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EXCHANGE RATE UNCERTAINTY AND INTERNATIONAL TECHNOLOGY TRANSFER

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JEL Classification: O33, L14, F31.

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Exchange Rate Uncertainty and International Technology Transfer

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Abstract

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1 Introduction

The access to superior technology increases firm efficiency and is a source of growth in total factor productivity (see Mendi, 2007), which ultimately has a positive effect on growth. Furthermore, the use of a superior technology may bring about positive external effects, usually known in the literature as spillover effects. The existence of positive diffusion effects implies that the social benefits of technological imports exceed the private benefits to the importing firm. Thus analyzing factors that facilitate or hinder the acquisition of foreign technology is of relevance in the study of the determinants of a country's development.

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This paper analyzes the role of a potential obstacle to the acquisition of foreign technology, namely exchange rate uncertainty. We propose a licensing model to study the impact of changes in the exchange rate as well as exchange rate uncertainty on a domestic firm's decision to purchase the right to use a cost-reducing technology. We assume that he effective implementation of the superior technology requires the undertaking of non-contractible investments by the licensor as well as by the licensee. While the first-best contract involves the use of a fixed fee (no distortion in output decisions), variable payments must be included to provide the parties to the transaction –and especially the licensor- with incentives to make the non-contractible investments. Exogenous changes in the exchange rate, as well as exchange rate uncertainty may prevent the parties from undertaking the investments required for the correct transfer of the technology, which might prevent the transfer altogether.

Intuitively, exchange rate fluctuations introduce a wedge between the buyer and the seller's valuation for the technological transfer. For instance, the possibility of a devaluation of the domestic currency, reduce the value of the locally-generated revenues in terms of the foreign currency. If this problem is serious enough, the set of feasible contracts might be empty, in the sense that there is no fixed fee and/or royalty rate that both parties may find acceptable in order to transfer the technology.

Our model is based on that in Choi (2001), who analyzes technology transfer under moral hazard. In his model, licensor and licensee had to make non-contractible investments that increase the value of the technology to be transferred. Contract terms are thus chosen to provide the parties with the right incentives to undertake such costly investments. We adapt Choi's model to allow for fluctuations in the exchange rate. In our model, changes in the exchange rate occur in the interim between the licensor and the licensee's specific investment decisions. This fits the case of a transfer of technology where there is a relationship between the parties that extends for several years. Our results are also driven by the interdependence of the licensor and the licensee's decisions to undertake relationship-specific investments. In order for the licensee to enjoy a cost reduction, both the licensor and the licensee must choose strictly positive levels of investment. This contrasts with the assumption in Choi (2001) of additive effects of the licensor and the licensee's investment levels on the licensee's marginal cost if using the licensor's technology. Finally, notice that we do not assume risk aversion on either the licensor or the licensee's side, in contrast to Bousquet et al

(1998), and yet increasing exchange rate uncertainty decreases the likelihood of technology transfer.

To the best of our knowledge, no papers have analyzed the effect of exchange rate uncertainty on the international technology transfer process. There are some papers that study the impact of exchange rate fluctuations on investment and growth. For instance, Cottani et al. (1990) find a strong negative correlation across countries between real exchange rate instability and per capita income growth, using a sample of developing countries. Darby et al (1999) propose a theoretical model based on Dixit and Pindyck (1994) to find that there are situations where increasing volatility in the exchange rate negatively affects investment. Bleaney and Greenaway (2001) find that, for a panel of 14 sub-Saharan countries, investment is negatively affected by exchange rate instability. Servén (2003) also finds a negative effect of real exchange rate uncertainty on private investment, using a sample of developing countries.

Our paper thus stresses the importance of exchange rate stability to foster technology transfer. This conclusion could be potentially useful when designing policies, especially in developing countries. In fact, if a country has to rely on foreign technology to enhance its productivity, and exchange rate fluctuations hamper this process, then the government should seriously consider policies that produce exchange rate stability. The conclusions from the model that we present are against the case of a competitive devaluation. While such devaluation might bring about a temporary cost advantage that could boost exports in the short run, it would make the acquisition of technology harder, which has a negative effect on productivity and growth in the long run. It also introduces an additional factor to be taken into account when evaluating the benefits of a monetary union, or the potential costs of leaving an existing one.

The structure of the paper is as follows. We present the model in Section 2. In Section 3, we consider the case of a deterministic exchange rate. We introduce exchange rate uncertainty in Section 4. Finally, Section 5 discusses the implications of the model and introduces some concluding comments.

2 The model

Consider a domestic monopolist in the production of a given product. The monopolist faces a linear demand function $p = a - bq$, and has access to a technology that allows production to be carried out at constant marginal cost $c > 0$. There is also a foreign patentee, who owns a cost-reducing process technology. The use of the superior technology allows the licensee to produce at a cost $c(e, i) = c_F(1 - e \cdot i)$, where $e, i \in [0, 1]$ are the licensor and licensee's normalized investment levels. Notice that the licensee cost function is such that $c(0, i) = c(e, 0) = c_F$, $c(1, 1) = 0$, and $\frac{\partial c}{\partial e} \leq 0$, $\frac{\partial c}{\partial i} \leq 0$. Hence, the licensee's production cost is zero if and only if the technology is transferred and both the licensor and licensee choose the maximum investment levels. Furthermore, we assume $c_F \geq c$. This cost function is intended to represent a situation where the technology is new to the licensee and an effective implementation of the technology requires costly actions on both sides. For example, technologies with an important tacit component are well represented by this cost structure: the licensee must increase its absorptive capacity, and the licensor must exert effort to make sure the licensee receives the right level of tacit knowledge.

The licensee's outside option is to use the existing technology, that is, to produce at cost c. We assume that the licensee must opt for one of the two technologies, which means that if it accepts the licensor's offer, the licensee can not switch back to the existing technology. Finally, let $\alpha(e) = \alpha \cdot e$ and $\beta(i) = \beta \cdot i$ be the licensor and licensee's costs per unit of investment.

Our model focuses on arm's-length transfers of the technology from the licensor to the licensee. Consider contracts defined by F and r, where F is a fixed payment, independent of output produced, and r is the royalty rate, which determine variable payments. We consider royalty rates as a fixed payment per unit sold, denominated in the domestic currency. We could extend our analysis by considering the case of variable payments as a percentage of the licensee's sales, or fixed payment per unit sold denominated in the foreign currency. All these payment schedules are widely used in actual contracts, see for instance Mendi (2005), or Vishwasrao (2007).

The exchange rate ρ is denominated in units of the foreign currency per unit of the domestic currency. Both the fixed and the variable payments are denominated in the domestic currency. We assume that there is parity between the domestic and the foreign currencies at time of contracting, and that this exchange rate is subject to variation prior to the licensor's choice of its relationship-specific investment e, but after the licensee chooses its investment level i. We assume away the possibility of the licensee borrowing in the first periods an amount equal to all future payments, converting them into foreign currency at parity, and making future payments as scheduled.

Notice that this would eliminate the effect of exchange rate uncertainty. We assume that this is not feasible for the licensee either because of lack of credit market development in the licensee's country, or because the time span between the signing of the contract and the licensor's choice is long enough. Of course, relaxing these constraints would increase the likelihood of an efficient transfer of technology.

We assume that the licensor makes the licensee a take-it-or-leave-it offer, specifying contract terms F, r, where r is a fixed payment, denominated in domestic currency, per unit sold. The timing of the game is as follows:

1. The licensor makes the licensee a TIOLI licensing contract offer F, r.

2. The licensee accepts or rejects the contract offer. If accept, the licensee pays the fixed fee F upfront. The licensee also chooses its investment in absorptive capacity i.

3. The exchange rate ρ is determined.

4. The licensor chooses its investment level e. The licensee's production costs $c(e, i)$ are thus determined.

5. Production takes place, and variable payments (if any) are realized as specified in the contract.

Notice that, the licensor makes its choice of specific investment $e \in [0, 1]$ after observing the realization of the exchange rate ρ. As we will see below, this implies that the licensor might choose a zero level of investment if the realization of the exchange rate fails to reach some threshold level.

This assumption on timing is crucial in our results. If both parties could commit to choosing their investment levels before the exchange rate is observed, uncertainty would not have any effect, since both parties would make their decisions based on expected exchange rates. However, in our model an increase in variance increases the probability of the licensor not undertaking the required investment. We now proceed to analyze the licensor and the licensee's problems at the different stages, with and without exchange rate uncertainty.

3 Deterministic exchange rate

We begin our analysis by considering the simple case of a deterministic exchange rate. This is the particular case, which assumes that both parties know ex-ante what the relevant exchange rate will be.

The contract terms (F, r) must be such that both the licensor and the licensee have the incentive to undertake the level of investment required for the successful transfer of the technology. Of course, in order for the licensor to choose a positive investment level, variable payments must be introduced. If all payments were fixed, the licensor's optimal effort level would be zero.

Given our assumptions on demand and cost functions, at stage 4, given r and i, the licensor's problem reads

$$\max_{e \leq 1} F + \rho \cdot r \cdot \frac{a - c_F(1 - ei) - r}{2b} - \alpha \cdot e$$

The solution to the licensor's problem at stage 4 defines an optimal investment function $e^*(i, r)$. Notice that, given the functional form of the licensee's cost function, the licensor's revenues are linear in e, and so are its costs. Hence, the solution will be either $e = 0$ or $e = 1$. Specifically,

$$e^*(i, r) = \begin{cases} 0 \text{ if } i < \frac{2b\alpha}{\rho r c_F} \\ 1 \text{ if } i \geq \frac{2b\alpha}{\rho r c_F} \end{cases}$$

At the previous stage, the licensee chooses i anticipating the licensor's investment choice in the following stage. Thus, the licensee's relevant constraint is its acceptance constraint, i.e. that its profits if using the licensor's technology exceed those if using the existing one. The licensee solves

$$\begin{array}{rl} \max\limits_{i \leq 1} & \frac{(a - c_F(1 - e^*(i,r) \cdot i) - r)^2}{4b} - F - \beta \cdot i \\ \text{s.t.} & \frac{(a - c_F(1 - e^*(i,r) \cdot i) - r)^2}{4b} - F - \beta \cdot i \geq \frac{(a-c)^2}{4b} \end{array}$$

The solution to the licensee's problem defines a function $i^*(r)$ that the licensor takes into account when optimally choosing the royalty rate r. Notice that $\frac{\partial e}{\partial i} = 0$ for $i \neq \frac{2b\alpha}{\rho r c_F}$. Furthermore, if $i < \frac{2b\alpha}{\rho r c_F}$, then $e^* = 0$, which also implies that $\frac{\partial c}{\partial i} = 0$. Now, for $i \geq \frac{2b\alpha}{\rho r c_F}$, the licensee's gross profits are convex in i, which implies that the licensee will choose $i = 1$ as long as its acceptance constraint is satisfied. But notice that if $i^* = e^* = 1$, the licensee's acceptance constraint becomes

$$\frac{(a - r)^2}{4b} - \beta \geq \frac{(a - c)^2}{4b}$$

which implies that a necessary condition for the licensee's acceptance constraint being satisfied is $r \leq a - \sqrt{(a-c)^2 + 4b\beta}$. This imposes an upper bound on the royalty rate that is acceptable to the licensee. Thus, the licensee's optimal investment function $i^*(r)$ (provided that the licensor adjusts the fixed fee F so as to satisfy the licensee's acceptance constraint) is

$$i^*(r) = \begin{cases} 0 \text{ if } r > a - \sqrt{(a-c)^2 + 4b\beta} \\ 1 \text{ if } r \leq a - \sqrt{(a-c)^2 + 4b\beta} \end{cases}$$

Finally, at stage one, the licensor's problem is

$$\begin{aligned} &\max_{F, r \geq 0} F + \rho \cdot r \cdot \tfrac{a - c_F(1 - e^*(i^*(r), r) \cdot i^*(r)) - r}{2b} - \alpha \cdot e^*(i^*(r), r) \\ &\text{s.t. } \tfrac{(a - c_F(1 - e^*(i, r) \cdot i) - r)^2}{4b} - F - \beta \cdot i \geq \tfrac{(a-c)^2}{4b} \end{aligned}$$

Of course, the licensor will always make the licensee's acceptance constraint binding, provided that $e = i = 1$. Recall that, since $c_F > c$, the new technology generates a lower value thanthe old one if either $e \neq 1$ or $i \neq 1$. We can then express the fixed fee as a function of the royalty rate. The licensor's problem then reads:

$$\begin{aligned} &\max_{r \geq 0} \tfrac{(a-r)^2}{4b} - \beta \cdot i - \tfrac{(a-c)^2}{4b} + \rho \cdot r \cdot \tfrac{a-r}{2b} - \alpha \\ &\text{s.t. } r \geq \tfrac{2b\alpha}{\rho c_F}, \quad r \leq a - \sqrt{(a-c)^2 + 4b\beta} \end{aligned}$$

whose first-order condition reads

$$-\frac{a-r}{2b} + \frac{\rho}{2b}[a - 2r] \leq 0$$

which implies that an interior solution (ignoring the constraints imposed by the licensor and the licensee) is given by

$$r = a\frac{1-\rho}{1-2\rho}$$

Notice that if $\rho < \frac{1}{2}$, then the optimal (interior) royalty would exceed a. On the other hand, if $\rho \in \left(\frac{1}{2}, 1\right]$, then the royalty would be negative. Furthermore, if $\rho < \frac{1}{2}$, the licensor's profits increase with r, whereas if $\rho > \frac{1}{2}$, its profits are decreasing with r. Notice that the licensor's constraint imposes a lower bound on the royalty rate, whereas the licensee imposes an upper bound on the royalty rate. Intuitively, the licensee must be high enough so that the licensor has the incentive to make the non-contractible investment, although it has to be low enough so that the licensee accepts the contract. Also notice that the licensor's constraint depends on the realization of the exchange rate, specifically introducing a negative relationship between the exchange rate and the royalty rate. Thus, the lower the exchange rate (expressed in terms of units of the foreign currency per unit of the domestic currency), the higher the royalty rate that the licensor will demand in order to make the relationship-specific investment. Furthermore, $\lim_{\rho \to 0} \frac{2b\alpha}{\rho c_F} = \infty$, which means that the lower bound on the royalty rate goes to infinity as the exchange rate approaches zero. Since the licensee's constraint does not depend on the realization of the exchange rate, there will be a threshold value of the exchange rate, $\widetilde{\rho}(r)$ such that for $\rho < \widetilde{\rho}(r)$ there exist no value of r that implements the transfer of the technology. This leads to the formulation of the following proposition.

Proposition 1 *Absent exchange rate uncertainty, the transfer of technology will take place only if the realization of the exchange rate exceeds some threshold value.*
Proof. *From the licensor's incentive constraint, we have that, in order for it to choose $e = 1$, it is necessary that $r \geq \frac{2b\alpha}{\rho c_F}$. On the other hand, in order for the licensee to accept the licensor's offer and choose $i = 1$, it is necessary that $r \leq a - \sqrt{(a-c)^2 + 4b\beta}$. Since $\lim_{\rho \to 0} \frac{2b\alpha}{\rho c_F} = \infty$, there is always a value of ρ such that $a - \sqrt{(a-c)^2 + 4b\beta} = \frac{2b\alpha}{\rho c_F}$ and if ρ is below that level, there is no value of r that satisfies both constraints.* ■

For $\rho \geq \widetilde{\rho}$, the licensor will choose r depending on whether its effect on its own profits is positive or negative. As we pointed out above, if $\rho < \frac{1}{2}$, the licensor's will choose the lowest r that satisfies the licensor and the licensee's constraints. If $\rho > \frac{1}{2}$, the licensor's choice will depend on whether the solution $r = a\frac{1-\rho}{a-2\rho}$ satisfies the two constraints. Specifically, if $a\frac{1-\rho}{1-2\rho} < \frac{2b\alpha}{\rho c_F}$, the licensee will choose $r = \frac{2b\alpha}{\rho c_F}$. If $\frac{2b\alpha}{\rho c_F} \leq a\frac{1-\rho}{1-2\rho} \leq a - \sqrt{(a-c)^2 + 4b\beta}$, then $r = a\frac{1-\rho}{1-2\rho}$. Finally, if $a\frac{1-\rho}{1-2\rho} > a - \sqrt{(a-c)^2 + 4b\beta}$, then $r = a - \sqrt{(a-c)^2 + 4b\beta}$ and there will be no fixed fee.

4 Exchange rate uncertainty

We now take one step forward in our analysis and study the case of a stochastic exchange rate. Assume that the exchange rate is a random variable distributed according to a distribution function $G(\rho)$ on the interval $[\underline{\rho}, \overline{\rho}]$ Both the licensor and the licensee know this distribution function, although the licensor chooses its non-contractible investment levels after observing the realization of the exchange rate. This will allow it to make its choice conditional on the realization of the exchange rate. In contrast, the licensee must make its choice before the realization of the exchange rate is known. However, the licensee foresees the licensor's optimal behavior in the following stage and estimates the probability that the licensor chooses $e = 1$. The licensee incorporates this information in its computation of its own expected profits. We will see below that, holding constant the expected exchange rate, if the expand the range of variation of the exchange rate, the probability of efficient transfer might decrease, and it might even be the case that the contract is not signed, in the sense that there are no contract terms (F, r) that jointly satisfy the licensor and the licensee's constraints.

Relative to the case of no exchange rate uncertainty, the licensor's problem at stage four does not change, since it is able to observe the realization of the exchange rate, as well as the licensee's choice of i prior to making its choice of e. Thus, the optimal investment rule is the same as in the previous case. Notice that this implies that the licensee will choose $e = 1$ (provided that the licensee chooses $i = 1$) only if $\rho \geq \widetilde{\rho} = \frac{2b\alpha}{rc_F}$.

Given the licensor's optimal investment rule, the licensee is able to identify two intervals of ρ, specifically $\rho < \widetilde{\rho}$ and $\rho \geq \widetilde{\rho}$. In the former interval, the licensor chooses $e = 0$, whereas in the latter, it chooses $e = 1$. Recall that the licensee chooses $i = 1$ if it chooses a positive investment level. This is the case if its acceptance constraint is satisfied when $i = 1$, i.e. the licensee chooses $i = 1$ if its expected profits exceed those if rejecting the licensor's offer:

$$\int_{\underline{\rho}}^{\widetilde{\rho}} \frac{(a - c_F - r)^2}{4b} dG(\rho) + \int_{\widetilde{\rho}}^{\overline{\rho}} \frac{(a - r)^2}{4b} dG(\rho) - F - \beta \geq \frac{(a - c)^2}{4b}$$

or

$$\frac{(a - c_F - r)^2}{4b} G(\widetilde{\rho}) + \frac{(a - r)^2}{4b} (1 - G(\widetilde{\rho})) - F - \beta \geq \frac{(a - c)^2}{4b}$$

At the initial stage, the licensor chooses the royalty rate to maximize its own profits, subject to the licensee's acceptance constraint and to its own incentive constraint, which defines the threshold value $\widetilde{\rho}(r)$. The licensor will always adjust the value of the fixed fee to make the licensee's constraint binding. Then,

$$F = \frac{(a-c_F-r)^2}{4b}F\left(\widetilde{\rho}\right) + \frac{(a-r)^2}{4b}\left(1-F\left(\widetilde{\rho}\right)\right) - \beta - \frac{(a-c)^2}{4b}$$

This way, we may write the licensor's expected profits as

$$\begin{aligned} E\pi^{lsor} &= \frac{(a-c_F-r)^2}{4b}G\left(\widetilde{\rho}\right) + \frac{(a-r)^2}{4b}\left(1-G\left(\widetilde{\rho}\right)\right) - \beta - \frac{(a-c)^2}{4b} + \\ &\quad + \int_{\underline{\rho}}^{\widetilde{\rho}} \rho \cdot r \cdot \frac{a-c_F-r}{2b} dG(\rho) + \int_{\widetilde{\rho}}^{\overline{\rho}} \rho \cdot r \cdot \frac{a-r}{2b} dG(\rho) - \alpha = \\ &= \left[\frac{(a-c_F-r)^2}{4b} + r \cdot \frac{a-c_F-r}{2b} \cdot E\left[\rho|\rho<\widetilde{\rho}\right]\right] G\left(\widetilde{\rho}\right) + \\ &\quad + \left[\frac{(a-r)^2}{4b} + r \cdot \frac{a-r}{2b} \cdot E\left[\rho|\rho \geq \widetilde{\rho}\right]\right]\left(1-G\left(\widetilde{\rho}\right)\right) - \beta - \frac{(a-c)^2}{4b} - \alpha \end{aligned}$$

Whether or not the licensor's technology is transferred depends on the existence of a royalty rate that satisfies the licensee's acceptance constraint and at the same time induces the licensor to choose $e = 1$. In particular, the licensee's acceptance constraint is crucial. We observe that the licensee's expected profits if $i = 1$ are a weighted average of its profits if the licensor chooses $e = 0$ and its profits if the licensor chooses $e = 1$, the weights being $G\left(\widetilde{\rho}\right)$ and $\left(1 - G\left(\widetilde{\rho}\right)\right)$, respectively. Therefore, the shape of the distribution $G(\cdot)$ matters when determining the licensee's expected gross profits if using the licensor's technology and undertaking $i = 1$.

In particular, if under an alternative distribution $H(\cdot)$ it is the case that $H\left(\widetilde{\rho}\right) > G\left(\widetilde{\rho}\right)$, then the licensee's expected gross profits, holding r constant, decrease. Of course, the licensor will adjust the contract terms (F, r). If $F > 0$, then the licensor will have to lower F. However, if the constraint $F \geq 0$ becomes binding, the licensor will be forced to reduce r. But notice that when the licensor reduces the value of r, it also lowers the threshold value $\widetilde{\rho}$, thus reducing the probability of the licensor choosing $e = 1$ at stage four. if the new distribution $H(\cdot)$ assigns a high enough probability to low realizations of the exchange rate, then it may be the case that there is no value of r that allows for the realization of the transfer. This is because, since the licensee's profits as a function of r decrease when the distirbution changes in this way and since the licensee's expected gross profits are concave in r, these gross profits may fall short of the reaservation profits as the distribution changes.

We may summarize the previous discussion by means of the following proposition:

Proposition 2 *Given a distribution $G(\cdot)$, there is always an alternative distribution $H(\cdot)$ such that $E(\rho)$ is the same for both distributions, but there is no transfer of the technology if the distribution is $H(\cdot)$.*

What the proposition implies is that, holding constant the expected value of the exchange rate, increasing variance reduces the probability of transfer. This is because the modification in the shape of the distribution assigns a greater probability to the extreme values of the discount factor, which reduces the licensee's expected profits and therefore makes it harder for its acceptance constraint to hold.

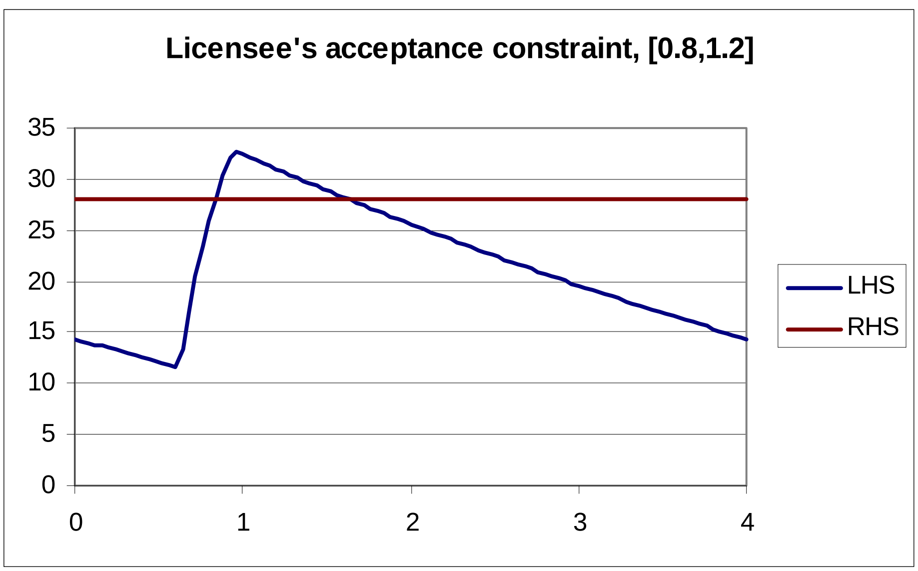
4.1 Numerical examples

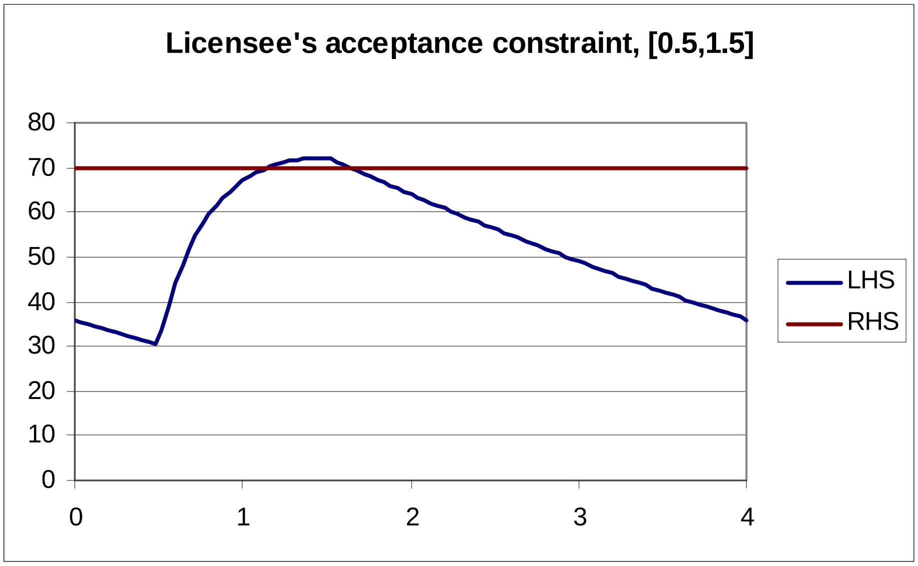
We will illustrate this analysis by means of some numerical examples. The purpose of this exercise is to show that an increase in exchange rate uncertainty may prevent the technology from being transferred, even if the expected exchange rate remains the same.

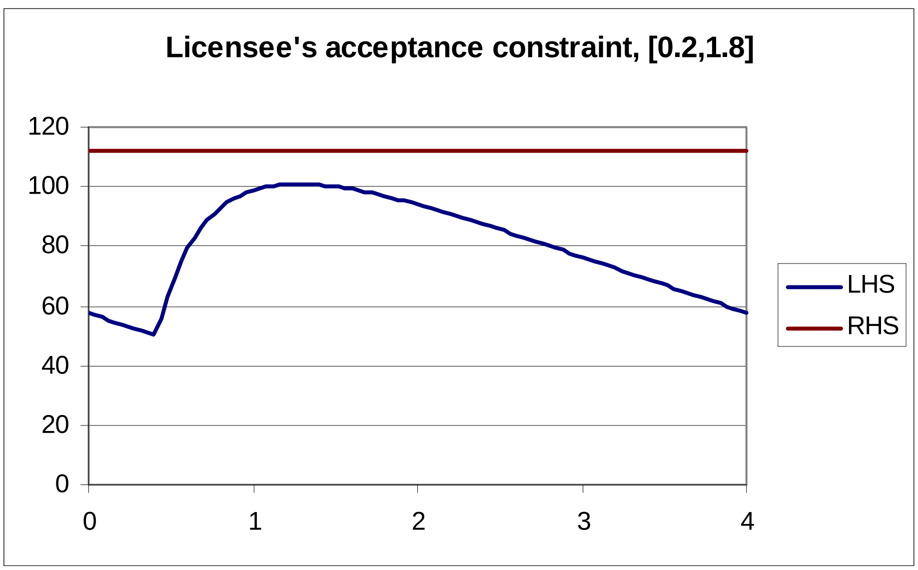
Assume that the demand function is $p = 10 - q$. Costs are $c = 2$ and $c_F = 4$. Recall that $c(e,i) = c_F(1 - e \cdot i)$, with $e, i \in [0,1]$. Further assume that $\alpha = \beta = \frac{3}{2}$. With this parameters, and assuming no exchange rate uncertainty, the technology will be transferred as long as $\rho \geq \frac{1}{2}$. For these realizations of the exchange rate, the licensor chooses a royalty rate $r = 1.633$, which is the maximum consistent with acceptance by the licensee. If, holding everything else constant, we now set $\beta = 2$, the royalty is $r = 1.515$. If $\alpha = 2$ and $\beta = \frac{3}{2}$, the technology is transferred only if $\rho \geq 0.65$, and the optimal royalty is $r = 1.633$. Notice that in all three cases, the technology is transferred if there is parity between the two currencies, i.e. if $\rho = 1$.

Let us now consider the case of exchange rate uncertainty, and consider the original levels of the investment costs, i.e. $\alpha = \beta = \frac{3}{2}$. What we will do is to consider values of $\overline{\rho}$ and $\underline{\rho}$ such that $E\rho = 1$, given that ρ follows a uniform distribution on $[\underline{\rho}, \overline{\rho}]$. We will see that increasing the amplitude of the interval –and therefore the variance of the distribution– will eventually make the transfer of the technology impossible.

For instance, if $[\underline{\rho}, \overline{\rho}] = [0.8, 1.2]$, then royalties in the interval $[0.841, 1.601]$ will permit the transfer of the technology. Notice that the licensor's profits are increasing in the royalty rate, which implies that it will choose the highest royalty in the interval. If $[\underline{\rho}, \overline{\rho}] = [0.5, 1.5]$, the interval of feasible royalties is reduced to $[1.161, 1.601]$. Finally, if $[\underline{\rho}, \overline{\rho}] = [0.2, 1.8]$, there is no royalty rate that implements the technology transfer. This is because the licensee's acceptance constraint is not satisfied for any value of r. The evolution of the right-hand side and the left-hand side of the licensee's incentive constraint as a function of the length of the interval is displayed in Figures 1, 2, and 3.




Licensee's acceptance constraint, [0.5,1.5]
80
70
60
50
40
30
20
10
0
0
1
2
3
4
LHS
RHS


Licensee's acceptance constraint, [0.2,1.8]
120
100
80
60
40
20
0
0
1
2
3
4
LHS
RHS

5 Conclusions

We have presented a model to analyze the effects of exchange rate fluctuations on a firm's technological imports activities. The model assumes that it is necessary that both the licensor and the licensee exert some costly effort, so that the technology is efficiently transferred. The payment mechanism, which we have assumed to include an upfront fee, F, plus a constant per-unit royalty payment, r, must provide the parties with the incentives to undertake such investments. In particular, the royalty rate must be high enough so that the licensor has the incentive to make the relationship-specific investment, but it can not be too high to make the upfront payment negative.

The exchange rate plays the role of introducing a wedge between the licensor and the licensee's valuation for the technology. Initially, the exchange rate is known to both parties, and normalized to one. However, after the parties sign the contract, but before they make their relationship-specific investments, there is some variation in the exchange rate. Given this variation, and given the payment schedule stipulated in the contract, the parties might decide not to undertake the required investment.

We analyze first the case of deterministic exchange rates. By making use of the model, we find that the parties' incentive and acceptance constraints impose an upper and a lower bound on the realization of the exchange rate that would permit the transfer of the technology. In the case of stochastic exchange rates, we argue that there is always a degree of exchange rate variability that prevents the transfer of technology from taking place.

We believe that our model could be used as an argument in favor of exchange rate stability in countries that depend on foreign technology. The uncertainty introduced by exchange rate fluctuations may even keep profitable technological transfers from happening, which has negative consequences on domestic productivity and ultimately on growth. Furthermore, the lack of access to superior technology prevents the country from taking advantage of potential diffusion effects that the use of a superior technology might bring about.

There are a number of testable hypotheses that could be derived from our theoretical model. First, the transfer of know-how is associated with royalty payments, a result also suggested in Macho-Stadler et al (1996). Also, the transfer of know-how is most affected by exchange rate fluctuations, since it requires costly actions on the seller's side, as well as a minimum degree of absorptive capacity. Thus, within a country, know-how is most likely to be transferred between domestic firms rather than internationally. Additionally, the likelihood of international transfers of know-how increases with exchange rate stability. To see this, one could compare the ratio codified knowledge to know-how across different countries. The transfer of know-how also increases with financial development, access to credit, and the existence of instruments to hedge against exchange rate fluctuations.

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