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Better technology may be sold for a lower fee: The ad valorem tariff and licensing contract

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Abstract

The main purpose of this study is to investigate how a relationship arises between an ad valorem tariff and licensed technology in a licensing contract. To this end, we study a two-country, two-firm duopolistic trade model. We consider a product market in which a high-tech foreign firm can license its production technology to an importing country. The government of the importing country chooses an ad valorem tariff rate but has no commitment power. In our model, the home government raises the tariff rate as the licensed technology improves. Our two main results in the case that a highly productive technology is licensed are paradoxical: First, better technology is sold for a lower fee in a licensing contract. Second, the profits of both the licenser and licensee decrease as the licensed technology improves. In other words, cost reduction reduces the profits of both the licenser and licensee. These findings indicate that because of the role played by the ad valorem tariff, technology licensing does not always benefit both the licensee and the licenser.

JEL codes: D43; F13; L13

Key words: Licensing contract; Ad valorem tariff; Fixed fee

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1 Introduction

Is better technology sold for higher fee? If so, this is an everyday occurrence. However, if *better* technology is sold for a *lower* fee in a licensing contract, this appears slightly paradoxical. In this paper, we present results to this effect in the case that a highly productive technology is licensed: First, better technology is sold for lower fee. Second, similar to the first result, both the licenser's and the licensee's profits decrease as the licensed technology improves. In other words, cost reduction reduces the profit of both firms.

Recently, some theoretical studies (e.g., Kabiraj and Marjit 2003; Mukherjee 2010; Mukherjee and Pennings 2006) have focused on international technology licensing, and this field is gradually growing. With regard to technology licensing, our study is closely related to the model of Mukherjee and Pennings (2006) and Mukherjee (2010).[1] The former focus on the welfare effects of licensing and consider the situation that licensing is done by a foreign monopolistic exporter and that a duopoly arises as an outcome of technology licensing. They show that the home country gains more surpluses from technology licensing (i.e., increased competition). However, they assume that the government of the home country imposes a specific tariff. Since they do not consider the ad valorem tariff, further examination of the form of tariffs and technology licensing is needed. Mukherjee (2010) considers the case of technology licensing from a low-cost firm to a high-cost one and compares Cournot with Bertrand competition in a product market. His main finding is that social welfare may be higher under Cournot competition than under Bertrand competition. However, his analysis is limited to domestic competition; he does not consider the relationship between tariff policy and technology licensing.

The present paper is also related to a few works on specific and ad valorem instruments. Although relatively few existing works on trade policies focus on the role of ad valorem tariffs, some studies focus on the effects of this tariff, albeit in a different model.[2] For instance, Shea

[1]In the context of international trade and technology transfer, a few studies focus on technology licensing, for example, Kabiraj and Marjit (2003) and Horiuchi and Ishikawa (2009). The former show that in an international duopoly that comprises home and foreign firms, the tariff policy is more desirable than the free trade policy is, from the viewpoint of the home consumers when the foreign firm is allowed to license its technology. Horiuchi and Ishikawa (2009) examine a North-South technology transfer through intermediate products. They show that in a three-firm oligopolistic setting, a decrease in the tariff on the final good may induce technology transfer and that tariff reduction may enhance home welfare.

[2]Several studies examine ad valorem instruments in the context of taxation. After Bishop (1968) compared ad valorem and specific taxes, a series of studies have arisen on tax forms and their welfare implications. For instance, Delipalla and Keen (1992) compare ad valorem and specific taxes in a Cournot oligopoly with and without free entry. Myles (1996) discusses an optimal combination of ad valorem and specific taxation in an imperfect competitive market. Moreover, Ushio (2000) examines whether a shift from a specific to an ad valorem tax would enhance welfare.

and Shea (2006) use the conjectural variation approach and examine the relationship between ad valorem and specific tariffs under international duopoly. Collie (2006) considers the efficiency of ad valorem and specific trade policies (tariffs and subsidies) under asymmetric oligopoly. Additionally, Miyagiwa (2009) investigates the effects of a specific tariff, an ad valorem tariff, and an import quota on the firm and consumers' behavior when the production technology of the firm is unobservable. Although the above studies examine the effects of ad valorem tariff in various situations, they do not consider technology licensing. Thus, we believe that our investigation of the relationship between the ad valorem tariff and licensed technology in a licensing contract is a unique contribution to the existing literature.

Our main purpose is to investigate how a relationship arises between the ad valorem tariff and licensed technology in a licensing contract. We focus on the ad valorem tariff because this tariff is important in view of the following two points: First, in real international trade, an ad valorem tariff is more frequently observed than a specific tariff.[3] Second, in an imperfect competitive market, the ad valorem tariff directly alters the product price; thus, this tariff has a stronger effect on imports than a specific tariff does.

In order to demonstrate the above findings, we study an international Cournot duopoly in which a high-tech foreign firm (hereafter, the foreign firm) can license its production technology. This firm owns the production technology and exports the product to an importing country's market, where an ad valorem tariff is imposed on the product. Once the foreign firm licenses its technology to the importing country, a firm that has the same marginal production cost as the foreign firm has (hereafter, the home firm) comes into existence in the importing country; the foreign firm takes a fixed licensing fee from the home firm, which competes with the foreign firm in the home market. We commence our analysis from the situation that the production technology has been licensed by foreign firm; hence, the home firm has already come into existence.

Thus, our model is a two-country (home (importing) and foreign (exporting)), two-firm (home and foreign) duopolistic trade model with a licensing contract. We examine the following three-stage game: In the first stage, the level of the fixed licensing fee is decided through Nash bargaining between the home and foreign firms. Second, the government of the home country

[3] See the website of Japan Customs (URL: `http://www.customs.go.jp/toukei/index.htm`). In particular, see item 3: the mechanism of tariffs (in Japanese). Further, data from JETRO (Japan External Trade Organization) show that a similar situation exists in many countries. See the home page of JETRO (URL: `http://www.jetro.go.jp/indexj.html`).

chooses the ad valorem tariff rate. Third, the home and foreign firms compete *à la* Cournot in the home market.

The logic behind our results is as follows: When a highly productive technology is licensed, the output of the home firm decreases as the licensed technology improves. In our model, the home government raises the tariff rate as the licensed technology improves. However, if a highly productive technology is licensed, the effect of an increase in the tariff rate weakens because this rate is now sufficiently high. Since the effects of technology improvement dominate the effect of the tariff increase, the exports of the foreign firm increase and the output of the home firm decreases as the licensed technology improves. The output of the home firm is inverted U-shaped for the licensed technology, and this shape is a key factor behind our results. If a highly productive technology is licensed, the foreign firm attempts to lower the license fee because an improvement in the technology reduces both the output of the home firm and revenues from the license fee. Similar to the output of the home firm, the licensing fee is inverted U-shaped for the licensed technology. Since the profit of the home and foreign firms is decided by bargaining and depends on the fixed fee, each firm's share is the same as its own bargaining power. The profit of the two firms is basically the same except for bargaining power. Hence, both firms' profits are inverted U-shaped for the licensed technology.

The remainder of this paper is organized as follows: Section 2 presents the model. Section 3 discusses the analysis of our model, and Section 4 concludes.

2 The Model

We consider a partial equilibrium trade model with a homogeneous product. A high-tech foreign firm produces this product at a marginal cost c ($0 < c \leq 1$) and exports this product to a market in the home country. We call the foreign firm's marginal production cost c *licensed technology*. The inverse demand function in the home market is $p = 1 - X$, where p is the price and X is the aggregate amount of products. In the home country, there exists a home firm that does not have the technology to produce the product. Hence, this firm must be licensed by the foreign firm if the former produces the product. We denote the exports of the foreign firm as x_F and the output of the home firm as x_H. Then, $X = x_F + x_H$.

We assume that when the foreign firm licenses the technology, it uses a fixed-fee contract and the fixed fee, f, is determined through Nash bargaining. Further, we suppose that if the negotiation breaks down, both firms' profits are equal to zero. We denote the profits of the foreign and home firms as π_F and π_H respectively. Hence, the Nash bargaining solution is given by

$$f = \underset{f}{\text{argmax}}\ \alpha \log[\pi_F] + (1-\alpha)\log[\pi_H], \tag{1}$$

where α ($0 \leq \alpha \leq 1$) measures the bargaining power of firm F relative to that of firm H.

Given the level of the fixed fee, the government of the home country chooses the level of the ad valorem tariff τ so as to maximize social welfare. Social welfare is equal to the summation of consumer surplus, the home firm's profit, and tariff revenue. Consumer surplus is $(1/2)X^2$, and tariff revenue is $\tau p x_F$. After the government's decision, the foreign and home firms compete in quantity.

In this model, the government cannot commit its policy. This assumption is motivated by the time-inconsistent nature of trade policy (see Mukherjee and Pennings 2006; Staiger and Tabellini 1987).[4] To summarize, we consider the following model.

Stage 1: The foreign firm decides the level of the fixed fee through Nash bargaining.

Stage 2: The home government chooses an ad valorem tariff rate τ.

Stage 3: The foreign and home firms choose their outputs x_F and x_H respectively.

The profit of the foreign firm is

$$\pi_F = ((1-\tau)p - c)\, x_F + f. \tag{2}$$

The profit of the home firm is

$$\pi_H = (p - c)\, x_H - f. \tag{3}$$

The social welfare of the home country, SW, is

$$SW = \frac{1}{2}(x_H + x_F)^2 + \pi_H + \tau p x_F. \tag{4}$$

We assume complete information. The model is solved by backward induction and only pure strategies are considered. For simplicity, this paper does not discuss incentives to license.

[4]Other studies focussing on the time-inconsistent trade policy include Ishizawa (1995), who considers the case wherein the government is not committed to a tariff policy. In his model, the government may revise the tariff after the production stage. Additionally, Neary and Leahy (2000) further investigate the time-inconsistent problem of trade policies.

However, even if we consider these incentives, our results hold under some conditions. In other words, the foreign firm licenses technology in the equilibrium if this firm's bargaining power is greater than that of the home firm. Since the foreign firm has the technology and the home firm does not, the assumption of bargaining power is natural.

3 Analysis

This section examines the effects of an improvement (or a deterioration) in the licensed technology, c, on the firms' output and profit and on the fixed fee.

From (2) and (3), the first-order conditions yield the optimal outputs in stage three.

$$x_F = \frac{1-\tau-c(1+\tau)}{3(1-\tau)}, \quad x_H = \frac{1-\tau-c(1-2\tau)}{3(1-\tau)}. \tag{5}$$

In the final stage of the game, $(\partial x_H/\partial c) < 0$ if $\tau < 1/2$, but $(\partial x_H/\partial c) \geq 0$ if $\tau \geq 1/2$.

Putting (5) into (4) and differentiating it with respect to τ, we obtain the first-order condition leading to the optimal ad valorem tariff rate:

$$\tau(c) = \frac{2+c-\sqrt{c(4+5c)}}{2(1+c)}. \tag{6}$$

Differentiating (6) with respect to c, we obtain

$$\frac{d\tau}{dc} = -\frac{(2+3c)+\sqrt{c(4+5c)}}{2(1+c)^2\sqrt{c(4+5c)}} < 0, \quad \frac{d^2\tau}{dc^2} = \frac{2+12c+24c^2+15c^3+c(4+5c)\sqrt{c(4+5c)}}{(1+c)^3\left[c(4+5c)\right]^{3/2}} > 0.$$

The optimal ad valorem tariff (6) is decreasing and convex with respect to the licensed technology c. Note that the convexity is in sharp contrast with the specific tariff.[5]

First, let us verify the property of the output or export of both firms.

Proposition 1. *Suppose that a highly productive technology is licensed (i.e., $c \leq c_1 \simeq 0.0472136$). Then, a decrease in c reduces the output of the home firm but increases the export of the foreign firm.*

Proof. Substituting (6) into (5), we obtain the following equilibrium output of the home firm:

[5]If the imposed tariff is specific, then the optimal tariff is linear and decreasing with respect to the marginal cost. Thus, the equilibrium outputs of the firms are also linear and decreasing with respect to the marginal cost. See Appendix.

$x_H = (1/6)\big[2 - 5c + \sqrt{c(4+5c)}\,\big]$. Differentiating this equation with respect to c yields

$$\frac{dx_H}{dc} = \frac{2 + 5c - 5\sqrt{c(4+5c)}}{6\sqrt{c(4+5c)}}.$$

Solving $dx_H/dc \geq 0$ for c, we obtain $c \leq c_1 \simeq 0.0472136$.

Similarly, substituting (6) into (5), we obtain the following equilibrium export of the foreign firm: $x_F = (1/3)\big[1 + 2c - \sqrt{c(4+5c)}\,\big]$. Differentiating this equation with respect to c yields

$$\frac{dx_F}{dc} = \frac{-2 - 5c + 2\sqrt{c(4+5c)}}{3\sqrt{c(4+5c)}}.$$

From a numerical calculation, $dx_F/dc < 0$ for all c in $[0,1]$. Q.E.D.

Proposition 1 states that the output of the home firm is inverted U-shaped with respect to c. Under the optimal ad valorem tariff (6), the output of the home firm is written as $x_H(\tau(c), c)$. To observe the *direct* and *indirect* effects of a change in c, we focus on $x_H(\tau(c), c)$. Differentiating $x_H(\tau(c), c)$ with respect to c, we obtain $(dx_H/dc) = (\partial x_H/\partial \tau)(d\tau/dc) + (\partial x_H/\partial c)$. This yields

$$3(1-\tau(c))^2 \cdot \frac{dx_H}{dc} = \underbrace{c \cdot \frac{d\tau}{dc}}_{\text{indirect effect}} + \underbrace{\big[-3(1-\tau(c))(1-2\tau(c))\big]}_{\text{direct effect}}.$$

The indirect effect (first term on the right-hand side) is always negative, but the direct effect (second term on the right-hand side) is eventually negative. If a highly productive technology is licensed (i.e., $c \leq c_1 \simeq 0.0472136$), the direct effect is negative and the indirect effect weakens because the tariff rate is now sufficiently high. Therefore, in that case, the output of the home firm increases as c increases.

Intuitively, we can consider the following logic: Suppose that $c \leq c_1$. When c increases, from $d\tau/dc < 0$, the optimal tariff rate decreases. Since the efficiency of production in the home firm decreases, the incentive of the home government to protect this firm weakens. However, the effects of the deteriorating efficiency of production dominate the rent-shifting effect from the home to the foreign firm that is caused by a tariff reduction; the exports of the foreign firm decrease. Then, strategic substitution in the product market works; the output of the home firm increases.

Next, we turn to the game of the first stage. Since the fixed fee is determined through Nash bargaining between the home and foreign firms, the first-order condition leads to

$$f^* = \frac{1}{18}\left[-5c^{3/2}\sqrt{4+5c} + c^2(11+4\alpha) + c(7-15\alpha) + \sqrt{c(4+5c)}(3\alpha-1) + 2\alpha\right]. \qquad (7)$$

Then, we obtain the following.

Proposition 2. *Suppose that $c < 0.0503762$ and $\alpha > \bar{\alpha}(c)$ or that $c > 0.0503762$ and $\alpha < \bar{\alpha}(c)$. Then, an increase in c increases the equilibrium fixed fee f^*, where*

$$\bar{\alpha}(c) = \frac{2 + 5c(7+10c) - (7+22c)\sqrt{c(4+5c)}}{6 + 15c + (8c-15)\sqrt{c(4+5c)}}.$$

Proof. Differentiating (7) with respect to c yields

$$\frac{\partial f^*}{\partial c} = \frac{[6+15c+\sqrt{c(4+5c)}(8c-15)]\alpha - 2 - 5c(7+10c) + \sqrt{c(4+5c)}(7+22c)}{18\sqrt{c(4+5c)}}.$$

For the coefficient of α in the numerator, $6+15c+\sqrt{c(4+5c)}(8c-15) > 0$ leads to $c < 0.0503762$. Hence, when c is small ($c < 0.0503762$), a large α makes $\partial f^*/\partial c$ positive. On the other hand, when c is large ($c > 0.0503762$), a large α makes $\partial f^*/\partial c$ negative. Solving $(\partial f^*/\partial c) = 0$ for α leads to

$$\alpha = \frac{2 + 5c(7+10c) - (7+22c)\sqrt{c(4+5c)}}{6 + 15c + (8c-15)\sqrt{c(4+5c)}} \equiv \bar{\alpha}(c).$$

Therefore, we obtain Proposition 2. Q.E.D.

Figure 1 shows the result of Proposition 2.

[Figure 1 here.]

In this result, three different types of the fixed fee curve can be observed. These types arise depending on the bargaining power of the foreign firm α. The first type is an inverted-U curve with respect to the licensed technology c, the second is monotonically decreasing for c, and the third has a bottom and peak for c. When the bargaining power of the foreign firm is strong (α is sufficiently close to 1), this firm's profit is largely accounted in the optimal fixed fee. If the home firm's output increases because of an increase in c, the foreign firm tries to compensate for a loss in its own profit in order to set a higher fee. When the bargaining power of the foreign firm is strong, the optimal fixed fee is single peaked with respect to c.

When the foreign firm's bargaining power is intermediate, the inverted-U property of the output of the home firm weakens. This is because the profits of both the home and foreign firms are equally accounted in the licensing fee decision. Thus, the optimal fee monotonically decreases as c increases.

If the foreign firm's bargaining power is weak, the optimal licensing fee has a bottom and peak with respect to c.[6] In this case, the home firm has almost all decisiveness on the decision of the license fee. This case is depicted in Figure 2.

[Figure 2 here.]

Let us explain this case according to three segmented intervals in the fixed fee curve.

(i) From zero to the bottom: When a highly productive technology is licensed (c is sufficiently small), an increase in c increases the output of the home firm. In the license fee decision, the home firm tries to considerably decrease the optimal fixed fee in order to increase its own profit.

(ii) From the bottom to the peak: The market share obtained by the foreign firm relatively recovers because the optimal ad valorem tariff decreases owing to an increase in c. Thus, the foreign firm gains a larger profit compared to the case of a smaller c. In the bargaining process, the foreign firm's wish is slightly accounted in the license fee decision. Thus, the fixed fee curve gradually increases as c increases.

(iii) Over the peak: In this interval, both firms' productivities are sufficiently low because c is sufficiently large. Then, the decrease in the optimal ad valorem tariff caused by an increase in c is not large and the volume of exports of the foreign firm is sufficiently small. Thus, the market share obtained by the home firm is large and the home firm's wish is strongly accounted in the decision of optimal license fee; hence, the fixed fee curve gradually decreases as c increases.

Finally, we consider the profits of both firms. Putting (5), (6), and (7) into (2) and (3) yields the profits of the home and foreign firms.

$$\pi_F^* = \frac{1}{18}\left[2 + c(-15 + 4c) + 3\sqrt{c(4 + 5c)}\right]\alpha, \tag{8}$$

$$\pi_H^* = \frac{1}{18}\left[2 + c(-15 + 4c) + 3\sqrt{c(4 + 5c)}\right](1 - \alpha). \tag{9}$$

[6] For example, when $\alpha = 0.08$, the bottom of the licensing fee curve f^* is at $c \simeq 0.0939195$ and the peak is at $c \simeq 0.335814$.

The equations (8) and (9) yield the following result.

Proposition 3. *Suppose that a highly productive technology is licensed (i.e., $c \leq c_2 \simeq 0.0504$). Then, a decrease in c reduces the profit of the home and foreign firms.*

Proof. Differentiating $(1/\alpha)\,\pi_F^*$ and $[1/(1-\alpha)]\,\pi_H^*$ with respect to c, we obtain

$$\frac{\partial \pi_F^*/\alpha}{\partial c} = \frac{\partial \pi_H^*/(1-\alpha)}{\partial c} = \frac{3(2+5c) - (15-8c)\sqrt{c(4+5c)}}{18\sqrt{c(4+5c)}} \leq 0 \quad \Leftrightarrow \quad c \leq c_2 \simeq 0.0504.$$

Thus, Proposition 2 holds. Q.E.D.

Figure 3 shows the result of Proposition 3.

[Figure 3 here.]

Surprisingly, Proposition 3 states that a cost reduction *reduces* the profits of all firms if a highly productive technology is licensed. In other words, the home and foreign firms' profits are inverted U-shaped with respect to c. The inverted-U property does not depend on the bargaining power of each firm. In the Nash bargaining process, an optimal fixed fee is decided in order to maximize the aggregate profit of the home and foreign firms. The maximized aggregate profit is shared between the home and foreign firms according to each firm's bargaining power; thus, the shape of the equilibrium profit is similar to that of the optimal fixed fee curve.

Since an increase in c raises the profit of the home firm for the range of $0 < c \leq c_2$ ($c_2 \simeq 0.0504$), one may think that social welfare in the home country also increases with c. However, we cannot obtain this result because the negative effect of production inefficiency dominates the positive effect of an increase in the profit of the home firm. This result ($\partial SW/\partial c < 0$) can be shown by a numerical calculation.

4 Conclusion

In this paper, we consider the relationship between an ad valorem tariff and fixed fee in an international licensing contract. A simple duopoly model with a fixed-fee licensing contract yields two interesting results in the case that a highly productive technology is licensed: First, better technology is sold for a lower fee. Second, similar to the first result, the profits of the home and foreign firms decrease as the licensed technology improves.

One may think that technology licensing creates a new firm (licensee) and gives the licenser revenues from the license fee, and hence, that technology licensing benefits both the licensee and licenser. However, our findings indicate that caution must be exercised in this regard. If the ad valorem tariff that is optimally chosen by an importing country and licenser (i.e., the foreign firm) is too efficient, the fixed-fee licensing contract induces a lower profit rather than that of a lower licensed technology.

Appendix

Specific tariff: If the imposed tariff is a specific one (labeled τ^S), the outputs of both firms in the final stage are given by $x_F = (1/3)(1 - 2\tau^S - c)$ and $x_H = (1/3)(1 + \tau^S - c)$. The social welfare of the home country is

$$SW = \frac{1}{2}(x_H + x_F)^2 + [1 - (x_H + x_F) - c]\, x_H - f + \tau^S x_F.$$

Solving the first-order condition for the welfare maximization with respect to τ^S, we obtain the following optimal specific tariff: $\tau^S = (1/3)(1-c)$. The equilibrium outputs are $x_F = (1/9)(1-c)$ and $x_H = (4/9)(1 - c)$. Thus, if the specific tariff is imposed, an improvement in the licensed technology always increases the outputs of the two firms.

Acknowledgments

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Figure 1: Increasing the fixed fee with less efficient technology.

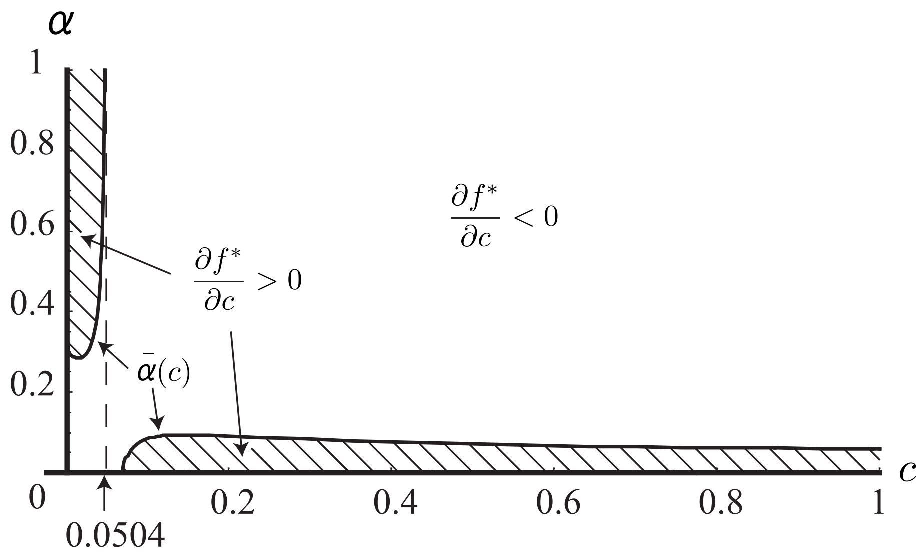

Figure 2: The equilibrium fixed fee with a bottom: $\alpha = 0.08$

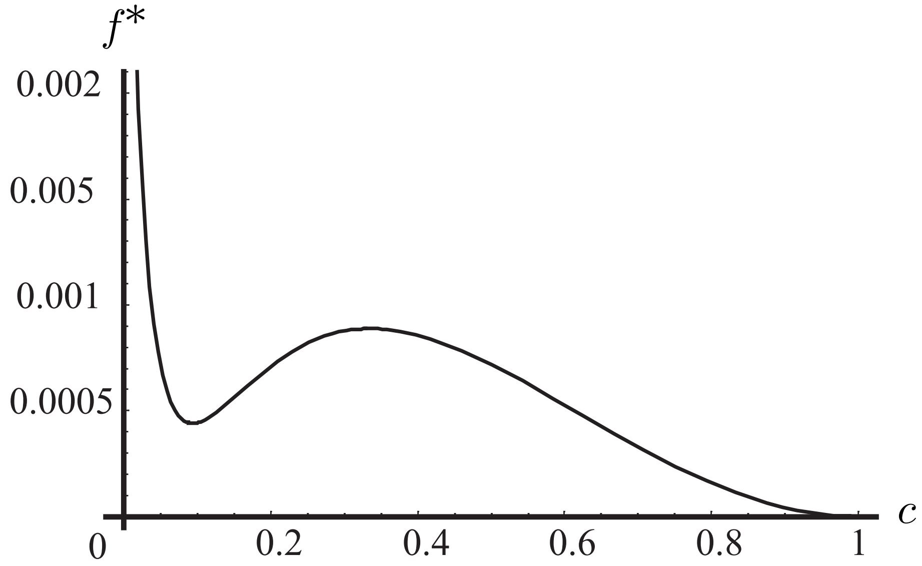

Figure 3: Increasing the profits with less efficient technology.