

An Economic Analysis of Technological Licensing with a Grantback Clause

Dusanee Kesavayuth ¹ ²

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¹Corresponding address: Department of Economics, University of Essex, Colchester, CO4 3SQ, United Kingdom. Email: dKesav@essex.ac.uk.

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Abstract

This paper studies the economic effects of grantbacks on technology licensing contractual form and future innovation incentives in the context of incomplete contracts. As a result of technological leapfrogging and nonverifiable quality of technology, the licensor will neither choose nor commit to transfer his best available technology when licensing. This problem disrupts the technology diffusion. This paper proposes the two-way (reciprocal) grantback clause to remedy this problem. Also the inclusion of a reciprocal grantback clause improves production efficiency since the royalty rate is optimally set at zero. The drawback of the reciprocal grantback clause is the reduction in innovation investment. However, the inclusion of grantback clauses will improve the welfare at the future R&D stage since it saves R&D duplication. The result of grantback clause inclusion on total welfare is ambiguous which implies that evaluate such policy with the "rule of reason" is preferable to the "per se rule".

JEL: L24, L52, K21, D23

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1 Introduction

It is generally accepted that licensing is one of the important business strategies practiced in many industries. The leading firms license out their technologies to followers in exchange for licensing income and alter a strategic R&D investment. Despite many benefits, both direct and strategic, patentees are also concerned that licensing may cause them a competitive advantage loss. Roberts and Mizouchi (1988) find that firms are often hesitant to license out their frontier patented technologies because they fear of a technology catch up or a leapfrogging from their own licensees. This hesitancy raises a concern that technology diffusion may not attain its efficient level.

At the same time, even though the patentees agree in the contract to transfer more advanced technology, the licensor may not license the one that is actually advance. The licensor may only license the technology that is is not the best available in their portfolio. Especially, when the contract enforcement agent cannot verify type or quality of the technology. This nonverifiability makes it difficult to enforce the contract agreement. In this regard, the paper proposes a remedy called a "*grantback clause*"— a clause which generally requires an exchange of newly developed technology based on the licensed one between contract parties. There are two common types of grantback clauses, "one-way" which requires the licensee to license out his follow-on innovations to the licensor and "reciprocal or two-way" which requires both licensor and licensee to license out the new discovery to one another.

There are some differences in US and European Community (EC, thereafter) regarding a legality of grantback clauses. Prior to 1946 in the US, grantback clauses occasionally appeared in the licensing agreements and no cases were found illegal. Later, the validity of grantback clauses has been legally challenged under two theories. First, grantbacks have been challenged as violating patent laws on the grounds that they allow the patentee (licensor) to expand the scope of a patent.¹ Second, they also violate anti-trust laws on the grounds of abuse of a monopoly position.² At present, grantbacks are not viewed as per se illegal and are assessed on the economic impacts, case by cases, under US regulations. EC regulation states clearly the characteristics of permissible grantback clauses.³

In the economics literature, grantback clauses have been challenged additionally on the ground of "Discouragement of Innovaton." In particular, this has been investigated by Choi (2002) and Van Dijk (2000). However, there have not been any economic models analyse the "reciprocal" grantback clause under the scope of incomplete contract.

This paper studies technology licensing with the reciprocal grantback clause in an incomplete contract framework. In particular, the following questions are addressed:

- (i) What is the incentive compatibility contract for advanced technology licensing with

¹Stokes & Smith Co. v. Transparent-Wrap Mach. Corp., 156 F.2d 198 (2d Cir. 1946), rev'd 329 U.S. 637 (1947).

²See, e.g., Imperial Chemical Indus., Ltd. v. United States, 105 F. Supp. 215 (S.D.N.Y. 1952); United States v. Besser Mfg. Co., 96 F. Supp. 304 (E.D. Mich. 1951); United States v. Aluminum Co. of America, 91 F. Supp. 333 (S.D.N.Y. 1950); United States v. General Electric Co. 82 F. Supp. 753 (D.N.J. 1949).

³See EC No. 772/2004, Article 5.

the reciprocal grantback clause?

(ii) What is the impact of the reciprocal grantback clause on the choice of licensing technology?

(iii) What are the effects on welfare?

The game consists of two players, licensor (patentee) and licensee. Prior to licensing, these firms are located in separate markets, so that there is no current market competition. The licensor owns a property right over the advanced technology which allows him to produce at a lower marginal cost and equips him with an ability to innovate a drastic and "borderless" future innovation⁴. We first identify the optimal two-part tariff (up-front fixed fee and royalty) for a contract with a reciprocal grantback clause and analyse the best licensor's choice of his patents. Next, the paper looks at the welfare effects at the future R&D stage. The findings with the reciprocal grantback will be compared with those without grantback clause and those with one-way grantback clause. Finally, total welfare and social planner's choice regarding the grantback clause will be analyzed.

The results in this paper demonstrate that first, the reciprocal grantback clause is a remedy for a moral hazard problem. Also, the reciprocal grantback clause requires only a positive up-front fixed licensing fee. Second, the reciprocal grantback clause slows down the pace of innovation. However, inclusion of the reciprocal grantback clause may improve welfare at the future R&D stage if the transfers of advanced technology are conditional on grantbacks and the accomplishment of a new innovation is difficult. The intuition stems from a trade-off between the positive benefits of parallel research activities versus the negative result from excessive cost of R&D duplication. Finally, the analysis of total welfare provides an ambiguous conclusion depends on the R&D difficulty. Incorporating a grantback clause to a licensing contract possibly improves or deteriorates welfare depending on the nature of specific innovation market characteristic. This results potentially has an implication for policy reform of the EU licensing regulation in particular the Technology Transfer Block Exemption Regulation which state some permissible characteristics of grantback clauses. Because the observable market characteristics are both complicated and difficult to be clearly identified; therefore, using "rule of reason" provides more sensible and flexible legal practice. This paper proposes that the validation of grantback clause using the rule of reason would be more appropriate.

The remainder of the paper is organised as follows. Section 2 provides a brief summary of licensing regulations regarding a grantback clause. Section 3 presents the literature review. Section 4 describes a model of incomplete licensing contract. The conclusion is in section 5.

⁴This assumption could be justified with the existing example in the case of Videocassette Recorder (VCR), Ampex Corporation was the first company that introduced this product in 1956. Later, it licensed a patented technology to Sony who was the first company to mass-market VCR for home use. Then in 1980s the US market and also the world market were dominated by Sony.

2 Licensing Regulations

The two major types of well-established licensing regulations are US regulation and European Community regulation. There are some similarities and some differences between these two regulations. The two transatlantic regions have been trying to coordinate their competition laws and intellectual property rights (IP) laws with one another. In a static framework, intellectual property right laws protect an innovator's benefits, while consumer's welfare is saved under the shield of competition law. In a dynamic framework, the competition law puts limits on the uses of property right while the IP creates the uses of that particular property rights. These two areas of laws confine to maintain both short and long-term market efficiency. Regarding licensing regulations, the EC focuses more on the competitive relationship of parties while US law focuses less on this issue but considers more the nature of competition absent the license. Regarding procedural context, the EC licensing agreements are questionable unless exempted according to the "*block exemption*", while the US permits them unless specifically prohibited.

2.1 Regulations in The United States

The innovator's right to intellectual property is protected under the U.S. Patent Act which is listed in Title 35 of the U.S. Code. This version of the Patent Act was last updated in March 2000. The main regulations regarding competition laws are the Sherman Act and the Clayton Act, which have regulated US competition for a century approximately. There are many compatible regulations which have been added as guidelines for evaluating anti-competitive activities. Beginning with the Reagan administration, US competition policy has moved away from an anti-trust and towards pro-patent policy. The general principle is that market power will not be presumed when dealing with intellectual property rights. However, the different perspectives between competition law and intellectual property rights law still be considered.

Regarding a technology transfer, the 1995 Antitrust Guideline for the Licensing of Intellectual Property Right (thereafter, The Guideline) describes the joint antitrust enforcement policies of the Department of Justice and the Federal Trade Commission. The Guideline has been established and it provides a framework for dealing with innovation markets in particular. It views licensing activities as pro-competitive and welfare enhancing in general. Despite this, there are concerns that licensing arrangements may harm the competition in the relevant market under specific conditions.

The Guideline provides a 'safety zone', which states that "the government will not challenge a restraint in an IP licensing arrangement if (a) the restraint is not facially anti-competitive; and (b) licensor and its licensees collectively account for no more than 20% of each relevant market significantly affected by the restraint..."⁵.

Regarding grantback clauses, section 5.6 of the Guideline describes that grantback provisions in technology licensing are not 'per se illegal'. Hence, a rule of reason will be applied case by case when analysing the anti-competitive effects of grantback clauses.

⁵Section 4.3 of The Guideline

The Guideline favours "non-exclusive" rather than the exclusive grantback clauses which are claimed to substantially reduce the licensee's incentive to innovate, thereby limiting innovation market competition.

2.2 Regulations in The European Community

The property rights of innovator are protected under the community patent, also known as the European Community Patent or EC patent (or sometimes abbreviated as COMPAT.) The major pillars of European competition law are Articles 81 and 82. Article 81 prohibits agreements and practices with anti-competitive objectives or effects, while Article 82 prohibits abuses of dominant position. Article 81(1) lists the restrictive activities which are considered harmful to competition, and Article 81(3) provides the so called "Block Exemption". The activities engaged in research and development and technological transfers will be considered in the block exemption and will be exempted from the restriction of Article 81(1). The EC Technology Transfer Block Exemption Regulation, EC No. 240/96 (thereafter, TTBER) regulated licensing activities during 1996-2004. The TTBER was reviewed and updated in 2004. Currently, "The Treaty to Categories of Technology Transfer Agreements" No. 772/2004 (thereafter, New-TTBER), which valids for 10 years from 1 May 2004, is applied in EC. The treaty covers various kinds of intellectual property rights, namely, technology patents, know-how, copyright, and neighboring rights, but not sub-licenses, research and development agreement, patent pooling agreements and marketing or distribution agreements

In brief, the treaty describes lists of licensing agreement characteristics which are allowed under the Block Exemption. The main purpose of the licensing agreement must be for technology transfer. The treaty must also contribute to efficiency improvements and promote competition. Some revisions are more consistent with the U.S. Guidelines. Further, According to the European Competition Commission, this new regulation shifts from the old legalistic and form-based approach to a more economic and effects-based approach, which assesses the impact of agreements on the relevant market.

The main revisions can be summarized as follows;

- Introducing a "Safe Harbour" which states market thresholds above which the technology transfer will be presumed pro-competitive⁶.
- Providing a clearer distinction between competitors and non-competitors⁷. Also, the new treaty became stricter with a treatment of IP licenses between competitors.
- Covering licenses of copyright in software and of design rights.

Both the TTBER and the New-TTBER concern inclusion of a grantback clause in order to protect incentives to innovate and the appropriate application of intellectual

⁶EC Competition Commission will not concern the agreements which are done by the parties whose market shares does not exceed the threshold. The threshold is at 20% of combined market share when the parties are competitors, and at 30% of individual market share when the parties are non-competitors.

⁷Competitors are competing undertakings on the relevant technology market and/or the relevant product market. (EC No 772/2004, Article1(j)).

property rights. The exclusive grantback clause will be concerned in general. The TTBER prohibits exclusive grantback clauses when the innovation is a severable improvement⁸. In this case, the grantback clause is required to be "two-way" or reciprocal⁹. The TTBER stated that:

"...Undertakings by the licensee to grant back to the licensor a license for improvements to the licensed know-how an/or patents are generally not restrictive of competition if the licensee is entitled by the contract to share in future experience and inventions made by the licensor..."¹⁰

The revision under the New-TTBER regarding grantback clause is worth mentioning. The New-TTBER exempts *all* non-exclusive grantback obligations, whereas under the old system some of them were blacklisted. In detail, the New-TTBER states that;

"In order to protect incentives to innovate and appropriate application of intellectual property rights, certain restrictions should be excluded from the block exemption. In particular exclusive grant back obligations for severable improvements should be excluded. Where such a restriction is included in a license agreement only the restriction in question should be excluded from the benefit of the block exemption."¹¹

There is also a 'no-challenge' clause in Article 5.1(C) in which the licensee cannot challenge the validity of intellectual property rights which the licensor holds in the common market. Lastly, it should be noted that grantbacks of all types are exempted under the "safety harbor" in the New-TTBER.

The bottom line is the US regulation depends on the rule of reason which is more economic and effects-based approach. While the EC regulation is a form-based which specify clearly what are prohibited and what are not. In particular, while in the US it will be evaluated case by case and it could be allowed when provide overall positive effect, the present EC regulation prohibits an exclusive "reciprocal grantback clause" except within a safe harbour.

3 Related Literature

The literature on technology licensing has been expanding since the 1980's. A number of papers analyse the effects of licensing on the current product market. Those studies explain analytical arguments for and against technology licensing. The reasons for licensing start with the fact that innovators are the outsider who do not manufacture the product in existing market. They may be small research labs, universities or creative individuals who have limited ability. In case of outside innovator, the technological licensing helps

⁸Severable Improvement refers to improvement that can be exploited without infringing the licensed technology.

⁹EC No. 240/96 (20) and also more detail in EC No 240/96 Article 2 (4).

¹⁰EC No. 240/96 (20)

¹¹EC No. 772/2004 (14)

innovator to fully appropriate the innovations by expanding their markets or territories, exploiting complementary technology elsewhere, or fulfilling insufficient financial resource.

The economic literature provide additional strategic reasons for licensing. This strand of literature is when the patentee is one of the incumbents. For example, licensing can serve as a strategy to deter a strong entrant by licensing to a weaker firm, allowing the latter to stay as a potential competitor after expiration the patent (Rockett, 1990). With price competition or positive output royalties, licensing also facilitates collusion (Fauli-Oller and Sandonis, 2002). In addition, the licensor can also choose to license different types of technology to discourage imitation (Rockett, 1990).

Also there is a large number of papers describing the impact of licensing on innovation incentives. However, a formal analysis of the licensing on future R&D competition is quite rare. Gallini (1984) studies strategic incentives for licensing in a duopoly market with perfect Nash equilibrium. She presents ex-ante licensing in which the licensing agreement is signed before the innovation stage. Two firms compete for a drastic future innovation under strong patent protection. The findings show that licensing is the optimal strategy for the licensor only if the returns to R&D are asymmetric i.e. the entrant's returns are greater than the incumbent's. This asymmetry in returns for R&D reflects the asymmetry in the production market (marginal cost of incumbent is lower than the entrant). So, entrant has more incentive to invest in R&D than the incumbent. By license the current technology to the entrant, it reduce the entrant's incentive to develop further R&D. Therefore, less innovation occurs.

Galini and Winter (1985) studies licensing in a noncooperative R&D game to analyse the impact of licensing on the innovation pattern. This paper discuss information sharing through the licensing. The paper found two effects of licensing i.e. the replacement of inefficient production (so called ex-post incentive) and the elimination of inefficient research expenditure (so called ex-ante incentive). The balance of these two incentives affect innovations when there is licensing. The paper shows that the licensing tend to increase innovation investment when the different in cost is low due to ex post incentive dominates the ex-ante one. However, licensing may leads to lower innovation when the cost is asymmetric when the ex-ante incentive dominates the ex-post incentive.

Katz and Shapiro (1985) analyse licensing under a static Cournot model with one innovator (upstream) and two possible licensees (downstream). Licensing is allocated using first price auction bidding. With perfect Nash equilibrium, this study shows that it is optimal for a minor invention to be licensed when firms are symmetric. It arises because the reduction in both firms' cost will increase industry profit. The licensor can extract all the rent through the bids which then allow it to gain the higher profit in total. Also, the paper finds that the licensing is not always welfare improving. The major invention may not be licensed at all. The intuition stems from the nature of Cournot competition and the monopoly persistence incentive. Moreover, the paper shows that licensing always increase incentive of an upstream innovator to do R&D. The tendency of the increases depend on the licensor's bargaining power. The higher the licensor's bargaining power, the higher the licensor's innovation incentives and the possibility of licensing. However,

when the licensee appropriates most of the licensing gain, the possibility of licensing may decrease innovation incentives.

More recently, Van Dijk (2000) shows that in addition to the direct income effect, the licensing provides also a strategic benefit by moving private R&D investment (which is too high) toward the social optimal level. The overinvestment of the private is caused by two negative externalities, common pool externality and business stealing effect. The licensing is a tool that internalise the business stealing effect and common pool externality. By licensing, the incumbent induce the entrant to take into account the existing profit, in other way internalise the business stealing effect. Also, the entrant considers more of its rival innovation investment (since now they become partner through the licensing process). The common pool problem is partially solved with licensing since the entrant is discouraged by the replacement effect as well as the incumbent. So, after licensing total private R&D investment falls.

Extending Katz and Sharpiro (1985), Mukherjee and Mukherjee (2002) assumes that the innovator is also one of the manufacturers (inside innovator). The work shows more restriction for the case where licensing will increase innovation investments. The licensing may increase or decrease incentives to innovate in this case. The innovation investment will fall if: first, the licensor's bargaining power is not sufficiently large, second is when R&D cost is high and third is when the product is insufficiently substituted. The intuition lies under the assumption of Cournot competition that the licensor consider also its product market loss and also the possibility of ex-post licensing.

The following analysis regarding relationship between licensing and innovation consider the cumulative innovations. This concept is introduced by Scotchmer in series of her papers (Scotchmer, 1991,1995, 2004). She defines the necessity of licensing as a mean to solve blocking patent problem arise from broad patent. In particular, Green and Scotchmer (1995) investigates the policy that is most effective at ensuring that the first innovator's incentive is safe when there is a second generation of innovation. The paper allows licensing of a new technology to serve as a starting point for developments of the follow-on innovations. The findings show that the types of licensing agreements, i.e. ex-ante and ex-post innovation, affect the optimal patent policy as well as innovation of the first generation. The ex-ante licensing is preferred over the ex-post licensing because: first, the ex-ante licensing ensures that innovation is invested if joint profit increases and second is that it will soften R&D competition in the future. The ex-ante licensing force both licensor and licensee to share the cost of innovation and the incremental revenue. The second generation innovation will not be deterred as long as the joint profit increases. Also, the license internalise the replacement effect into the licensee's consideration. Then, the race for follow-on technology become less intense.

Despite many positive effects from licensing, there are concerns that licensing may cause the licensor risk such as piracy, revenue dependency, and lost of the technological advantage. The licensing is not only transfer of patent right, but also licensor allows licensee to access the know-how. This impose major risk to the licensor in the sense that the licensing may create potential competitor for the future R&D race. These negative

factors may cause the licensor abstains from licensing out his patent which can negatively affect technological diffusion. It is difficult to design a contract that prevents licensor abstains from licensing his IP. As a response to the problem, it has been suggested that the technology "grantback" provision could remedy the licensor's fear of the negative effects. The studies we have reviewed so far analyse licensing without any grantback clause, apart from Van Dijk (2000).

There are two main economic papers studying grantback clauses. First, Van Dijk (2000) studies the impact of grantbacks on a drastic innovation using a stochastic model of technological competition. He models two grantback clause scenarios, both "one-way" and "reciprocal". He assumes that the pioneering patent on the current technology is *not* blocking the improvement, which can be viewed as a "severable improvement". The licensor and the licensee in the model share equal bargaining power and the licensing agreement occurs under Nash bargaining. The paper shows that the grantback clause reduces total private innovation. In this case, the reduction in innovation is welfare improving since the private total innovation is higher than the social optimal one. At the final stage, Van Dijk finds that the "one-way" grantback still induces social overinvestment in R&D which is still a welfare improvement compared to the case when a grantback clause is absent. Second, a reciprocal grantback clause induces a social underinvestment in R&D. The intuition behind these finding stems from the fact that licensing allow the other firm to internalise the common pool externality and the business stealing effect. Inclusion of the grantback reduce the returns of licensee's further innovation. It creates a free-riding problem which strenghtens the common pool externality. The one-way grantback dampen licensee's innovation. The reciprocal grantback additionally dampen the licensor's innovation. Therefore, it cause social underinvestment in R&D.

Another related study is Choi (2002) with the framework of incomplete contracts. Choi studies the licensing decision with grantback clause for the game with one licensor and one licensee. The model assumes a grantback clause as "one-way", from the licensee to the licensor. The model assumes also that there are two type of IP, one with superior quality that makes future innovation possible for its owners. The quality levels of two IPs are private information of the patentee. The licensing contract specifies a two-part tariff. He shows that a positive royalty rate is required in addition to a fixed fee for the contract to be incentive compatible. The positive royalty requirement can be explained by the inability to design a complete contract at the license contracting stage, so the positive royalty rate will further compensate the loss that would occur in the future market, in addition of specified fixed fee. He also shows that when the contract include a grantback clause, the royalty rate that satisfies the incentive capability constraint will be lower than the one without. It can be explained simply by the fact that part of licensee's rent will be transfer via grantback clause to compensate the lost of licensor. Therefore, less royalty income is needed to be applied on top of a fixed fee. Also his finding shows that effect of grantback clause on innovation incentives are in general ambiguous and dependent on the nature of R&D complementary and the magnitude of the licensor and the licensee's incentive changes. The incentive to innovate for licensee is unambiguously decrease with

inclusion of a grantback clause. To respond this reduction, the licensor may increase or decrease its innovations efforts depends on nature of R&D investment. The welfare issue of inclusion of a grantback clause is also discussed. The result is ambiguous depends on magnitude of saving social cost of R&D duplication. In case that R&D is rather easy, eliminate the duplication of R&D cost could be welfare improving. The model of Choi is sufficiently distinct, which complies with the concept of "severable improvement"¹². However, the exclusive one-way grantback in Choi's model does not comply with the 1996 TTBER since this regulation requires the exclusive grantback to be reciprocal.

Both Van Dijk and Choi study a market where there are two firms engaged in licensing process. This assumption prevent us to look into exclusivity issue. According to New-TTBER, an obligation on the licensee to grant an exclusive license to the licensor falls *outside* the scope of the block exemption when the improvement is consider severable improvements to the licensed technology. As a consequence of the updated regulation in 2004, both one-way and reciprocal exclusive grantback clause would be not be exempted under the block exemption. Consequently, the grantback clauses that have character as in Choi and Van Dijk's models is viewed as restrictive to the competition. Therefore, it will be assessed using "rule of reason" on the basis of Article 81(3)¹³.

The aim of this paper is to extend a model of one-way grantback clause in Choi (2002) to incorporate instead a "two-way" or "reciprocal" grantback clause. In this case both parties under the contract are obligated to share the future discovery with one another. According to EC NO 240/96 (The old TTBER), an exclusive reciprocal grantback clause was included in the block exemption if the innovation is a severable. But, under the new TTBER, this exclusive reciprocal grantback is excluded from the block exemption and required assessment under "rule of reason" following Article 81(3). To this regard, licensing decision, future innovation incentives and welfare results will be analyzed and compared to the case that grantbacks are absent or an "one-way" grantback clause is available.

4 Incomplete Contract Licensing ¹⁴

This model explains a technological transfer between two risk-neutral firms $i = \{Licensor(L), Licensee(l)\}$. The licensor possesses two types of technology $T = \{cutting - edge(C), Standard(S)\}$. The cutting-edge technology enables the licensee to produce at a lower marginal cost c_0 , while the standard one gives a higher marginal cost of technology c_1 . In additional to the usage allowance of a patented technology, the licensing process fast-tracks the licensee's technological capacity. When more advanced technology is transferred, the licensee is more capable of doing innovation. One type of technology is more advance than another. If the licensor keeps more advance technology (cutting-edged) to himself and license out the inferior one to his licensee. The licensee will be at inferior competitive position in

¹²see footnote 27 in Choi (2002).

¹³EC No 240/96 (20) excludes an exclusive one-way grant back to be "one-way" when follow-on improvement is severable. The regulation allow in this case the reciprocal type". The new EC No 772/2004 (14) excludes all type of an "exclusive" grant back for the severable improvement.

¹⁴A model of "complete contract" licensing can be found in appendix.

the follow-on innovation race. With the cutting-edge technology, the licensee will be able to compete and may win the follow-on innovation race with probability of θ . With standard technology, the licensee is unlikely to win (the probability for licensee to win the innovation race is less than θ , which can be simplified by normalize to zero).

The property rights of innovation are fully protected by the patents, so imitation is illegal and then not permitted. Hence, the licensee cannot produce any goods that use this technology without getting license. So, the licensee's reservation utility equals zero. The licensing is voluntary and must be agreed upon by both parties. The patentee will choose to have contract with one firm. So the licensing will be contracted between two firms. There are many potential homogeneous licensees. The licensor is indifferent to license to any one of them, so the licensor can offers "take-it-or-leave-it" contract and has the absolute bargaining power.

The licensor considers the returns in both the current and future markets. The technologies available in a current market are the patented ones. Assume that there is no direct market competition between the licensor and the licensee in the current market. Both are located in two different segmented markets¹⁵, which means they are non-competitors under the EC regulations¹⁶.

The future market has a value of V which is exogenous. The follow-on innovation is drastic and the current technology will be obsolete¹⁷. The winner of the innovation race takes all the market value and the loser gets nothing because of patent protection.

There are two periods in the game (see in figure A below) The first period, licensor chooses which type of technology to license. In the same period, production takes place. The licensing contributes extra income to licensor. Let R^T denote the licensor's royalty revenue and F^T denote the licensor's income from the up-front fixed fee when he licenses out technology type T. The current market payoffs comprise of the firm's own current market profit, a licensing fixed fee revenue and royalty income. Note also that, between the first and second periods there is a follow-on innovation race, in which both licensor and licensee simultaneously compete for a drastic innovation of value V . The second period payoff is the expected value of the new innovation. Let ϕ_i^T be player i 's expected return of follow-on innovation given that type T technology is transferred.

¹⁵Different markets may be in term of locations, customer groups or product markets. For example, British Telecom who operates communication service for UK market v.s. Sprint Nextel who operates the same service for the US market. This assumption also implies that technology is licensed only to one firm in a given market.

¹⁶According to TTBER, licensing between competitors will not be covered under the Regulations if the licensee is obligated to produce at minimum quantity or to use his best endeavours (see Article 7(4) of EC No 240/96). For New-TTBER, the general framework of restrictions on technology licensing between competitors or between non-competitors are similar, except for the market-share thresholds (see Article 3 and 4 of EC No.772/2004)

¹⁷E.g. landline telephone is a current technology and internet based telephone is a follow-on technology.

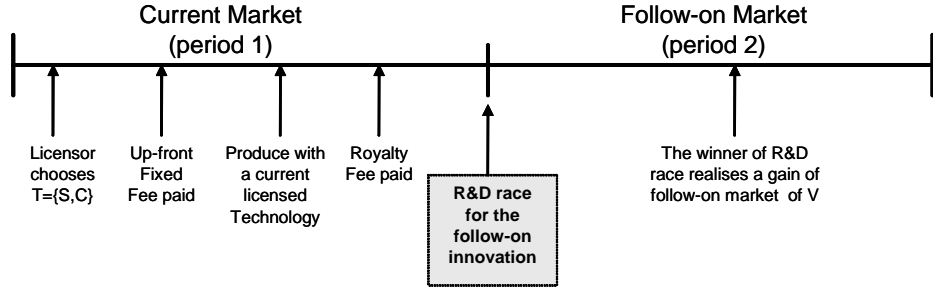


Figure A: Timeline of the Model

The type of technology cannot be verified by the third party who enforces a contract commitment, i.e. Antitrust authorities or a court, due to their limited ability to measure relevant variables, which constitutes the type of technology in this case. Hence, if a licensor promises to transfer a cutting-edge technology, his commitment cannot be enforced because the type of technology cannot be verified. There is then, a moral hazard problem as a result of incompleteness of the underlining contract. In order to facilitate transfers of "the best" available technology, the contracting parties need a mechanism which is self-enforcing. In this study, the optimal two-part tariff $\{r, F\}$ where r is royalty rate and F is fixed fee is derived¹⁸. The fixed fee is a transfer from the licensee to the licensor, which is restricted to be positive.¹⁹ The royalty rate is a percentage of a verified variable, taken to be output production (assume that demand is linear and price is normalized to unity; then output represents revenue). There are two constraints needed, an "incentive compatibility constraint" (ICC) and a "Individual Rationality Constraint" (IRC).

4.1 Benchmark Model²⁰

Without any grantback clause: The first benchmark model describes a scenario without any grantback clause. We solve the game backwards. Starting with the second period when both the licensor and the licensee make their future innovation decisions based on the expected market value they may get by winning the innovation race. In case that the licensed technology is cutting-edge, if there is no cost for R&D and no discounting, we will have the expected payoff for the second period as follows:

$$\phi_L^C = (1 - \theta)V \quad (1a)$$

$$\phi_I^C = \theta V \quad (1b)$$

Where ϕ_L^C is the expected return to the licensor for the cutting-edge technology li-

¹⁸ According to Rostoker (1984), 46% of the licensing agreements require two-part tariffs of royalty rate and fixed fee. The royalty rate alone was used in 39% of the cases and the fixed fee alone was used just 13% of the time.

¹⁹ In this paper, innovation investment is sole responsible of each firm. The licensor will not contribute to any of the licensee's cost of innovation eventhough the grantback clause is included in the contract. So, there is no transfers from the licensor to licensee which restrict the fixed fee to only be positive.

²⁰ Adopted from Choi (2002) with adjusted notations. His model describes incomplete contract without and with a one-way grantback clause.

censing, and ϕ_l^C is the expected return to the licensee. When licensing the standard technology, the licensor keeps his leading position and he will win the race for the follow-on innovation with probability one. Therefore, the expected payoffs for licensing the standard technology are

$$\phi_L^S = V \quad (1c)$$

$$\phi_l^S = 0 \quad (1d)$$

Where ϕ_L^S is the expected return to the licensor for the standard technology licensing, and ϕ_l^S is the expected return to the licensee

The fixed fee, which can be set differently according to the type of the technology, is paid before the production. The licensee who wants the cutting-edge type will pay for F^C at the time he gets access to technology. The fixed fee is defined at the first stage of the game, which will be calculated later as we adopt here backward induction method. When the licensee gets technology, he cannot verify the true type until he starts using the technology to produce output.

At this stage, since the type of technology is not directly observed but can be observed by level of output, the royalty rate (r^T) is conditional upon production output which is a verifiable variable. Let $\pi_i(\cdot)$ and $q_i(\cdot)$ be the profit and profit maximising output, respectively, for player $i = (L, l)$. Thus, royalty revenues ($R^T(r^T)$, where $T = (C, S)$) can be described as follows:

$$R^C(r) = r q_l(c_0 + r) \quad , \quad R^S(r) = r q_l(c_1 + r). \quad (2)$$

The expected gain at this point onward for the licensor is a royalty revenue plus expected gain from the future market. We omit the fixed fee here since it has been already defined at the earlier stage of the game. This fixed fee will be defined later according to backward induction.

In order to guarantee that the cutting-edge technology will be transferred by the licensor, the royalty rate must be set at the level where the expected returns from licensing cutting-edge technology at this point onward are higher than the ones of a standard technology. Therefore, the licensor's incentive compatibility constraint (ICC) for the cutting-edge technology licensing is

$$R^C(r^C) + \phi_L^C \geq R^S(r^C) + \phi_L^S, \quad (ICC)$$

Also, the royalty rate must be defined such that the licensee prefers to get the cutting-edge technology instead of the standard type. The individual rationality constraint (IRC) defines that the licensee's expected returns is higher with the cutting-edge technology is transferred than when the standard one is transferred. The IRC will give a restriction to the upper-bound of the royalty rate.

$$\pi_l(c_0 + r^C) + \phi_l^C - R^C(r^C) \geq \pi_l(c_1 + r^C) + \phi_l^S - R^S(r^C) \quad (IRC)$$

From both ICC and IRC, we then can identify the royalty rate for the cutting-edge technology licensing which is equivalent to

$$\text{From ICC,} \quad R^C(r^C) - R^S(r^C) \geq \phi_L^S - \phi_L^C \quad (3a)$$

$$r^C [q_l(c_0 + r^C) - q_l(c_1 + r^C)] \geq \theta V \quad (3b)$$

$$\text{From IRC, } \pi_l(c_0 + r^C) + \theta V - \pi_l(c_1 + r^C) \geq R^C(r^C) - R^S(r^C) \quad (3c)$$

$$\pi_l(c_0 + r^C) - \pi_l(c_1 + r^C) + \theta V \geq r^C [q_l(c_0 + r^C) - q_l(c_1 + r^C)] \quad (3d)$$

$$\text{Hence, } \frac{\pi_l(c_0 + r^C) - \pi_l(c_1 + r^C) + \theta V}{[q_l(c_0 + r^C) - q_l(c_1 + r^C)]} \geq r^C \geq \frac{\theta V}{[q_l(c_0 + r^C) - q_l(c_1 + r^C)]} \quad \text{\textcircled{3e}}$$

From ICC and equation 3a, an increase in royalty income when cutting-edge technology is actually transferred must be sufficiently larger than the loss of expected future market gain. On this basis, the optimal royalty rate will be set based on the trade-off between the increases in royalty revenue and the expected loss of future market revenue when licensing out a cutting-edge technology. The licensor reaps more royalty income when output is higher and the output is higher when the licensee receives a better technology. However, when the licensor licenses out his better technology, he may lose his leading position in the future market due to the licensee's leapfrogging which depends on θ . Hence as θ increases we see that the range for which licensing a cutting-edge technology is less desirable. The licensor must obtain some compensations for this loss by charging licensing royalty and/or fixed fee. Hence, the optimal royalty rate (at this stage is equation 3e) is positive to compensate for the licensor's future market loss when leapfrogging is possible as a result of technology licensing. Also, the royalty rate cannot be too high so that the licensee does not favour of receiving the cutting-edge technology. So, the value of royalty is restricted to be less than the expression of on the left of equation 3e which is derived from IRC.

Assume that there exists a minimum royalty rate $r^*(\theta)$ that satisfies the ICC with equality for all $\theta \in (0, 1)$. Note that since the denominator is positive and $V > 0$, we have $\frac{dr^*}{d\theta} > 0$ implies that it is more costly to satisfy both constraints when the licensee has higher potential to catch-up the technological frontier (the higher θ , the higher the probability that licensee will win the innovation race). The higher θ may influence the licensor to abstain from licensing his cutting-edge technology. To convince the licensor, a higher royalty rate is required²¹.

Also we have to define a licensing fixed fee (F^T) which has a main purpose to extract the rents from the licensee in both current market (which is licensee's product market profit) and expected future innovation (which is the licensee's expected value of future innovation). Since we assumed earlier that the licensor has all bargaining power, he can optimally set the fixed fee to extract all possible economic rents that the licensee expects to get.

²¹It should be noted that the existence of r^* does not guarantee that the licensor will voluntarily license out the best technology. The licensor will voluntarily license out cutting-edge technology conditional on profit, which will be discussed later in this paper.

$$F^C = \pi_l(c_0 + r^*(\theta)) + \phi_l^C = \pi_l(c_0 + r^*(\theta)) + \theta V \quad (4)$$

As we assume at the beginning that there is no direct competition in the current market. The licensor always use the best technology he has to product the output for his market territory which is π_L . The licensor's "total" payoff for the cutting-edge technological transfer (Π^C) is the sum of his own product market profit (π_L), the expected return from his own future innovation (ϕ_L^C), the royalty income and the fixed fee ($R^C(r) + F^C$), which equals to

$$\Pi^C = \pi_L + r^*(\theta)q_l(c_0 + r^*(\theta)) + \pi_l(c_0 + r^*(\theta)) + V \quad (5)$$

The total payoff for licensing the cutting-edge technology depends on θ . It is straightforward to show that $\frac{d\Pi^C}{d\theta} < 0$ ²², that is, the higher the licensee's leapfrogging ability, the less total payoff for licensor when he transfers a cutting-edge technology. Hence, the licensor will opt to transfer a standard technology instead.

For a standard technology licensing, the ICC is unnecessary since the licensor would prefer to transfer the standard technology instead of be honest and transfer the cutting-edge one when the monitoring is difficult. In this case, the royalty rate for standard technology can be set at the minimum of zero which is equivalent to the complete contract case. With the up-front fixed fee equals $\pi_l(c_1)$, the total profit for licensing a standard technology is independent of θ .

$$\Pi^S = \pi_L + \pi_l(c_1) + V \quad (6)$$

From $\Pi^C(\theta)$ and Π^S , it is clear that there is a unique θ^* such that when $\theta \leq \theta^*$ then $\Pi^C(\theta) \geq \Pi^S$ (see figure 1a and 1b). This means that a transfer of a cutting-edge technology is incentive compatible for the licensor only when the licensee's leapfrogging ability is sufficiently low. The intuition is that when the licensee possesses high ability to win the follow-on innovation, the licensor's fear for losing his future market competitiveness dominates the extra revenue from licensing. Then, the licensor opts out of transferring his best technology.

In the presence of the contract incompleteness, the optimal fixed fee alone cannot guarantee that the contract will be binding. The licensor would not commit to transfer the cutting-edge technology after the up-front fixed fee has been paid. A positive royalty rate is necessary to persuade the licensor to commit with the contract and transfer a cutting-edge technology transfer as he promises. In order to encourage the licensor to transfer the cutting-edge technology, the licensor must limit his expected future competitive loss. The grantback clause is evaluated below to serve this purpose.

With a One-way Grantback Clause: Lets now consider when grantback is a one-

²²By using envelope theorem, $\frac{d\Pi^C}{d\theta} = r^*(\theta)\frac{\partial q}{\partial\theta}(c_0 + r^*(\theta)) * \frac{\partial r^*(\theta)}{\partial\theta}$. We know that $\frac{\partial r^*}{\partial\theta} > 0$, but $\frac{\partial[q(c_0+r^*(\theta))]}{\partial\theta} = \frac{\partial[q(\cdot)]}{\partial r^*} \frac{\partial r^*}{\partial\theta} < 0$ since $\frac{\partial[q(\cdot)]}{\partial r^*} < 0$. So, $\frac{d\Pi^C}{d\theta} < 0$

way from the licensee to the licensor. Keeping all notations as previously, let assume that follow-on innovation has the market value of $V = V_L + V_l$, where V_L and V_l are the licensor's and licensee's future innovation market values, respectively. When the licensor transfers the cutting-edge technology to the licensee, he can expect to get some of the licensee's expected return according to grantback clause. In this case the second period expected payoffs with the cutting-edge technology transfer will be

$$\bar{\phi}_L^C = (1 - \theta)V + \theta V_L \quad (7a)$$

$$\bar{\phi}_l^C = \theta V - \theta V_L = \theta V_l \quad (7b)$$

The expected payoffs when the licensor licenses the standard technology are

$$\bar{\phi}_L^S = V \quad (7c)$$

$$\bar{\phi}_l^S = 0 \quad (7d)$$

Using the similar concept of ICC and IRC, we derive

$$R^C(\bar{r}^C) + \bar{\phi}_L^C \geq R^S(\bar{r}^C) + \bar{\phi}_L^S, \quad (\overline{ICC})$$

$$\pi_l(c_0 + \bar{r}^C) + \bar{\phi}_l^C - R^C(\bar{r}^C) \geq \pi_l(c_1 + \bar{r}^C) + \bar{\phi}_l^S - R^S(\bar{r}^C) \quad (\overline{IRC})$$

From both \overline{ICC} and \overline{IRC} , we then can identify the royalty rate for the license of the cutting-edge technology as

$$\text{From ICC,} \quad R^C(\bar{r}^C) - R^S(\bar{r}^C) \geq \bar{\phi}_L^S - \bar{\phi}_L^C \quad (8a)$$

$$\bar{r}^C [q_l(c_0 + \bar{r}^C) - q_l(c_1 + \bar{r}^C)] \geq \theta V_l \quad (8b)$$

$$\text{From IRC, } \pi_l(c_0 + \bar{r}^C) + \theta V - \pi_l(c_1 + \bar{r}^C) \geq R^C(\bar{r}^C) - R^S(\bar{r}^C) \quad (8c)$$

$$\pi_l(c_0 + \bar{r}^C) - \pi_l(c_1 + \bar{r}^C) + \theta V_l \geq \bar{r}^C [q_l(c_0 + \bar{r}^C) - q_l(c_1 + \bar{r}^C)] \quad (8d)$$

$$\text{Hence, } \frac{\pi_l(c_0 + \bar{r}^C) - \pi_l(c_1 + \bar{r}^C) + \theta V_l}{[q_l(c_0 + \bar{r}^C) - q_l(c_1 + \bar{r}^C)]} \geq \bar{r}^C \geq \frac{\theta V_l}{[q_l(c_0 + \bar{r}^C) - q_l(c_1 + \bar{r}^C)]} \quad (8e)$$

Let \bar{r}^C be the minimum royalty rate to satisfy the \overline{ICC} and \overline{IRC} given the probability of losing future competition θ , when the contract includes a one-way grantback clause. Since $V_l < V$, the incentive compatibility constraint has been relaxed with the grantback clause. Therefore, we have $\bar{r}^C(\theta) < r^*(\theta)$.

The payoff from transferring the cutting-edge technology and standard technology can be written as

$$\bar{\Pi}^C = \pi_L + \bar{r}(\theta)q_l(c_0 + \bar{r}(\theta)) + \pi_l(c_0 + \bar{r}(\theta)) + V \quad (9)$$

$$\bar{\Pi}^S = \pi_L + \pi_l(c_1) + V \quad (10)$$

Let $\bar{\theta}^*$ be the unique value such that $\bar{\Pi}^C > \bar{\Pi}^S$ if and only if $\theta < \bar{\theta}^*$. From the fact that $\bar{r}^C(\theta) < r^*(\theta)$, it implies $\bar{\theta}^* > \theta^*$. The grantback clause provides two benefits. First, the grantback clause allows the cutting-edge technology to be transferred for a wider range of parameters. Second, even though the cutting-edge technology is transferred without grantback, inclusion of grantback reduces the royalty rate, in turn inducing more efficient output level. (See figure 1a)

4.2 Licensing with Reciprocal Grantbacks

4.2.1 The Licensing Decision

This section analyses the grantback clause according to the 1996 TTBER, which allows the exclusive grantback clause as long as it is a reciprocal one i.e. the licensee is, by the contract, entitled to share in the future the severable improvement made by the licensor. Keeping all notation as previously. With reciprocal grantbacks, both parties are obligated to share their success when the innovation is discovered. The licensor must share his success to the licensee as well as the licensee has to share its with the licensor. The expected payoffs with cutting-edge technology licensing in the second period are

$$\tilde{\phi}_L^C = (1 - \theta)V - \underbrace{(1 - \theta)V_l}_A + \underbrace{\theta V_L}_B = V_L \quad (11a)$$

$$\tilde{\phi}_l^C = \theta V + \underbrace{(1 - \theta)V_l}_A - \underbrace{\theta V_L}_B = V_l \quad (11b)$$

A is the grantback from the licensor to the licensee and B is the grantback from the licensee to the licensor. For standard technology licensing, the licensor has to share his innovations with the licensee if he discovers a new improvement based on the licensed technology. Remember that with a standard technology $\theta = 0$ and the licensee cannot win the innovation race over the licensor. Hence, there is only the A -grantback. The expected payoffs with standard technology licensing are

$$\tilde{\phi}_L^S = V - \underbrace{V_l}_A = V_L \quad (11c)$$

$$\tilde{\phi}_l^S = 0 + \underbrace{V_l}_A = V_l \quad (11d)$$

Therefore; ICC and IRC become

$$R^C(\tilde{r}^C) + \tilde{\phi}_L^C \geq R^S(\tilde{r}^C) + \tilde{\phi}_L^S \quad (\text{ICC-r})$$

$$\pi_l(c_0 + \tilde{r}^C) + \tilde{\phi}_l^C - R^C(\tilde{r}^C) \geq \pi_l(c_1 + \tilde{r}^C) + \tilde{\phi}_l^S - R^S(\tilde{r}^C) \quad (\text{IRC-r})$$

Notice that $\tilde{\phi}_i^S = \tilde{\phi}_i^C$ with reciprocal grantbacks: expected returns are the same regardless of the type of licensed technology. From both ICC-r and IRC-r, we then can identify

the royalty rate for the cutting-edge technology licensing which is equivalent to

$$\text{From ICC-r, } \tilde{r}^C [q_l(c_0 + \tilde{r}^C) - q_l(c_1 + \tilde{r}^C)] \geq 0 \quad (12a)$$

$$\tilde{r}^C \geq 0 \quad (12b)$$

$$\text{From IRC-r, } \pi_l(c_0 + \tilde{r}^C) - \pi_l(c_1 + \tilde{r}^C) \geq R^C(\tilde{r}^C) - R^S(\tilde{r}^C) \quad (12c)$$

$$\frac{\pi_l(c_0 + \tilde{r}^C) - \pi_l(c_1 + \tilde{r}^C)}{[q_l(c_0 + \tilde{r}^C) - q_l(c_1 + \tilde{r}^C)]} \geq \tilde{r}^C \quad (12d)$$

$$\text{Hence, } \frac{\pi_l(c_0 + \tilde{r}^C) - \pi_l(c_1 + \tilde{r}^C)}{[q_l(c_0 + \tilde{r}^C) - q_l(c_1 + \tilde{r}^C)]} \geq \tilde{r}^C \geq 0 \quad (12e)$$

If we define \tilde{r} as a royalty rate which satisfies the ICC-r and IRC-r, equations (12a) - (12e) show that the royalty rate with reciprocal grantbacks *does not* depend on θ . The minimum royalty rate that satisfies the ICC-r is lower than the one without grantbacks. the reciprocal grantback clauses give a minimum royalty rate lower than a royalty rate in the case of one-way grantback clause and the one without any grantback clauses. The licensor voluntarily licenses out his cutting-edge technology at the minimum royalty rate of zero. The intuition lies under the fact that there is no expected loss of future market competitiveness when there is a reciprocal grantback clause. The expected return of future innovation is guaranteed for the licensor at V_L , regardless of the type of transferred technology. Hence, the production-distorted royalty rate become irrelevant to facilitate cutting-edge technology transfer when the incomplete contract requires a reciprocal grantback clause.

The licensor can optimally set the fixed fee to reap all foreseen economic rents from the licensee. Therefore, fixed fees are as follows;

$$\tilde{F}^C = \pi_l(c_0) + \tilde{\phi}_l^C = \pi_l(c_0) + V_l \quad (13)$$

$$\tilde{F}^S = \pi_l(c_1) + \tilde{\phi}_l^S = \pi_l(c_1) + V_l \quad (14)$$

Consequently, in period one the licensor's total payoff with the transfer of his cutting-edge and standard technology are

$$\tilde{\Pi}^C = \pi_L + \tilde{F}^C + \tilde{\phi}_L^C = \pi_L + \pi_l(c_0) + V_l + V_L = \pi_L + \pi_l(c_0) + V \quad (15)$$

$$\tilde{\Pi}^S = \pi_L + \tilde{F}^S + \tilde{\phi}_L^S = \pi_L + \pi_l(c_1) + V_l + V_L = \pi_L + \pi_l(c_1) + V \quad (16)$$

The result shows that $\tilde{\Pi}^C > \tilde{\Pi}^S$, meaning that the licensor always prefers to license out his cutting-edge technology regardless of the licensee's leapfrogging ability (θ). Even though the licensing contract is incomplete, incorporating a reciprocal grantback clause helps to facilitate a transfer of the best available technology with the provision of a fixed fee only. Production efficiency is improved when the royalty rate is driven down to zero. The result is shown in Figure 1(b).

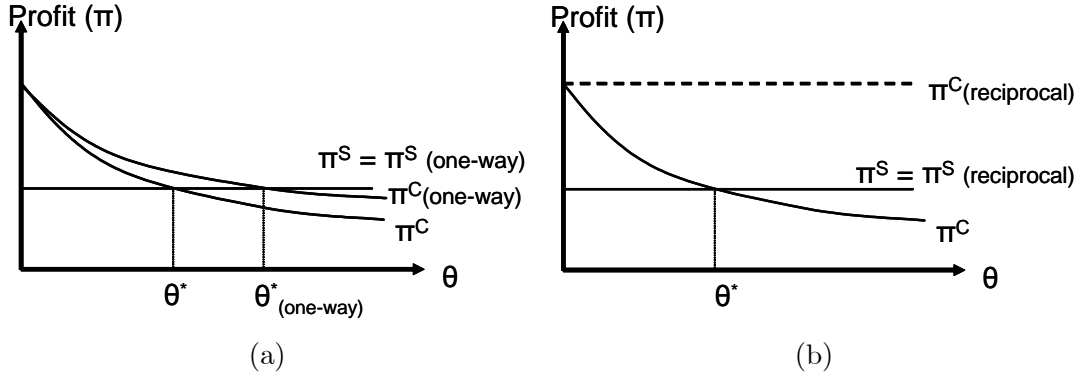


Figure 1: The licensor's profits under different schemes of grantback clause and different types of transferred technology. (a) One-way grantback (b) Reciprocal grantback

We can conclude that under the existence of the reciprocal grantback clause, the licensor's total payoff with the cutting-edge technological transfer is always higher than the one with the standard technological transfer. The minimum royalty rate to satisfy ICC is zero. Proposition 1 summarizes the findings.

Proposition 1 *Inclusion of a positive royalty rate is unnecessary for the transfer of the cutting-edge technology to be ex post incentive compatible, even though a contract is incomplete, as long as the licensing agreement requires a grantback clauses that are reciprocal.*

The proposition shows that reciprocal grantbacks give the lowest royalty rate (at zero) even with the presence of contract incompleteness. This result extends Choi (2002) who demonstrates that one-way grantbacks reduce the royalty rate, but not to zero. The incentive for the licensor to actually supply the cutting-edge technology comes from the fact that the cutting-edge technology enable the licensee to innovate the new innovate technology which then it will be shared by the licensor according to the grantback clause in addition to a higher licensing income.

The key to the argument for a zero royalty rate is that grantbacks restore the licensor's future competitiveness by reducing the uncertainty of the expected gain. Without grantbacks, the licensor does not commit to license out his best technology or he may ask the licensee for a relatively high royalty rate and fixed fee to cover his expected competitive loss from leapfrogging. With the reciprocal grantback, the clause provides a condition of mutual sharing of the success in the future market. The licensor guarantees his returns at V_L regardless of the type of the licensed technology. Hence, there is no benefit of having a royalty rate. In this case, product market inefficiency is also diminished.

At the same time, the reciprocal grantbacks help to limit the licensor's market dominance. One-way grantbacks give the licensor the power to extract benefits from the licensee, which could be viewed as an abuse of market dominance. The licensor should not be given the privilege based on his current technology to the exploit licensee's future innovations. Hence, the reciprocal grantback clause balances the forces between intellectual property rights and competition laws.

4.2.2 R&D Incentives with Reciprocal Grantbacks

The main criticism of all types of grantbacks is that they diminish the licensee's incentive to innovate and thereby create potential adverse effects on future innovation. Also, the effects on the licensor's incentive to innovate should be taken into account. Van Dijk (2000) looks at the innovation output and he finds that all types of grantbacks reduce total innovations because the grantbacks partially internalise the common pool externality²³ as well as reduce the business stealing externality. However, in Van Dijk (2000), the total innovation level with a grantback clause is still higher than the social optimal level. Choi (2002) looks at innovation incentives using the critical value of R&D cost. He shows that the licensor may increase or decrease his own R&D effort in response to changes in the licensee's R&D. Changes in the licensor's innovation incentive depend upon the nature of R&D competition, whether R&D is a strategic complement or substitute. For complementary R&D, the licensor's innovation incentive will decrease, while it will increase with R&D substitutability. Therefore, the total innovation in Choi's model is in general ambiguous.

Assume that the licensee and the licensor invest in innovation with probability β and σ , respectively, without a grantback clause. Let these probabilities be $\tilde{\beta}$ and $\tilde{\sigma}$, respectively, with a reciprocal grantback clause. In this paper, we assume that both the licensee and the licensor simultaneously decide on their future innovation after the licensing decision. Each firm independently draws the cost of developing a new product (k_i) from a distribution G . The cost of innovation is a private information and the firms do not know the rival's R&D cost. By assuming private information, the decision to undertaken R&D of each firm is independent of other's. The firm will undertake his R&D based only on his own critical value of R&D cost denoted as k_i^* , otherwise each firm's innovating decision may be affected strategically by observing the other's cost.²⁴

The probabilities (β , σ , $\tilde{\beta}$ and $\tilde{\sigma}$) can be modelled as a function of innovation cost (k_i) distributed according to function G .²⁵ The winner is determined randomly with probability $\frac{1}{n}$ (i.e., $1/2$ when there are only two players). The innovation decision is made when innovation cost is lower than the critical value k_i^* . Once the firm invest, discovery is guaranteed. Market value of follow-on innovation is $V = V_L + V_l$. The payoffs for the innovation race are

Table 1: Payoffs Without Grantbacks

given β and σ	Licensor invest (σ)	Licensor does not invest ($1-\sigma$)
Licensee invest (β)	V_l, V_L	$V, 0$
Licensee does not invest ($1 - \beta$)	$0, V$	$0, 0$

Table 2: Payoffs With Reciprocal Grantbacks

given $\tilde{\beta}$ and $\tilde{\sigma}$	Licensor invest ($\tilde{\sigma}$)	Licensor does not invest ($1-\tilde{\sigma}$)
Licensee invest ($\tilde{\beta}$)	V_l, V_L	V_l, V_L
Licensee does not invest ($1 - \tilde{\beta}$)	V_l, V_L	$0, 0$

²³The Common Pool Externality was first noticed by Barzel (1968) in public economics.

²⁴This line of assumption is more practically since the R&D of each firm will be kept secret.

²⁵i.e., $\sigma = G(k_L)$ and $\beta = G(k_l)$ with $\frac{\partial G}{\partial k} > 0$.

Licensee's Innovation Incentives: Given probability of the licensor to invest in innovate both with or without grantback clauses (σ and $\tilde{\sigma}$), the licensee's expected returns with a reciprocal grantbacks is $\tilde{\psi}_l^R$ and the expected returns without a reciprocal grantback clause is ψ_l^R , where $R \in \{Innovate(I), Not Innovate(D)\}$, are

$$\psi_l^I = \sigma V_l + (1 - \sigma)V - k \quad (17a)$$

$$\psi_l^D = 0 \quad (17b)$$

$$\tilde{\psi}_l^I = \tilde{\sigma} V_l + (1 - \tilde{\sigma})V_l - k \quad (17c)$$

$$\tilde{\psi}_l^D = \tilde{\sigma} V_l \quad (17d)$$

Without grantbacks, the licensee will invest in the innovation if and only if $\psi_l^I > \psi_l^D$, which implies the critical value of innovation cost $k_l^* = \sigma V_l + (1 - \sigma)V \implies k_l^* = V_l + (1 - \sigma)V_L$. In this case, the licensee undertakes R&D iff

$$k \leq k_l^* = V_l + (1 - \sigma)V_L = V - \sigma V_L \quad (18)$$

The licensee sets his investment up to the value of market if he is the only active firm in the innovation race. That is he can appropriate his investment up to $V_l + V_L$. At the same time, he knows that the licensor also races for the discovery. Therefore, he has to take into account the possibility that he may not be the winner, which then decrease his innovation by $-\sigma V_L$.

With reciprocal grantbacks and the same analogue way, the critical value of innovation cost is $\tilde{k}_l^* = \tilde{\sigma} V_l + (1 - \tilde{\sigma})V_l - \tilde{\sigma} V_l \implies (1 - \tilde{\sigma})V_l$. Then innovation is undertaken by the licensee when

$$k \leq \tilde{k}_l^* = (1 - \tilde{\sigma})V_l \quad (19)$$

Comparison of the two critical value of R&D cost shows the licensee's critical cost of R&D with grantback clause is unambiguously lower than the one without grantback clause i.e. $\tilde{k}_B^* < k_B^*$ ²⁶ for all σ and $\tilde{\sigma}$. As β and $\tilde{\beta}$ are $G(k)$ with a positive first derivative, we can conclude from $\tilde{k}_B^* < k_B^*$ that $\tilde{\beta} < \beta$. This result confirms Choi (2002) and Van Dijk (2000) that grantback clauses reduce the licensee's innovation incentive. The intuition is simply because the licensee cannot fully appropriate his innovation because he has to share part of the success with the licensor according to grantback clause. He obtains only V_l since he has to give away V_L proportion to the licensor. Also the reciprocal grantbacks allow the licensee to free-ride the licensor's success since he is now entitled to get a proportion V_l when the licensor discovers new innovation. Hence, the licensee reduces further his innovation by $\tilde{\sigma} V_l$. This finding shows the licensee's critical value of innovation cost with a reciprocal grantback depends negatively on the licensor's innovation behavior as the result of the licensee's free-riding on the licensor's innovation investment.

²⁶ $k_l^* - \tilde{k}_l^* = V_l + (1 - \sigma)V_L - (1 - \tilde{\sigma})V_l \Rightarrow (1 - \sigma)V_L + \tilde{\sigma} V_l > 0$

Licensors's Innovation Incentives: From table 1 and 2 provided earlier, we can analyse the licensor's innovation incentive given the licensee's probability to invest in R&D $(\beta, \tilde{\beta})$ in an analogue way. Let ψ_L^R and $\tilde{\psi}_L^R$ be licensor's expected returns without and with reciprocal grantbacks, respectively. We have

$$\psi_L^I = \beta V_L + (1 - \beta)V - k \quad (20a)$$

$$\psi_L^D = 0 \quad (20b)$$

$$\tilde{\psi}_L^I = \tilde{\beta} V_L + (1 - \tilde{\beta})V_L - k \quad (20c)$$

$$\tilde{\psi}_L^D = \tilde{\beta} V_L \quad (20d)$$

Therefore, we can specify the licensor's innovation incentives using the critical value of innovation by the following conditions;

$$k \leq k_L^* = V_L + (1 - \beta)V_L \quad (21)$$

$$k \leq \tilde{k}_L^* = (1 - \tilde{\beta})V_L \quad (22)$$

A comparison of conditions in equations (21) and (22) show that $k_L^* > \tilde{k}_L^*$ ²⁷. Hence, we can say that $\sigma > \tilde{\sigma}$. As a consequence of the reciprocal grantback, the licensor also reduces innovation incentives of follow-on R&D as a result of an appropriability problem, the internalization of common pool externality and also the free-riding. The result obtained here shows that the reciprocal grantbacks deteriorate total incentives to innovate compared to the ones without grantback or the one with "one-way" grantbacks. The finding is consistent with Van Dijk (2000)²⁸ that R&D incentive is lower when incorporate a grantback clause into the contract. The findings of Van Dijk (2000) indicate one-way grantbacks helps alter a private innovation to be closer to the social optimal, but still be higher. The reciprocal grantbacks reduce the private innovation to be lower than the social optimal. However, this paper does not state that the innovation with the reciprocal grantback clause is higher or lower than the social optimal level. We investigate this in the next section.

4.2.3 Welfare Effects at the R&D Stage

From the previous section, we have shown that reciprocal grantbacks reduce follow-on innovation incentives of both licensor and licensee. However, we cannot guarantee the transfer of a cutting-edge technology without a grantback clause which may jeopardize the availability of future innovation. At this point, a grantback clause inclusion should be reviewed base on trade-offs between: "reduction in total innovation incentives" and "increases in the probability of discovery" of a new innovation.

²⁷ $k_L^* - \tilde{k}_L^* = V_L + (1 - \beta)V_L - (1 - \tilde{\beta})V_L$
 $\Rightarrow (1 - \beta)V_L + \tilde{\beta}V_L > 0$

²⁸ Van Dijk identify the amount of R&D which can imply innovation incentive. The higher the unit of R&D, the higher the innovation incentive.

In this section, we focus on a welfare at the future R&D stage. To simplify the analysis, let keep the assumption that the licensor and the licensee's markets are of equal i.e. $V_I = V_L = \frac{V}{2}$. The rent obtained by the licensor equals social welfare (both in the future R&D stage) because the licensor possesses all bargaining power, so he obtains all the economic rents.

Assume that each player's probability to invest in R&D is distributed as a cumulative distribution function $G(x) = \frac{x}{\gamma V}$. x is uniformly distributed between $[0, \gamma V]$, where $\gamma \geq 1$. We can interpret γ as a parameter representing "the difficulty of R&D project".²⁹ The innovation is less likely to be discovered when R&D is difficult (high γ). From equations (19) and (22), the licensee and the licensor's critical values of innovation cost with the reciprocal grantback are $\tilde{k}_I^* = (1 - \tilde{\sigma})\frac{V}{2}$ and $\tilde{k}_L = (1 - \tilde{\beta})\frac{V}{2}$. Given $G(x) = \frac{x}{\gamma V}$, the licensee's probability to invest in R&D is $\tilde{\beta}^* = G(\tilde{k}_I^*) = \frac{(1 - \tilde{\sigma})}{2\gamma}$. Also, the licensor's probability is $\tilde{\sigma}^* = G(\tilde{k}_L^*) = \frac{(1 - \tilde{\beta})}{2\gamma}$. Therefore, we can derive $\tilde{\sigma}^*$, $\tilde{\beta}^*$, \tilde{k}_I^* and \tilde{k}_L^* as follows

$$\tilde{\sigma}^* = \tilde{\beta}^* = \frac{1}{1 + 2\gamma} \quad (23)$$

$$\tilde{k}_I^* = \tilde{k}_L^* = \frac{\gamma}{1 + 2\gamma} V \quad (24)$$

The welfare prior to R&D comprised of two component. The *first* component is the *expected value of innovation* which is the product of the probability of discovering new innovation and a innovation market value (V). The *second* component is the *expected innovation costs*.

$$\widetilde{W}^C = \overbrace{[1 - (1 - \tilde{\beta}^*)(1 - \tilde{\sigma}^*)]V}^{\text{First}} - \overbrace{\int_0^{\tilde{k}_I^*} x dG - \int_0^{\tilde{k}_L^*} x dG}^{\text{second}} \quad (25a)$$

$$= \frac{1 - 4\gamma + 7\gamma^2}{8\gamma^3} - \frac{x^2}{2\gamma V} \Big|_{\tilde{k}_I^*} - \frac{x^2}{2\gamma V} \Big|_{\tilde{k}_L^*} \quad (25b)$$

$$= \frac{(1 + 3\gamma)}{(1 + 2\gamma)^2} V \quad (25c)$$

Having more firms engaging in innovation contributes to more R&D activities. Social total effort of innovation rise and this increases the chance of overall discovery. However with more labs, society faces duplication in R&D cost. In order to see more clearly, the comparisons are separated into two parts. First is the comparison between the one-way and the reciprocal grantbacks and second the analysis without grantbacks and with the reciprocal grantback.

One-way vs. Reciprocal Grantbacks: Let denote welfare in the one-way grantback innovation market as \overline{W}^C . With the same analogue of \widetilde{W}^C , we derive $\overline{W}^C = [\frac{1}{2\gamma} +$

²⁹Choi (2002) interprets γ as R&D difficulty while Van Dijk (2000) interprets it as R&D efficacy. A higher γ means that R&D is rather difficult or efficacy is lower.

$$\frac{(\gamma-1)(3\gamma-1)}{8\gamma^3}]V.^{30}$$

Lemma 1 $\overline{W}^C > \widetilde{W}^C$ for all $\gamma \geq 1$.

Proof. Since (i) $\gamma \geq 1$ (ii) $1 + \gamma^2(4\gamma^2 + 4\gamma - 5) > 0$ and (iii) $8\gamma^3(1 + 2\gamma)^2 > 0$, we obtain that $\overline{W}^C - \widetilde{W}^C = \frac{1+\gamma^2(4\gamma^2+4\gamma-5)}{8\gamma^3(1+2\gamma)^2}V > 0$ ■

A simple explanation is that the reciprocal grantback clause also deteriorates the licensor's innovation incentives in addition to the reduction of the licensee's innovation incentives. In this case, $\tilde{\sigma}^*$ is less than the $\bar{\sigma}^*$ of one-way grantback, which in turn deteriorates the probability of discovering a new technology³¹. This result is displayed in figure 2(a)

No Grantback vs. Reciprocal Grantback Clauses: There are two possible scenarios in the absence of grantbacks depends upon type of transferred technology. Refer to figure 1a and 1b; a standard technology is transferred when $\theta > \theta^*$, while a cutting-edge technology is transferred when $\theta < \theta^*$.

First, consider when the standard technology is transferred ($\theta > \theta^*$), the licensee is not capable of innovating. Therefore $\beta^* = 0$. The licensor's probability of innovation is $\sigma^* = 1/\gamma$.³² Then, the expected social welfare with a standard technology licensing is

$$W^S = \sigma^*V - \int_0^{k_L^*} x dG = \frac{V}{2\gamma} \quad (26)$$

In this case, the society saves on a duplication cost of R&D since there is only one lab engaging in R&D activities. However, the probability of discovery solely depends upon the licensor's probability to invest in innovation.

Second is when the cutting-edge technology is transferred ($\theta < \theta^*$), both the licensor and the licensee possess the same technology. The licensee's expected R&D cost given the licensor's probability to innovate is $k_l^* = \sigma^*\frac{V}{2} + (1 - \sigma^*)V$, which yields a probability to innovate of the licensee equal to $\beta^* = G(k_l^*) = \frac{1}{\gamma} [1 - \frac{\sigma^*}{2}]$. Applying symmetry, we can derive the following results, $\sigma^* = \beta^* = \frac{2}{1+2\gamma} = p$ and $k_l^* = k_L^* = k^* = \frac{2\gamma}{1+2\gamma}V$. The licensor's and licensee's critical values of R&D costs and probabilities to invest in the innovations are, then equal. Expected social welfare in the R&D stage with cutting-edge technology licensing is³³

$$W^C = [1 - (1 - p)^2]V - 2 \int_0^{k^*} x dG = \frac{4\gamma V}{(2\gamma + 1)^2} \quad (27)$$

Thus, the following lemma can be stated:

Lemma 2 I) $\widetilde{W}^C > W^S$ if $\gamma > \frac{1+\sqrt{3}}{2}$. II) $\widetilde{W}^C < W^C$, $\forall \gamma > 1$

³⁰This is equivalent to equation 18 in Choi (2002) which can be found the detail in Appendix II.

³¹ $[1 - (1 - \tilde{\beta}^*)(1 - \tilde{\sigma}^*)] < [1 - (1 - \tilde{\beta}^*)(1 - \bar{\sigma}^*)]$ because $\tilde{\sigma}^* < \bar{\sigma}^*$.

³² $\sigma = G(k) = \frac{k}{\gamma V}$, $k^* = V \Rightarrow \sigma^* = \frac{1}{\gamma}$

³³This is similar to equation 20 in Choi (2002).

The choice of technology type depends upon the difficulty of R&D activity. The intuition comes from duality between the *benefits of parallel research activities* vs. the *excessive cost of R&D duplication*. The parallel research adds (one) more R&D lab into R&D race in turn increases probability of discovery which may benefit social welfare. These activities are possible as a result of cutting-edge technological transfers. However, allowing one more research lab increases R&D cost. These trade-off between duplication cost and parallel research will be balanced at a specific critical value γ^* . The transfer of cutting-edge technology will improve welfare in the follow-on innovation market if the innovation is difficult (or R&D efficacy is low) i.e. $\gamma > \gamma^*$. The positive effect of parallel research activities dominates the negative effect of duplication in R&D cost, which improves welfare. On the other hand, when innovation is rather easy, $\gamma < \gamma^*$, adding more research labs is unnecessary. In this case, the negative effect of excessive R&D cost dominates the positive one from R&D diversification. Thus, it turns out that concentrated innovation activity with only one licensor lab is preferable.

With a reciprocal grantback, we separate the analysis into two cases. First, $\widetilde{W}^C > W^S$ if $\gamma > \widetilde{\gamma}^* = \frac{1+\sqrt{3}}{2} \approx 1.366$. Thus, for $\gamma < \frac{1+\sqrt{3}}{2}$, welfare in the R&D stage is higher by licensing a standard technology than licensing a cutting-edge technology that includes a reciprocal grantback clause. In this case, licensing a standard technology is better because the positive effect from parallel research labs is relatively small and outweighed by the benefit from saving the excessive R&D duplication cost when R&D is easy.

The second case shows that \widetilde{W}^C is unambiguously *less* than W^C . Since transfer of cutting-edge technology is unconditional to inclusion of grantback clauses, there will be no efficiency gains from including them. At the same time the reciprocal grantbacks reduce R&D incentive due to free-riding and the associated appropriability problems. No firms can fully appropriate the innovation which implies that they will reduce their R&D efforts and wait to extract partner's success. Each firms has less incentive to innovate. The final consequence is the benefit from parallel research activities diminishes and then welfare is lower than the one without grantbacks. These results are displayed in figure 2(b).

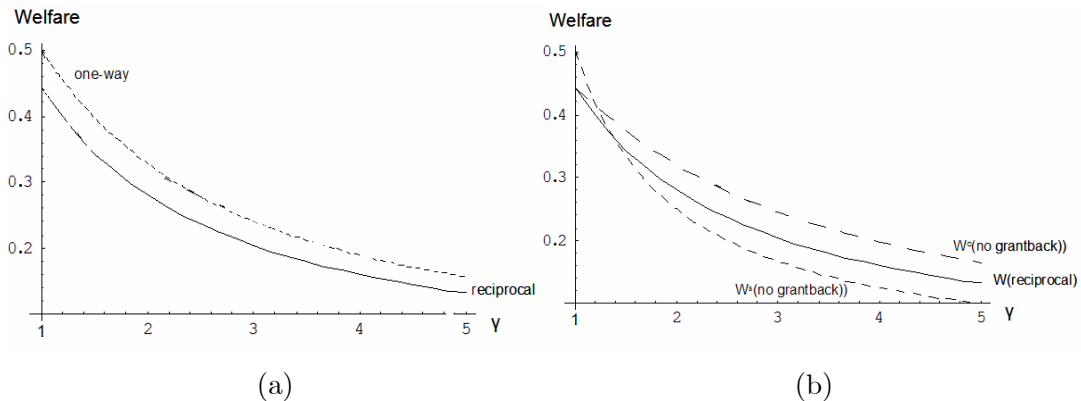


Figure 2: Welfares at the R&D Stage under different schemes of grantback clauses and different types of transferred technology.

Combining the results found earlier in the licensing decision section and R&D stage welfare analysis, we can derive the next proposition:

Proposition 2 *If $\theta > \theta^*$, the inclusion of a reciprocal grantback clause helps promote a cutting-edge technology transfer and enhances welfare when R&D is sufficiently difficult ($\gamma > \gamma^* \approx \frac{1+\sqrt{3}}{2}$). However, when $\theta < \theta^*$, the inclusion of a reciprocal grantback is irrelevant to promote a cutting-edge technology transfer and also reduce welfare.*

The proposition states an important policy implication that can be elaborated as follows. If the licensee's probability of leapfrogging is low ($\theta < \theta^*$), the licensor is less reluctant to license out his cutting-edge technology. The cutting-edge technology is voluntarily transferred unconditional on an inclusion of a grantback clause. Incorporate a reciprocal grantback clause in licensing contract would deter both licensee and licensor's innovation incentives, then decrease welfare. Thus, the social planner as well as the licensor do not prefer inclusion of a reciprocal grantback clause.

On the contrary, in a market where the probability of leapfrogging is high ($\theta > \theta^*$), the licensor has low incentive to transfer his best technology. In order to encourage the transfer of high quality technology, the reciprocal grantbacks should be included "if" R&D is sufficiently difficult, i.e. $\gamma > \gamma^*$. In this case the grantback clause helps to increase the benefit of parallel research activities. However, when innovation is rather simple, an excessive innovation investment should be prevented which implies that only one lab is needed and the standard technology licensing will be chosen with no grantback clauses.

Also the ICC must be satisfied³⁴ ³⁵ with the lowest royalty rate using the reciprocal grantbacks. In order to confirm this finding, the analysis is as follows.

When the licensor transfers the cutting-edge technology, both licensor and licensee are able to innovate i.e. $\tilde{\sigma}$ and $\tilde{\beta} > 0$. The overall probability of discovery equals $\tilde{\sigma}\tilde{\beta} + \tilde{\sigma}(1 - \tilde{\beta}) + (1 - \tilde{\sigma})\tilde{\beta}$. If the standard technology is transferred then $\tilde{\beta} = 0$, and overall probability of discovery becomes $\tilde{\sigma}$. Hence, the licensor's expected returns are defined as

$$\tilde{\phi}_L^S = V_L[\tilde{\sigma}] - \int_0^{\tilde{k}_L^*} x dG \quad (28)$$

$$\tilde{\phi}_L^C = V_L[\tilde{\sigma}\tilde{\beta} + \tilde{\sigma}(1 - \tilde{\beta}) + (1 - \tilde{\sigma})\tilde{\beta}] - \int_0^{\tilde{k}_L^*} x dG \quad (29)$$

It is very easy to show that $\tilde{\phi}_L^C > \tilde{\phi}_L^S$ for $\gamma \in [0, \infty)$.³⁶ The cutting-edge technology is transferred with zero royalty rate for all positive values of γ . We can conclude that when a reciprocal grantback clause is part of the contract, transfers of the cutting-edge

³⁴Without any grantbacks, the expected returns for the licensor depend on type of the transferred technology. The expected returns for standard technology transfer is $\phi_L^S = W^S$. When cutting-edge technology is transferred, both firms share equal rents, so $\phi_L^C = \frac{1}{2}W^C$. Substituting the values of W^S and W^C obtained in the R&D stage, we get $\phi_L^S > \phi_L^C$. The contract needs a positive royalty rate to satisfy ICC.

³⁵For one-way grantback, the expected return for licensor can be found in the Appendix section of Choi (2002).

³⁶ $\tilde{\phi}_L^S - \tilde{\phi}_L^C = V_L[-\tilde{\beta} + \tilde{\sigma}\tilde{\beta}] < 0$

technology dominate transfers of the standard one. This finding is different from the model of one-way grantback, which shows that there is a positive interval of $1 < \gamma < \bar{\gamma}$ where a transfer of standard technology is preferred.³⁷ With the reciprocal grantback clause, the range for zero royalty rate is wider and transfer cutting-edge technology is more common with the reciprocal grantback clause.

4.2.4 Full Welfare Analysis

The full welfare that incorporates current market producer and consumers' surpluses will be the focus in this section. The social planner has control over the type and inclusion of grantback clause, but not the R&D decision, the licensing or other aspects of the contract.

The total profit for the licensor can be expressed as the total producer's surpluses PS^C and PS^S for cutting-edge and standard technology transfers without grantbacks, respectively. The licensor has 4 choices as follows: standard technology transfer without grantback, cutting-edge technology transfer without grantback, cutting-edge technology transfer with one-way grantback and cutting-edge technology transfer with reciprocal grantback. From proposition 2, the royalty rate (r) can be identified as a function of the R&D difficulty, γ . With a transfer of standard technology, the producer's surplus is $PS^S(\gamma) = \pi_L + \pi_l [c_1] + W^S$. With a transfer of cutting-edge technology, the producer's surplus of all cases are in Table 3.

Table 3: producer's surplus with a Transfer of Cutting-edge Technology

Without any grantback clauses	$PS^C(\gamma) = \pi_L + r^*(\gamma) * q_l [c_0 + r^*(\gamma)] + \pi_l [c_0 + r^*(\gamma)] + W^C$
One-way grantback, with $\bar{r} < r^*$	$\overline{PS}^C(\gamma) = \pi_L + \bar{r}(\gamma) * q_l [c_0 + \bar{r}(\gamma)] + \pi_l [c_0 + \bar{r}(\gamma)] + \overline{W}^C$
Reciprocal grantback	$\widetilde{PS}^C(\gamma) = \pi_L + \pi_l [c_0] + \widetilde{W}^C$

π_L is the same for all cases, so it is irrelevant. Comparison of the producer surpluses of all possible cases give us the following results:

Lemma 3 $\widetilde{PS}^C(\gamma) > PS^S$ when R&D is rather difficult. However when R&D is rather easy, $\overline{PS}^C(\gamma) > PS^S$ if the licensee's current market must be sufficiently large.

Proof. (γ) For $\gamma > \gamma^* \approx \frac{1+\sqrt{3}}{2}$, $\widetilde{W}^C > W^S$ and $\pi_l [c_0] > \pi_l [c_1]$. It is obvious that $\widetilde{PS}^C(\gamma) - PS^S(\gamma) = \pi_l [c_1] + W^S - \pi_l [c_0] - \widetilde{W}^C > 0$. For $\gamma < \frac{1+\sqrt{3}}{2}$, $\overline{PS}^C(\gamma) > PS^S(\gamma)$ if $\pi_l [c_0] - \pi_l [c_1] > W^S - W^S$. These conditions imply current market size is larger than the expected future market. ■

Lemma 4 $\overline{PS}^C > \overline{PS}^C$ and $\widetilde{PS}^C > PS^C$ if the licensee's current market is sufficiently large.

Proof. From Lemma 1 and Lemma 2 II, we know that $\widetilde{W}^C < \overline{W}^C$ and $\widetilde{W}^C < W^C$. However with positive royalty rate $\bar{r}(\gamma)$ and r^* where $r^* > \bar{r}(\gamma)$, we have $\pi_l [c_0] > \pi_l [c_0 + \bar{r}(\gamma)] +$

³⁷When R&D is easy (the value of γ is relatively low), the licensor realises that benefits from diversification of research activities are less important. Thus, the licensor will opt to transfer a standard technology.

$\bar{r}(\gamma) * q_l [c_0 + \bar{r}(\gamma)] > \pi_l [c_0 + r^*(\gamma)] + r^*(\gamma) * q_l [c_0 + r^*(\gamma)]$. In order to get $\widetilde{PS}^C > \overline{PS}^C$, we must have $\pi_l [c_0] - [\bar{r}(\gamma) * q_l(\cdot) + \pi_l(\cdot)] > \overline{W}^C - \widetilde{W}^C$.

Also, in order to have $\widetilde{PS}^C > PS^C$, we must have $\pi_l [c_0] - [r^*(\gamma) * q_l(\cdot) + \pi_l(\cdot)] > W^C - \widetilde{W}^C$. These conditions imply that licensee's current market is sufficiently large. ■

Lemma 5 *The licensor transfers the cutting-edge technology and incorporates a reciprocal grantback clause in the contract when the licensee's current market is sufficiently large,*

Proof. From lemma 3 and 4. ■

The licensor must evaluate the trade-off between the rents from the current (licensing incomes) and the potential of the future market when he designs the licensing contract. The licensor chooses to license out the cutting-edge technology and requires a reciprocal grantback clause when we expect that the current market is sufficiently large. The large current market size will compensate for the expected loss in the future market. In this case, the licensor allows the licensee to produce his output at most efficient level at the lowest marginal cost (c_0). By doing so, the licensor receives higher licensing income by setting the optimal up-front fixed fee at $\pi_l [c_0] + \widetilde{\phi}_l^C$.

Let assume that the social planner focuses on consumer's surplus (CS).³⁸ Let $CS^T(c)$ denote consumer's surplus in the current market where $\frac{\partial CS}{\partial c} < 0$.³⁹ The comparison of consumers' surpluses under different condition is according to lemma 6.

Lemma 6 $CS^S(c_1) < CS^C(c_0 + r^*(\gamma)) < \overline{CS}^C(c_0 + \bar{r}(\gamma)) < \widetilde{CS}^C(c_0)$.

Proof. We know that $r^*(\gamma) > \bar{r}(\gamma) > 0$. Also for IRC to be binding, $c_0 + r^*(\gamma) < c_1$. Then we can say that $(c_1) < (c_0 + r^*(\gamma)) < (c_0 + \bar{r}(\gamma)) < (c_0)$. Since $\frac{\partial CS}{\partial c} < 0$, we can conclude that $CS^S < CS^C < \overline{CS}^C < \widetilde{CS}^C$. ■

We know that both one-way and reciprocal grantbacks relax the ICC and lower the licensee's effective marginal cost. So, grantback clause positively affects current market consumer's surplus. Hence, $\widetilde{CS}^C(c_0)$ is the highest among the four alternatives.

When the licensor voluntarily transfers a cutting-edge technology unconditional on grantbacks,⁴⁰ the licensor would like to include grantback clause in the contract because it allows the licensor to reap the licensee's rent. The licensor will choose the grantback clause type which gives him the highest producer's surplus. At the same time, the social planner shall protect the consumers's surplus at the highest by requires the reciprocal grantback clause. If the current market is sufficiently large and the expected licensing revenue outweighs the expected future loss, then the social planner and private licensor will incline to choose the reciprocal grantback clause. Under other circumstances, however, it is likely that the licensor may choose one-way grantback clause since it allows the licensor

³⁸The government competition authorities's main objective is to encourages companies and markets to operate to the benefit of consumers and efficient businesses. However, when comes to the trade-off between consumers and businesses, the government will focus more on the benefit of consumers.

³⁹This is a general assumption. The lower the marginal cost, the more output produced in the market. Then consumer surplus is higher.

⁴⁰when $PS_S^C(\gamma) > PS_S^S(\gamma)$. This situation may arise when probability of leapfrogging is low (low value of θ) or R&D is relatively difficult (high value of γ).

to reap the licensee's rent without sharing anything. The concern is whether the social planner should require the licensor to use a reciprocal grantback clause instead. With the reciprocal grantback clause, the private licensor fully internalizes the reduction in innovation incentives, so the licensor may choose not to include any grantback clause then charge higher royalty rate instead which then harmful for consumers even more than allowing one-way grantback clause.

When a transfer of cutting-edge technology is conditional on grantbacks,⁴¹ the high positive royalty rate is needed to encourage the licensor to transfer the cutting-edge technology to the licensee. In this case, the social planner should allow grantback clause since it helps to reduce the royalty rate and benefit consumers. With the one-way grantback clause, the social planner must keep the optimal royalty rate for one-way grantbacks (\bar{r}) as sufficient low as $\bar{r} < c_1 - c_0$, so that the grantback would be socially beneficial and thus permitted. Otherwise, prohibition of the one-way grantback clause can be welfare improving. The anti-competitive effect in this case stems from the fact that the product market price with the cutting-edge technology is too high⁴², but not due to deterioration of innovation incentives.⁴³ The social planner in this case would prefer the reciprocal over the one-way grantbacks since the minimum royalty rate is zero with the reciprocal grantback in turns provide more benefit for consumers.

The bottom line is that consumer and producer's surpluses are sensitive to the inclusion and also the type of grantback clause. The social planner should evaluate each particular markets characteristic very carefully. Permission of an appropriate type of grantback clause will provide a positive benefit to both consumers and firms. But allowing only a specific type of grantbacks and then apply it to all markets similarly may be harmful to both consumers and firms because this specific type may not be the correct type for that particular market.

To summarize section 4.2, the main findings are: first, the reciprocal grantback restores market output efficiency since the product distorted royalty rate is optimal at zero. Second, the grantback clause facilitates the cutting-edge technology transfer and improves welfare when the probability of leapfrogging is high and R&D is difficult. The reciprocal grantback clause enables R&D diversification which enhances the potential of the society to discover a new technology. Finally, the evaluation of the inclusion and type of grantback clause is very sensitive. The results may be varied based on specific market environment. This implies that the permission of grantback clauses should be reviewed case by case.

⁴¹ $PS_S^S(\gamma) > PS_S^C(\gamma)$. This situation may arise when probability of leapfrogging is high (high value of θ) or R&D is relatively easy (low value of γ).

⁴² If effective cost with cutting-edge technology is higher than the one of standard technology. Then consumers become worse off with the inclusion of grantbacks.

⁴³ Choi explains in his study that in this case the competition in R&D is actually intensified with grantbacks. He concludes it is misled to say that that grantbacks are harmful due to innovation slowdown.

5 Conclusion

In this paper, the licensing contract with grantback clause is analyzed under the environment that the type of a transferred technology is nonverifiable. The incomplete contract approach which accounted for both incompleteness and dynamic effects of licensing on innovation competition is applied. The aim of this paper is to apply the economic theories of licensing and innovation to evaluate the regulations regarding technology licensing and the results toward innovations. The model allows us to analyse the inclusion of grantback clauses and its links to innovation incentives as well as the licensing decision. The intuitive results of this paper are based on the dualities that represent the complex relationships behind the story.

The findings of this paper are that: nonverifiability and moral hazard problems can be solved by incorporating the reciprocal grantback clause in the licensing contract. The output production of a current technology is more efficient with the reciprocal grantback clause due to the zero optimal royalty rate. Even though the reciprocal grantback clause slows down innovation pace, it improves welfare at the R&D stage when a transfer of advanced technology is conditional on the grantback and the accomplishment of new innovation is rather difficult. This result depend on the positive benefits of parallel research activities versus the negative result from excessive cost of R&D duplication. The results obtained at the total welfare stage are varied depends upon market characteristics which is difficult to be clearly observed. Hences, the inclusion of grantback clauses should be reviewed case by case based on the rule of reason rather than applying the specific "per se" requirements to all industry.

There are some possible extensions for this paper. It is very interesting to relax some of assumptions for example allow non-exclusive licensing. It is also possible to allow more a competition in the current market between the licensor and many potential licensees in which the licensing scheme would be different or the licensee may possess some bargaining power. Another possible extension is to study a non-drastic innovation instead of a drastic one which may provide another interesting story.

Appendix I
Licensing with Complete Contract⁴⁴

Referring to all notions, we have expected payoffs in a second period for the licensor and the licensee with cutting-edge technology respectively as follows:

$$\phi_L^C = (1 - \theta)V \text{ and } \phi_I^C = \theta V.$$

With standard technology:

$$\phi_L^S = V \text{ and } \phi_I^S = 0.$$

Under a complete contract, the type of technology transferred can be verified. Then the contract can effectively specify the type of technology. The optimal contract can be specified with a licensing fixed fee (F_S^T) and a royalty rate (r). The royalty revenues with cutting-edge and standard technology are

$$R_L^C(r) = rq(c_0 + r) \text{ and } R_L^S(r) = rq(c_1 + r)$$

The licensor can optimally set the fixed fee to extract all possible economic rents that the licensee expects to get. Thus, $F^C = \pi(c_0 + r) + \theta V$. When cutting-edge technology is licensed, the licensor's total payoffs are

$$\Pi^C = R^C(r) + F^C + \phi_L^C = rq(c_0 + r) + \pi(c_0 + r) + V \quad (\text{A1})$$

By the envelope theorem, we know that $\frac{d[rq(c_0+r)+\pi(c_0+r)]}{dr} = rq'(c_0 + r) < 0$. Then, the optimal royalty rate (r) is zero. With a complete contract, the licensor can set a higher optimal fixed fee to extract all the licensee's gains when he licenses his best technology, hence the royalty rate is not necessary. Also by applying only a fixed fee, there is less "production distortion". The loss of competitive advantage by licensing the best technology is offset by the higher fixed fee. For this reason, the payoff for the licensor when cutting-edge technology is licensed is given by

$$\Pi^C = \pi(c_0) + V \quad (\text{A2})$$

Then the fixed cost for licensing standard technology is $F^S = \pi(c_1) + V$. The total payoff for licensing standard technology $\Pi^S = F^S + \phi_I^S$, which is

$$\Pi^S = \pi(c_1) + V \quad (\text{A3})$$

⁴⁴This section is summarised from Choi (2002) page 810-811, with adjusted notations in order to match the notations in previous sections.

Appendix II

Welfare Prior to R&D Stage

A) Note for equation 25: Given $G(x) = \frac{x}{\gamma V}$. So, $x = G(x) * \gamma V$. Hence $\int_0^k x dG = \int_0^k G(x) * \gamma V dG. \implies \gamma V \int_0^k G(x) * \gamma V dG. \implies \gamma V \frac{G^2}{2} \implies \frac{\gamma V}{2} (\frac{x}{\gamma V})^2 \implies \frac{x^2}{2\gamma V}$

B) Derivation of the welfare with one-way grantbacks: the licensee's critical values of innovation cost with the reciprocal grantback are $\bar{k}_l^* = \frac{V}{2}$ and the licensor's is $\bar{k}_L^* = (1 - \bar{\beta})V$. Given $G(x) = \frac{x}{\gamma V}$, the licensee's probability to invest in R&D is $\bar{\beta}^* = G(\bar{k}_l^*) = \frac{1}{2\gamma}$. Also, the licensor's probability is $\bar{\sigma}^* = G(\bar{k}_L^*) = \frac{(2\gamma-1)}{2\gamma^2}$.

The welfare prior to R&D comprised of two component. The *first* component is the *expected value of innovation* which is the product of the probability of discovering new innovation and a innovation market value (V). The *second* component is the *expected innovation costs*. Hence,

$$\begin{aligned} \widetilde{W}^C &= \overbrace{[1 - (1 - \bar{\beta}^*)(1 - \bar{\sigma}^*)]V}^{\text{First}} - \overbrace{\int_0^{\bar{k}_l^*} x dG - \int_0^{\bar{k}_L^*} x dG}^{\text{second}} \\ &= [\frac{1}{2\gamma} + \frac{(\gamma - 1)(3\gamma - 1)}{8\gamma^3}]V. \end{aligned} \tag{30}$$

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