\delta^\alpha)^z}\right)^{-\frac{\alpha}{1-\alpha}} - w^N\varepsilon^\kappa f^M \tag{15}$$

Similarly, using (8) and (13-15), we obtain the corresponding two curves as follows (as in Figures (a) and (b)):

$$A_1(h) \equiv \left[\frac{(1-\alpha)+\varepsilon^{\kappa-\frac{\alpha}{1-\alpha}}\left(w^N\right)^{\frac{1}{1-\alpha}}\alpha^{-\frac{\alpha}{1-\alpha}}\left(f^S-f^N\right)/\lambda}{\left(1-\frac{1}{2}\alpha\right)\left(\frac{1}{2}\right)^{\alpha/(1-\alpha)}}\right]^{(1-\alpha)/\alpha h} \tag{16}$$

$$\begin{aligned} A_{M1}(h) \quad &\equiv \quad \left[\frac{(1-\alpha)+\varepsilon^{\kappa-\frac{\alpha}{1-\alpha}}\left(w^N\right)^{\frac{1}{1-\alpha}}\alpha^{-\frac{\alpha}{1-\alpha}}\left(f^M-f^N\right)/\lambda}{1-\frac{1}{2}\alpha\left[1+\delta^\alpha\left(1-2h\right)\right]}\right]^{(1-\alpha)/\alpha h} \\ &\times\left[\frac{2}{(1+\delta^\alpha)^{(1-h)}(1-\delta^\alpha)^h}\right]^{1/h} \end{aligned}$$

[5] For example, see Antràs and Helpman (2004) and He and Yu (2015).

Lemma 1 **(i)** *When* $\kappa < \frac{\alpha}{1-\alpha}$, *an increase in* ε *will shift the intersection of* $A_1(h)$ and $A_{M1}(h)$ *down and to the right;*

(ii) *when* $\kappa > \frac{\alpha}{1-\alpha}$, *an increase in* ε *will shift the intersection of* $A_1(h)$ and $A_{M1}(h)$ *up and to the left.*

Proof: Suppose $A_1(h)$ and $A_{M1}(h)$ intersect at $\widetilde{h}$ (i.e. $A_1(\widetilde{h}) = A_{M1}(\widetilde{h})$).

At $\widetilde{h}$, it is straightforward to show that when $\kappa < \frac{\alpha}{1-\alpha}$, we have $\frac{dA_{M1}(h)}{d\varepsilon}\frac{\varepsilon}{A_{M1}(h)} < \frac{dA_1(h)}{d\varepsilon}\frac{\varepsilon}{A_1(h)} < 0$ (correspondingly, the intersection of $A_1(h)$ and $A_{M1}(h)$ moves down and to the right). When $\kappa > \frac{\alpha}{1-\alpha}$, we have $\frac{dA_{M1}(h)}{d\varepsilon}\frac{\varepsilon}{A_{M1}(h)} > \frac{dA_1(h)}{d\varepsilon}\frac{\varepsilon}{A_1(h)} > 0$ (correspondingly, the intersection of $A_1(h)$ and $A_{M1}(h)$ moves up and to the left).■

An alternative (and also the simplest) way to distinguish between Case (a) and Case (b) is to notice that the intersection of $A(h)$ and $A_M(h)$ is above ω in Case (a) but is below ω in Case (b) (see Figures (a) and (b)). Therefore, the results in Lemma 1 indicate how product quality could play an important role in explaining whether Case (a), or Case (b), will actually become the equilibrium outcome. Thus, we obtain the following proposition:

Proposition 1 *If higher quality requires a higher level of fixed cost,*

(i) *when* $\kappa < \frac{\alpha}{1-\alpha}$, *the product cycle of low-quality (resp. high-quality) products follows the path in Case (a) (resp. Case (b)).*

(ii) *when* $\kappa > \frac{\alpha}{1-\alpha}$, *the result is reversed. That is, the product cycle of low-quality (resp. high-quality) products follows the path in Case (b) (resp. Case (a)).*

From (13-15), notice that κ is the quality elasticity of fixed costs and $\frac{\alpha}{1-\alpha}$ is the quality elasticity of variable profits. When $\kappa < \frac{\alpha}{1-\alpha}$ (*resp.* $\kappa > \frac{\alpha}{1-\alpha}$), total profits increase *(resp.* decrease) with product quality. Also notice that, at the intersection of $A_1(h)$ and $A_{M1}(h)$ (i.e. $\pi^S_{M1}(h) = \pi^M_1(h)$), variable profits under multinational are higher than under subcontracting because the former's fixed cost is higher. Since the quality elasticity is the same for both, variable profits under multinational increase faster than under subcontracting. Consequently, the total profit under multinational increases (*resp.* decreases) faster than under subcontracting if $\kappa < \frac{\alpha}{1-\alpha}$ (*resp.* $\kappa > \frac{\alpha}{1-\alpha}$). Therefore, when $\kappa < \frac{\alpha}{1-\alpha}$ (*resp.* $\kappa > \frac{\alpha}{1-\alpha}$), high-quality products favour (*resp.* do not favour) the emergence of multinationals. It is only when $\kappa = \frac{\alpha}{1-\alpha}$ that product quality does not affect the choice of organizational structures in the product cycle.

3.2 Product Quality and Variable Cost

The production of high-quality products also may require more variable inputs/costs (e.g. Crozet, Head and Mayer, 2011; Manova and Zhang, 2012; Kugler and Verhoogen, 2012). For the second specification, we assume that product quality is associated with iceberg-type variable costs. Specifically, we assume the following production function:

$$y_\varepsilon = \frac{1}{\varepsilon^\nu}\left(\frac{x_h}{1-z}\right)^{1-z}\left(\frac{x_l}{z}\right)^z, \qquad 0<z<1, \nu>0 \tag{17}$$

and obtain the profits corresponding to the three choices facing the parent firm in the North (as in (3-5)):

$$\pi_2^N(z) = (1-\alpha)\,\lambda\varepsilon^{\frac{\alpha(1-\nu)}{1-\alpha}}\left(\frac{w^N}{\alpha}\right)^{-\frac{\alpha}{1-\alpha}} - w^N f^N \tag{18}$$

$$\pi_{M2}^S(z) = \left(1-\frac{1}{2}\alpha\right)\lambda\varepsilon^{\frac{\alpha(1-\nu)}{1-\alpha}}\left(\frac{2\left(w^N\right)^{(1-z)}\left(w^S\right)^z}{\alpha}\right)^{-\frac{\alpha}{1-\alpha}} - w^N f^S \tag{19}$$

$$\pi_2^M(z) = \left(1-\frac{1}{2}\alpha\left[1+\delta^\alpha\left(1-2z\right)\right]\right)\lambda\varepsilon^{\frac{\alpha(1-\nu)}{1-\alpha}}\left(\frac{2\left(w^N\right)^{(1-z)}\left(w^S\right)^z}{\alpha(1+\delta^\alpha)^{(1-z)}(1-\delta^\alpha)^z}\right)^{-\frac{\alpha}{1-\alpha}} - w^N f^M \tag{20}$$

From (8) and (18-20), we obtain the corresponding two curves as follows (as in Figures (a) and (b)):

$$A_2(h) \equiv \left[\frac{(1-\alpha)+\varepsilon^{\frac{\alpha(v-1)}{1-\alpha}}\left(w^N\right)^{\frac{1}{1-\alpha}}\alpha^{-\frac{\alpha}{1-\alpha}}\left(f^S-f^N\right)/\lambda}{\left(1-\frac{1}{2}\alpha\right)\left(\frac{1}{2}\right)^{\alpha/(1-\alpha)}}\right]^{(1-\alpha)/\alpha h} \tag{21}$$

$$\begin{aligned} A_{M2}(h) \quad &\equiv \quad \left[\frac{(1-\alpha)+\varepsilon^{\frac{\alpha(v-1)}{1-\alpha}}\left(w^N\right)^{\frac{1}{1-\alpha}}\alpha^{-\frac{\alpha}{1-\alpha}}\left(f^M-f^N\right)/\lambda}{\left(1-\frac{1}{2}\alpha\left[1+\delta^\alpha\left(1-2h\right)\right]\right)}\right]^{\frac{(1-\alpha)}{\alpha h}} \\ &\times\left[\frac{2}{(1+\delta^\alpha)^{(1-h)}(1-\delta^\alpha)^h}\right]^{\frac{1}{z}} \end{aligned}$$

Lemma 2 (i) *When $\nu<1$, an increase in ε will shift the intersection of $A_2(h)$* and *$A_{M2}(h)$ down and to the right; and*

(ii) w*hen* $\nu > 1$, *an increase in* ε *will shift the intersection of* $A_2(h)$ and $A_{M2}(h)$ *up and to the left.*

Proof: The method is similar to the proof of Lemma 1.■

Thus, we obtain the following proposition:

Proposition 2 *If higher quality requires more variable costs,*

(i) *when* $v < 1$*, the product cycle of low-quality (resp. high-quality) products follows the path in Case (a) (resp. Case (b)).*

(ii) *when* $v > 1$*, the result is reversed. The product cycle of low-quality (resp. high-quality) products follows the path in Case (b) (resp. Case (a)).*

From the variable profits in (18-20), notice that there is an increasing (*resp.* decreasing) return to quality when $\nu < 1$ (*resp.* $\nu > 1$). Also notice that, at the intersection of $A_2(h)$ and $A_{M2}(h)$, the variable profit under multinational is higher than under subcontracting because the former has a higher level of fixed costs. Since the quality elasticity is the same for both, high-quality products favour (*resp.* do not favour) the emergence of multinationals when $\nu < 1$ (*resp.* $\nu > 1$). It is only when $\nu = 1$ that product quality does not affect the choice of organizational structures in the product cycle.

3.3 Product Quality and Headquarter Intensity

In addition to product maturity, the share of the low-tech/high-tech input also captures many other important issues in production. For example, it is commonly known that production of high-quality products often requires more effective management (e.g. Verhoogen, 2008; Manova and Zhang, 2015). Thus, for our third specification, we assume that a higher quality requires a higher headquarter intensity in goods production. Specifically, we assume the following Cobb-Douglas production function:

$$y_\varepsilon = \left(\frac{x_h}{1-z_j}\right)^{1-z_j}\left(\frac{x_l}{z_j}\right)^{z_j}, \quad z_j = \frac{h(t)}{(1+\varepsilon)^{\gamma_j}},\ 0 < \gamma_j < 1,\ j = N, S, M \tag{22}$$

where z_j, the share of the low-tech input, is now affected by not only the maturity of the product but also the quality of the final product. Parameter γ_j is related to the three organizational choices: Northern production, multinational and subcontracting. We assume that $\gamma_S > \gamma_M = \gamma_N$. That is, in order to achieve the same level of quality for the final product, *ceteris paribus,* the headquarter intensity in subcontracting has to be higher than that in multinational or Northern production. Since product quality is the most difficult thing to control in an unaffiliated plant in the South, a higher headquarter intensity is required, *ceteris paribus*.

Following the same procedures as in Section 2, using (8) and (22), we obtain the corresponding two curves as follows (as in Figures (a) and (b)):[6]

$$A_3(h) = \left[\frac{1-\alpha}{\left(1-\frac{1}{2}\alpha\right)\left(\frac{1}{2}\right)^{\alpha/(1-\alpha)}}\right]^{\frac{(1-\alpha)(1+\varepsilon)^{\gamma_S}}{\alpha h}} \tag{23}$$

$$\begin{aligned} A_{M3}(h) &= \left[\frac{1-\alpha}{1-\frac{1}{2}\alpha\left[1+\delta^{\alpha}\left(1-2h/(1+\varepsilon)^{\gamma_M}\right)\right]}\right]^{\frac{(1-\alpha)(1+\varepsilon)^{\gamma_M}}{\alpha h}} \\ &\quad \times \left[\frac{2}{(1+\delta^{\alpha})^{(1-h/(1+\varepsilon)^{\gamma_M})}(1-\delta^{\alpha})^{h/(1+\varepsilon)^{\gamma_M}}}\right]^{\frac{(1+\varepsilon)^{\gamma_M}}{h}} \end{aligned}$$

Lemma 3 *An increase in ε will* **(i)** *shift $A_3(h)$ and $A_{M3}(h)$ to the right and* **(ii)** *move their intersection down and to the right.*

Proof: Suppose $A_3(h)$ and $A_{M3}(h)$ intersect at $\widetilde{\omega}$ (i.e. $\widetilde{\omega} \equiv A_3(h) = A_{M3}(h)$). Totally differentiating $A_3(h)$ and $A_{M3}(h)$ at $\widetilde{\omega}$ reveals that the $dh/d\varepsilon$ of $A_3(h)$ (i.e. the horizontal movement) is greater than that of $A_{M3}(h)$. Thus, relative to the original intersection of $A_3(h)$ and $A_{M3}(h)$, the new intersection moves down and to the right.■

The intuitions for the results are as follows. Since higher quality requires higher intensity of headquarter service, it increases the advantage of Northern production *vis-a-vis* subcontracting. As a result, $A_3(h)$ shifts up and $h(\bar{t})$ moves to the right. Similarly, it also increases the advantage of Northern production *vis-a-vis* multinational production and, as a result, $A_{M3}(h)$ shifts up and $h(\bar{t}_{MN})$ moves to the right. However, when comparing multinational production with subcontracting, higher quality increases the advantage of multinational *vis-a-vis* subcontracting. Therefore, the intersection of $A_3(h)$ and $A_{M3}(h)$ also moves down and to the right.

Thus, we obtain the following proposition.[7]

[6]The existence of $h(\bar{t}) \in (0,1)$ and $h(\bar{t}_{MS}) \in (0,1)$, and the intersection of $A_3(h)$ and $A_{M3}(h)$, can be proved in a similar way as in Antràs (2005).

[7]In their paper on organizational forms, Antràs and Helpman (2004) also find that integration takes place in headquarter-intensive sectors, but they do not discuss product quality. In our paper, headquarter intensity is just one of the three quality-cost specifications.

Proposition 3 *If high quality requires high intensity of headquarter service, the product cycle of low-quality (resp. high-quality) products follows the path in Case (a) (resp. Case (b)).*

4 Concluding Remarks

In this paper we show that how product quality could provide an important explanation for the different paths of the evolving organizational structures in the product cycle. We show that multinationals could emerge in the product cycle of high-quality products; however, the reverse could also happen. The outcome is dependent on how product quality is achieved and on whether or not there is an increasing/decreasing return to quality.

References

[1] Antràs, Pol. 2005. "Incomplete contracts and the Product Cycle." *American Economic Review,* 95(4): 1054–1073.

[2] Antràs, Pol, and Elhanan Helpman. 2004. "Global Sourcing." *Journal of Political Economy*, 112(3): 552-580.

[3] Basco, Sergi. 2013. "Financial Development and the Product Cycle." *Journal of Economic Behavior & Organization*, 94: 295–313.

[4] Biesebroeck, Johannes V., and Lijun Zhang. 2014. "Interdependent Product Cycles for Globally Sourced Intermediates." *Journal of International Economics*, 94(1): 143-56.

[5] Crozet, Matthieu, Keith Head, and Thierry Mayer. 2012. "Quality Sorting and Trade: Firm-level Evidence for French Wine." *Review of Economic Studies*, 79(2): 609-644.

[6] Hallak, Juan C., and Jagadeesh Sivadasan. 2013. "Product and Process Productivity: Implications for Quality Choice and Conditional Exporter Premia." *Journal of International Economics*, 91(1): 53-67.

[7] He, Huanlang and Zhihao Yu. 2015. "The Evolving Patterns of Global Production of Multi-Product Firms," *Canadian Journal of Economics,* August 2015 (forthcoming).

[8] Kugler, Maurice, and Eric Verhoogen. 2012. "Prices, Plant Size, and Product Quality." *Review of Economic Studies* 79(1): 307-39.

[9] Manova, Kalina B., and Zhiwei Zhang. 2012. "Multi-Product Firms and Product Quality." *NBER Working Paper* 18637.

[10] Motta, Massimo. 1993. "Endogenous Quality Choice: Price vs. Quantity Competition." *Journal of Industrial Economics* 41(2): 113–131.

[11] Shaked, Avner, and John Sutton. 1983. "Natural Oligopolies." *Econometrica* 51(5): 1469–1483.

[12] Sutton, John. 2007. "Quality, Trade and The Moving Window: the Globalization Process." *Economic Journal* 117(524): 469–498.

[13] Verhoogen, Eric. 2008. "Trade, Quality Upgrading and Wage Inequality in the Mexican Manufacturing Sector." *Quarterly Journal of Economics* 123(2): pp.489-530.

[14] Vernon, Raymond. 1966. "International Investment and International Trade in the Product Cycle." *Quarterly Journal of Economics*, 80(2), 190–207.