Global outsourcing or foreign direct investment: Why apple chose outsourcing for the iPod

Chu-Ping Lo*

Department of Agricultural Economics, National Taiwan University, Taipei, Taiwan

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ABSTRACT

A simple model is presented, where a firm's productivity is endogenized by its R&D investment. It shows that the most productive firms may prefer international outsourcing to foreign direct investment (FDI) in industries with a high innovation share. The high innovation share motivates the firms to economize on organizational cost in order to save resources for R&D investment, making outsourcing preferable to FDI because the former incurs a smaller organizational cost. This model helps explain why Apple Inc., belonging to the electronics industry, which has a particularly high innovation share, launched its innovative iPod through international outsourcing instead of FDI.

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1. Introduction

Helpman et al. (2004) argued that the most productive firms prefer foreign direct investment (FDI) to arms-length trade when faced with a proximity-concentration trade-off. Through empirical studies, Head and Ries (2003) examined the case of Japan, Girma et al. (2005) examined the case of the United Kingdom, and Wagner (2007) examined the case of Germany, with all in arguments that the most productive firms prefer FDI over exports. This assertion also gains theoretical support from Antràs and Helpman (2004), who applied an incomplete contract model to demonstrate that most productive firms prefer FDI and less-productive firms prefer international outsourcing. While Helpman et al. (2004) assume positive transportation costs and firms therefore face the choice of whether or not to export, transportation costs are assumed to be absent in the Antràs–Helpman's (2004) model. Instead, Antràs and Helpman (2004) apply an incomplete contract distortion to address the difference between FDI and international outsourcing strategies. In all, both approaches assert that the most productive firms prefer to FDI.

However, some of the world's most productive firms, especially in the electronics industry (e.g., Apple, Microsoft, Nokia, Hewlett-Packard)¹ carry out international outsourcing intensively and operate almost no FDI activities in launching their innovative products (e.g., iPod, game consoles, cell phones and notebook computers, respectively). For example, in October 2001, Apple first marketed the iPod, which was a “disruptive innovation” with a set of innovative functions (Clayton and Raynor, 2003). Being the most revolutionary portable media player in history, and in the six years after its launch, Apple sold over 100 million iPods worldwide (see Apple's “The Best Going On” conference). The success of iPod over competing music players came from radical innovations in its user-friendly interface and smooth integration with Mac and Windows through which users could easily purchase and download music/video content. Apple designed the majority of the system architecture of the iPod in-house but simultaneously outsourced the remaining four hundred-plus intermediate components to both domestic and international contractors.² Apple even contracted out

¹ *BusinessWeek* magazine and the Boston Consulting Group's ranking of “The World's Most Innovative Companies” in 2006 gave Apple Computer Inc. the top rank, Microsoft the fifth, Nokia the eighth, Sony the thirteenth, and Hewlett Packard the forty-second.

² A few high cost components were made by other companies, such as Japan's Toshiba (hard drive for on board storage), Korea's Samsung (flash memory for temporary storage), and U.S.-based Broadcom (integrated video processor for media playback) (Linden et al., 2007).

* Tel.: +886 233 662 653.

E-mail address: cplo@ntu.edu.tw.

its core software; for example, the user interface was designed with the help of Pixo, and the reference platform was designed by PortalPlayer (Kahney, 2006). Of the \$299 retail price for the 30GB video iPod, Apple accounted for a 25 percent share of the value for the core software design, while 36 percent is attributed to contracted manufacturers in the low-wage Asia-Pacific region that provide generic components and direct labor (Linden et al., 2007).³ Examples of the generic components and direct labor include the metal casing, provided by Taiwan's Foxconn, and assembly, completed in Chinese factories owned by Taiwanese firms such as Inventee Appliances and Foxconn (Einhorn, 2007). The pattern of global outsourcing also occurs with other electronics products, such as Hewlett-Packard's notebook computers, with 39 percent of the value of a notebook computer attributable to generic inputs and direct labor.

In contrast to the outsourcing literature (e.g., Antràs and Helpman, 2004; Antràs, 2005), which has argued that the most productive firms prefer FDI to international outsourcing especially when the product is at the innovative stage, both Apple and HP have worked closely with outside partners from the beginnings of design. This approach has been dramatically undertaken by the lead firms in the electronics industry (Sturgeon, 2002).

Why is then international outsourcing prevailing for the lead firms (i.e., most productive firms) in the electronics industries? The literature of global value chain provides an explanation: it is the advances in information technology (IT) enabling the electronics industry to more easily standardize the interfaces between components, such that the component modularization has made international outsourcing more attractive by allowing multiple firms to share the same generic components at a lower cost due to economies of scale (Sturgeon and Lee, 2001; Sturgeon, 2002).⁴ However, a shortcoming of the product modularization hypothesis is that the lead firms in the electronics industry (e.g., Apple computer and Hewlett-Packard) have contracted out not only generic but also non-generic components.

Another key factor facilitating the growth of international outsourcing in the product modularization hypothesis is the lead firms' desire to reduce fixed organization investment, especially in manufacturing facilities (Sturgeon and Lee, 2001). I borrow this concept in this paper, and argue that the prevailing dependence on global outsourcing in the electronics industry is largely due to Northern firms' leveraging the mass production capacity of those in the South. For example, Flextronics,⁵ a contract electronics maker headquartered in Singapore, worked with Microsoft in the initial stage of developing its innovative game console, Xbox, by building customized (as opposed to generic) mechanical parts and performing system tests. More importantly was Flextronics' capacity to ramp up production from zero to 100,000 consoles per week in less than five weeks. Production capacity was important because "if the system [Xbox] could not be built cost effectively and ramp up in volumes, it would have little chance against the more established systems on the market" (Carbone, 2002). Therefore, the innovative Microsoft focused on R&D activities in order to develop a game system that was technologically superior to rival systems (e.g., Sony's PlayStation), and then outsourced the

low-tech components to these contract firms that specialized in mass production, thereby avoiding the substantial organizational costs of establishing a production capacity abroad through FDI.⁶ With these specialized contract manufacturers around the world, the world's most productive and innovative firms, well known for their R&D capabilities, may prefer international outsourcing to FDI as a way to cut costs and improve general productivity when launching their innovative products because FDI incurs a larger fixed organization cost than international outsourcing.

The purpose of this study is to determine why the world's most productive and innovative firms may prefer international outsourcing to FDI. I incorporate Griliches' (1986) production function into Antràs–Helpman's (2004) model to argue that a Northern firm determines its global organizational structure based not only on a trade-off between low-waged production costs and incomplete contract distortion, but also on a trade-off between R&D investment and organizational cost. I argue that an increase in the innovation share augments the trade-off between R&D investment and organizational cost, which may take precedent over the trade-off between production costs and incomplete-contract distortion when the innovation share is sufficiently large. As it happens, in industries with a sufficiently high innovation share, the most productive firms tend to carry out international outsourcing activities rather than FDI because the high innovation share enhances the advantages of R&D investment. On the other hand, in industries with a relatively low innovation share, the most productive firms prefer FDI to outsourcing because outsourcing incurs a larger incomplete-contract distortion.

The remainder of this paper is organized as follows. In Section 2, I revisit Griliches' (1986) results by applying data from the Industrial R&D Investment Scoreboard reported by Eurostat to determine how the innovation share varies across industries. In Section 3, I add to Antràs–Helpman's (2004) model of Griliches' (1986) production function, in which firms' productivity is augmented by innovation, and I argue that this difference in the innovation share reshapes a firm's global organizational form. In particular, the ordering in Antràs–Helpman's (2004) model is reversed when an industry has a sufficient high innovation shares. Section 4 concludes.

2. R&D investment and productivity

It is well documented that research and development has a positive effect on productivity (e.g., Leonard, 1971; Mansfield, 1980; Griliches, 1980, 1986; Lichtenberg and Siegel, 1991; Medda et al., 2003).⁷ Theoretically, Griliches (1986) defined an augmented Cobb Douglas production function with an input of R&D investment and illustrated that R&D contributes to productivity growth in U.S. manufacturing.⁸ By using the National Science Foundation dataset on about 1000 of the largest U.S. manufacturing firms from 1957 through 1977, Griliches (1986) found that the innovation share, measured by the contribution of the R&D on

³ Distribution and retails accounted for another 25 percent. Inputs from Japan accounted 9 percent, while inputs from Taiwan accounted for 1 percent.

⁴ Nevertheless, the product modularization is also underway in many other sectors as well, such as apparel and footwear, toys, food processing, home furnishings and lighting, brewing, and automotive parts, pharmaceutical production, but not only been dramatic in the electronics industry (Sturgeon, 2002).

⁵ Foxconn also manufactures iPods for Apple, cell phones for Nokia, and computers for Hewlett Packard, among others.

⁶ In response to Microsoft's general production cost saving from outsourcing, Sony outsourced its PlayStation game console to Foxconn, a Taiwanese firm whose major production facilities are located in China.

⁷ Empirically, Griliches (1980) has revealed a positive and robust relationship between R&D and total factor productivity for the United States, as did Medda et al. (2003) for Italy.

⁸ The production function in Griliches' (1986) model is given by $Y = A/L^{1-\beta}C^\beta$ (see also Lichtenberg and Siegel, 1991), where L denotes labor and C denotes capital. Here, A denotes neutral technology stock that is accessible to all producers. R&D input $I = \sum s_i K_{t-i}$ is a measure of the distributed lag effect of past research investments on productivity, where K_{t-i} measures the real gross investment in research in period i , and s_i connects the levels of past research to the current state of knowledge.

Table 1

Cross-sectional productions: all industries. Dependent variable: log net income of OECD firms: 2005.

Industries	E. coefficient	No. of observation	R ²
All industries	0.12 (0.01)	1557	0.93
Industries with high innovation share ($\hat{r} \geq 0.3$)			
Computer hardware (ICB 9572)	0.46 (0.08)	55	0.95
Software (ICB 9537)	0.45 (0.07)	122	0.86
Semiconductors (ICB 9576)	0.43 (0.05)	91	0.91
Telecommunication equipment (ICB 9578)	0.35 (0.06)	61	0.94
Electronic components (ICB 2733)	0.30 (0.07)	48	0.94
Industries with medium innovation share ($0.3 > \hat{r} > 0.15$)			
Household goods (ICB 372)	0.27 (0.07)	26	0.97
Health care (ICB 453)	0.23 (0.05)	76	0.97
Industrial machinery (ICB 2757)	0.16 (0.04)	87	0.94
Industries with low innovation share ($\hat{r} \leq 0.15$)			
Aerospace and defense (ICB 271)	0.13 (0.06)	40	0.98
Pharmaceuticals (ICB 4577)	0.13 (0.06)	85	0.91
Food producers (ICB 357)	0.10 (0.07)	39	0.91
Construction and materials (ICB 235)	0.08 (0.05)	48	0.95
Chemicals (ICB 135)	0.07 (0.05)	109	0.90
Automobile and parts (ICB 335)	0.05 (0.05)	71	0.97

Net sales exclude sales of joint ventures and associates. Following Griliches (1986), R&D stock is the accumulated sum of R&D expenditures from 2002 through 2005 based on an assumption of 15 percent declining balance depreciation per year, where the R&D expenditure is cash investments funded by companies themselves. Standard errors are shown in parentheses.

Industries with fewer than 30 sample firms are not shown. Standard errors are shown in parentheses. The three industry groups are based on their estimated innovation share ($\hat{r}$).

productivity, ranges from 0.09 to 0.17.⁹ In revisiting Griliches' results, I use a more recent dataset from the Industrial R&D Investment Scoreboard reported by Eurostat, which collected data from more than 1,000 of the largest firms' audited financial accounts and annual reports from 2002 through 2005. These firms were publicly listed companies with registered head offices located within the OECD member countries. However, the Scoreboard designates companies in accordance with their sector classification, as defined by the Financial Times Stock Exchange Index (ICB Classification).

As shown in Table 1, my cross-sectional estimated innovation share on OECD firms for all industries in 2002–2005 is about 0.12, which is similar to Griliches's estimation that of U.S. firms in 1966–1977.¹⁰ Further examination of industry-specific innovation share finds variation among industries. Table 1 reports the estimation of the innovation share for each industry, based on the ICB Classification codes for various industries. Industries with less than 30 observations are not presented. As shown in Table 1, the estimated innovation share varies substantially among these industry groups. For example, the computer hardware industry has the highest innovation share at 0.46, and the automobiles and parts industry has the lowest at 0.05. Because of the variation among industries, I divide these industries into three groups: industries with an estimated innovation share larger than 0.30 are categorized as “Industries with High Innovation Share”; those with an estimated innovation share less than 0.15 are categorized as “Industries with Low Innovation Share”; and the remaining industries are categorized as “Industries with Medium Innovation Share.”

Most industries have a low innovation share of somewhere around 0.1 and belong to the “Industries with Low Innovation

Share” group. Five industries have exceedingly large estimated innovation shares, ranging from 0.30 to 0.46 (0.4 on average). Among these five industries, three have the same three-digit ICB code (957), and all have the same two-digit ICB code (95). In other words, the five industries belonging to the “Industries with High Innovation Share” group are all electronics and IT industries.

3. The model

The seminal model of Antràs and Helpman (2004) and Antràs (2005) provide the basic structure for my analysis, where labor is a unique factor of production. Assume that, in the North–South world, there are $J + 1$ industries, where J industries produce a continuum of differentiated products, and the remaining industry produces a homogeneous good. The homogeneous good is used as a numeraire that can be freely produced and traded in both countries in equilibrium. Consumers have similar preferences over all differentiated goods, and each consumer maximizes a utility function:

$$U = x_0 + \frac{1}{u} \sum_{j=1}^J X_j^u, \quad 0 < u < 1, \quad (1)$$

where x_0 represents the consumption of the homogeneous good, X_j is an index of aggregate consumption of the differentiated products in industry j , and u is a parameter representing the degree of substitution across differentiated-product industries. The aggregate consumption in industry j , in turn, is a constant elasticity substitution (CES) utility function of the consumption of different varieties of final goods $x_j(i)$:

$$X_j = \left[\int x_j(i)^\alpha di \right]^{1/\alpha}, \quad 0 < \alpha < 1, \quad (2)$$

where the range of variety i is endogenously determined. Assume that $\alpha > u$ so that varieties are more substitutable within an industry than across industries. This leads to an inverse demand function for each final good i as

$$p_j(i) = X_j^{u-\alpha} x_j(i)^{\alpha-1}, \quad (3)$$

where $p_j(i)$ is the price of the final good $x_j(i)$.

⁹ Please also see Eq. (4) for a clearer definition of the innovation share. To eliminate fixed effects, Griliches (1986) analyzed the growth rate of adjusted productivity on the growth rate of R&D investment, resulting in an estimation of 0.12, which is very close to his estimation in the cross-sectional level regression.

¹⁰ The biotechnology industry is notorious for its fledgling markets in which many firms have either negative net incomes or enormously large R&D spending, so I run two regressions, one that includes the biotechnology industry and another that does not. Both regressions have almost the same results. In comparison to other industries, only the biotechnology industry has a negative estimated elasticity; however, its small size does not affect our estimation.

In Antràs–Helpman's (2004) model, the unique final good producer of variety i draws a particular realization θ from a known distribution.¹¹ Instead, in this current model, I argue that the productivity is endogenously determined by a firm's Research and Development (R&D) decision as:

$$\theta = AI_N(i)^{r_j}, \quad (4)$$

where $I_N(i)$ denotes R&D investment made by the final good producer i in the North and A is an exogenous parameter denoting the neutral productivity. In (4), r_j is an industry-specific parameter denoting the extent to which skilled workers are efficiently employed, and $0 < r_j < 1$.¹² It will be shown clearly in a later discussion that r_j increases an industry's R&D intensity. A firm's productivity increases as the investment in R&D increases, but in diminishing returns. Obviously, in comparison to industries with a lower innovation share, a firm in an industry with a high innovation share, *ceteris paribus*, is encouraged to allocate more resources to R&D investment away from organization investment in order to raise productivity and revenue.

The firm i in an industry j is heterogeneous in productivity and then incorporates high- and low-tech inputs of $H_j(i)$ and $M_j(i)$ in production of the final good $x_j(i)$. The firm manufactures the high-tech inputs but relocates the low-tech inputs to the South by either FDI or international outsourcing. The production function is then given by:

$$x_j(i) = \theta \left(\frac{H_j(i)}{1 - z_j} \right)^{1 - z_j} \left(\frac{M_j(i)}{z_j} \right)^{z_j}, \quad 0 < z_j < 1. \quad (5)$$

The variable z_j represents the maturity of the industry j , with a larger z implying that the industry is at a more mature stage. Let the wages of the North and South be denoted as w_N and w_S , respectively, and let $w_N > w_S$. Incorporating (4) into (5), the production function is rewritten as

$$x_j = AI_N^{r_j} \left(\frac{H_j}{1 - z_j} \right)^{1 - z_j} \left(\frac{M_j}{z_j} \right)^{z_j}. \quad (6)$$

Becoming a Griliches-type (1986) production function, (6) presents an increasing-return-to-scale characteristic. For simplicity, the industry index j is dropped from all of the variables in the following discussion.

3.1. Division of surplus and organization costs

To focus on offshore production, I only discuss the cases where the low-tech inputs are produced either by FDI or by international outsourcing. As is well known, offshore production is limited by the incomplete nature of contracts governing international transactions. Due to the non-verifiability of the relevant state of the world, the presence of incomplete contracts leads the parties involved in offshore production to acquire partial returns, such that they may under-invest *ex ante* in relationship-specific investments. The threat of underinvestment motivates the Northern firm to purchase more residual rights from the subsidiaries located in the South by vertical integration (FDI) in order to reduce the impact of potential underinvestment in comparing to international outsourcing.¹³

Therefore, a trade-off associated with the allocation of ownership rights arises between organization costs and incomplete-contract

distortions. After a good quality prototype is provided, the two parties bargain over the surplus from the relationship-specific partnership. If such bargaining results in an agreement between the parties, from (3) and (5), then the potential revenue from the sale of the final good is:

$$R(i) = X^{u - \alpha} \theta^\alpha \left(\frac{H(i)}{1 - z} \right)^{\alpha(1 - z)} \left(\frac{M(i)}{z} \right)^{\alpha z}. \quad (7)$$

However, if the parties fail to agree, the outside option of the low-tech inputs producer will be zero while that of the high-tech inputs firms will vary with different organizational strategies. Following Antràs and Helpman (2004) and Antràs (2005), the *ex post* surplus share is dependent on a firm's organizational structure as $\beta_K \in (0, 1)$, where $K \in \{V, O\}$, where V denotes FDI, and O denotes international outsourcing. That is, the Northern final-good producer acquires a fraction of the *ex post* surplus (i.e., $\beta R(i)$) while the remaining surplus is attributed to the low-tech input provider (i.e., $(1 - \beta)R(i)$). Antràs and Helpman (2004) also assumed that an FDI firm acquires more leverage than one that outsources, resulting in the order of $\beta_V > \beta_O > 1/2$.¹⁴ Note that of the \$299 retail price for the 30 GB iPod, 36 percent of the value is attributed to generic inputs and direct labor provided in large part by firms in the Asia-Pacific region (Linden et al., 2007). Similarly, for a \$1400 HP notebook computer, about 39 percent of value is attributed to generic inputs and direct labor. Thus, at least in the electronics industry, it is feasible to assume that the β_O is around one-half to two-thirds.

Antràs and Helpman (2004) also assumed that FDI incurs larger fixed organizational costs (investment), such as $f_V > f_O$, where f_V and f_O denote the fixed organizational costs for FDI and international outsourcing, respectively. In this paper, I use the same ordering of division of surplus and organization costs.

3.2. Equilibrium

Suppose there are numerous low-tech input suppliers bidding for the low-tech input contract by paying t to the Northern firms, where t can be either positive or negative. The income transfer will cancel out in the joint profit maximization, so, for simplicity, I neglect it in the following discussion. As in Antràs and Helpman (2004) model, I assume unit productivity for manufacturing the H and M inputs in either country. However, in this current model, the productivity is endogenously determined by a firm's R&D investment, which is carried out by the North workers.

With the above set-up, a final good producer maximizes its profit:

$$\max_{I_N, H} \beta_K R - w_N I_N - w_N H - w_N f_K, \quad (8)$$

where the firm index i is dropped for simplicity. The first-order condition of (8) associated with the choices of H leads to $\alpha \beta_K (1 - z)R = w_N H$, while that associated with the choices of I_N leads to $\alpha r \beta_K R = w_N I_N$. The equilibrium shows that industries with a higher innovation share (i.e., r) tend to have higher R&D intensity (defined as $w_N I_N / R = \alpha r \beta_K$). Further, the low-tech inputs producer maximizes its profit as

$$\max_M (1 - \beta_K)R - w_S M. \quad (9)$$

The first-order condition of (9) associated with the choices of M is given by

$$\alpha(1 - \beta_K)zR = w_S M.$$

¹¹ A Pareto distribution as in Helpman et al. (2004).

¹² Jones (1999) referred it to as the "stepping on toes" effect (i.e., that duplication of R&D efforts is more likely when there are too many persons engaged in it). The duplication of activities reduces the efficient use of R&D resources.

¹³ Grossman and Hart (1986) argued that contractual rights consist of specific rights and residual rights. Since it would be too costly to list all the specific rights over assets in the contract, so foreign investors might find it advantageous to purchase the residual right to have full control over the asset.

¹⁴ Grossman and Helpman (2005) assumed that, in the case of international outsourcing, Nash bargaining makes the parties share equally in the surplus that accrues from the outsourcing contracts, that is, $\beta_S = 1/2$.

Fig. 1. Distribution of β^* of electronics and the other industries.

Combining (8) and (9), the profit of the headquarters firm under joint profit maximization is then given by

$$\pi_K(r, X, z) = X^{1-\alpha} \theta^\alpha H^{\alpha(1-z)} M^{\alpha z} - w_N I_N - w_N H - w_S M - w_N f_K. \quad (10)$$

Incorporating the above first-order conditions into (10), we obtain

$$\pi_K^C = X^{1-\alpha/(1-\alpha)} \theta^{\alpha/(1-\alpha)} \psi_K^C - w_N f_K^C, \quad (11)$$

where $\psi_K(\beta_K) = (1 - \alpha r \beta_K - \alpha [\beta_K(1-z) + z(1-\beta_K)]) / [(1/\alpha)(w_N/\beta_K)^{1-z} (w_S/(1-\beta_K))^z]^{\alpha/(1-\alpha)}$ (see Appendix A for the derivation). In (11), the profit maximization is equivalent to the maximization of its slope, ψ_K . The optimal division of share can then be derived by taking $\dot{\psi}_K(\beta_K) = 0$; in particular, we obtain $\beta^* = ((1-z+r/2)(1-\alpha z) - \sqrt{[(1-z+r/2)(1-\alpha z)]^2 - (1-2z+r)(1-\alpha z)(1-z)}) / (1-2z+r)$, which converges to the original Antràs and Helpman (2004) expression when $r = 0$.

As shown in Table 1, the majority of industries have an innovation share of around $r = 0.1$, but the electronics industry group alone has a high innovation share of about $r = 0.4$. We can plot $\beta^*(z)$ as a function of z for an industry j , which has a specific r_j , by simulation as shown in Fig. 1.

To sharpen the contrast, I introduce only two different industry groups in the simulation: one with a high innovation share of 0.4 and the other with a low innovation share of 0.1. The thin curve in Fig. 1 illustrates the case where $r = 0.1$, and the curve in bold illustrates the case in which $r = 0.4$. Specifically, the $\beta^*(z, r = 0.4)$ in Fig. 1 denotes the electronics industry and $\beta^*(z, r = 0.1)$ represents the other industries. It is easy to find out $\beta^*(0, r) = 1/(1+r)$ and $\beta^*(1, r) = 0$, suggesting that the optimal β^* for the skill-intensive industry is lower if the corresponding innovation share r is greater. For comparison, I also illustrate the division of surplus determined by bargain under FDI and under outsourcing modes in Fig. 1.

4. FDI vs. outsourcing

Outsourcing strategy dominates FDI in the labor-intensive industries (i.e., $z > 0.5$), as illustrated in Antràs and Helpman (2004) model. Thus, in this paper, I focus on the skill-intensive industries (i.e., $z < 0.5$), in which our results differ. To focus on our analysis, I also assume in this model that the wage gap between the North and the South is large enough so that the strategy of domestic production is preferred by all other organizational structures.

Fig. 2. Equilibrium in industries with a lower r .

In an industry with a low innovation share (a smaller r), β_V is closer to the optimal β^* curve than β_O , indicating $\psi_V > \psi_O$. Then, we can plot the profit with respect to the productivity $\theta_i^{\alpha/(1-\alpha)}$ for the low innovation share industries as in Fig. 2. As implied in (11), the slopes of the profit lines are crucially determined by ψ_K , indicating that the FDI mode is a more optimal strategy than the outsourcing mode for the most productive firms. This result is in line with Antràs–Helpman's (2004) model.

This current model deviates from Antràs–Helpman's (2004) model when the innovation share is sufficiently large. Fig. 1 shows that, the higher the innovation share in an industry, the closer the outsourcing mode is to the optimal division of surplus. That is, in an industry with a high innovation share (a larger r), β_O is closer to the optimal β^* curve than β_V , indicating $\psi_V < \psi_O$. As shown in Fig. 3, the slope of the profit line under FDI mode may be smaller than that of outsourcing mode, implying that the outsourcing

Fig. 3. Equilibrium in industries with a high r .

mode may be a more optimal strategy than the FDI mode and more profitable. As a result, the most productive firms in an industry with a higher innovation share may prefer international outsourcing to FDI. This is particularly true for the electronics industry, which has an especially large estimated innovation share compared to that of other industries. I argue that the high innovation share motivates Northern firms to economize on organizational spending in order to save resources for R&D investment, thereby making the firm more productive. Thus, the international outsourcing mode is preferred because it requires a lower organizational cost than FDI.

As is well known, the opportunistic underinvestment may take place when contracts are incomplete (Grossman and Hart, 1986; Hart and Moore, 1988). The division of surplus β_K is bargained over seeking to balance the underinvestment of the final-good producer and intermediate-input suppliers. Note that each party's severity of underinvestment is inversely related to the fraction of the surplus that it appropriates. I argue that an increase in R&D investment, which increases productivity and revenue more in an industry with a high innovation share than in an industry with a low one, enlarges the opportunity cost of underinvestment for both parties. As a result, the severity of underinvestment is scaled down when the innovation share of an industry is high. With less severity in opportunistic incentives, the profit-maximizing final good firms may adopt a structure of international outsourcing rather than FDI to economize on organizational costs.

This argument is somehow in line with that of Glass and Saggi (2001), who presented a product cycle model to argue that shifting production to the South increases product market profits through the lower wage cost of production there, and frees up Northern resources for innovation. However, our approach in this paper differs from that of their model in many respects. Their model is driven by differences in technology and wage rates between the North and South, whereas our model is driven by the differences in incomplete contracts and in organization costs between FDI and international outsourcing. Their model only addresses the problem of offshore production (international outsourcing only) or not while our analysis addresses the problem of which method of offshore production (i.e., FDI or international outsourcing) may play a more important role in freeing up the resources of Northern firms in improving productivity.

5. Conclusions

The difference in innovation share among industries impacts the firms' global organizational form. In an industry with a high innovation share, the Northern firm tends to economize on organizational investment in order to put more efforts into R&D investment while R&D investment and organizational costs are substitutive. That is, the firms in an industry with a larger innovation share are encouraged to devote more resources to R&D investment, *ceteris paribus*, in order to increase productivity and enlarge revenue but while simultaneously choosing a lower cost of global organizational form in order to minimize the aggregate nonproduction costs. While an increase in revenue (due to an increase in R&D investment) enlarges an opportunity cost of underinvestment for the two parties involved, the most productive firms in those industries with a larger innovation share tend to prefer international outsourcing to FDI while the incomplete contract distortion is restrained. This model helps explain why the world's most productive firms, such as Apple, Nokia, Microsoft, and HP (all in the electronics industry), often prefer international outsourcing to FDI when launching innovative products.

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Appendix A

From (8), we have $H = (\alpha\beta_K(1-z)/w_N)R$ and $I_N = (\alpha r\beta_K/w_N)R$. From (9), we have $M = (\alpha(1-\beta_K)z/w_S)R$. Plug the optimal H and M into (7), we obtain

$$R = X^{u-\alpha} \theta^\alpha \left(\frac{\alpha\beta_K}{w_N} R \right)^{\alpha(1-z)} \left(\frac{\alpha(1-\beta_K)}{w_N} R \right)^{\alpha z}. \quad (A1)$$

We can rearrange (A1) as

$$R = X^{u-\alpha/(1-\alpha)} \theta^{\alpha/(1-\alpha)} \left(\frac{\alpha\beta_K}{w_N} \right)^{\alpha(1-z)/(1-\alpha)} \left(\frac{\alpha(1-\beta_K)}{w_N} \right)^{\alpha z/(1-\alpha)}. \quad (A2)$$

The joint profit maximization in (10) is then given by

$$\begin{aligned} \pi_K(r, X, z) &= X^{u-\alpha} \theta^\alpha H^{\alpha(1-z)} M^{\alpha z} - w_N I_N - w_N H - w_S M \\ &\quad - w_N f_K \\ &= R - \alpha r \beta_K R - \alpha \beta_K (1-z) R - \alpha (1-\beta_K) z R \\ &\quad - w_N f_K \\ &= \{1 - \alpha r \beta_K - \alpha [\beta_K (1-z) + (1-\beta_K) z]\} R \\ &\quad - w_N f_K. \end{aligned} \quad (A3)$$

Plug (A2) into (A3), we obtain

$$\pi_K = X^{u-\alpha/(1-\alpha)} \theta^{\alpha/(1-\alpha)} \psi_K - w_N f_K, \quad (A4)$$

where

$$\psi_K(\beta_K) = \frac{1 - \alpha r \beta_K - \alpha [\beta_K (1-z) + z(1-\beta_K)]}{\left[(1/\alpha)(w_N/\beta_K)^{1-z} (w_S/1-\beta_K)^z \right]^{\alpha/(1-\alpha)}}$$

The optimal division of share can then be derived by taking $\psi_K(\beta_K) = 0$; It is equivalent to take derivative of $\{1 - \alpha r \beta_K - \alpha [\beta_K (1-z) + z(1-\beta_K)]\}[(\beta_K)^z (1-\beta_K)^{1-z}]^{\alpha/(1-\alpha)}$ with respect to β_K . It is then easy to calculate the optimal division of share β^* .

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