Grantbacks, Territorial Restraints and the Type of Follow-On Innovation: The "But for..." Defence

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Abstract

We analyse the effect of grant-back clauses in licensing contracts. Because they require the licensee to "give back" further innovation to the licensor without cpompensation of for a compensation that is not linked to the value of the follow-on innovation, grantback clauses decrease the licensee's ex post incentives to innovate, which is why competition authorities have expressed some concerns. The usual defence is that grantback clauses are required for the patent-owner to agree to license its technology: since familiarity with the technology increases the licensee's ability to further innovate and improve on the original technology, the initial patent-holder might prefer not to license in the first place as follow-on innovation might make its own technology obsolete. We examine the validity of this "but for" defence. Under current EU Law, grant-back clauses that apply to "non-severable" (read "infringing") innovations are considered to be innocuous while clauses that apply to "severable" innovations are much more likely to be frowned upon. We show that the current rule is questionable. In fact, grantback clauses do not increase the patent-holder's incentives to license when non-severable innovations are at stake but they do when severable innovations are concerned – suggesting that the "but for" defence might be valid for severable innovations but not foe non-severable ones.. These results are obtained under the assumption that licensing contracts can legally contain territorial restrictions between the market served by the licensor and the market served by the licensee. We revisit the analysis under the alternative assumption that such territorial restraints cannot be enforced. For non-severable innovations, licensing of the basic technology still occurs both with and withoiu a grantback clause. However, the owner of the basic technology is now strictly better off with a grant-back clause, while the licensee is worse off. With severable innovations, licensing can only occur without a grantback clause and provided that barriers

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to trade are sufficiently high. For parameters such that licensing occurs, the owner of the basic technology would actually strictly prefer not to use a grantback clause in the licensing contract. This further undernines the traditional “but for” defence and suggests a form of complementsarity between territorial restraints and grantbacks.

Key words: licensor and licensee; severable and non-severable innovation; licensing contract; grant-back clause; Nash bargaining solution.
JEL classification: **,K21, L24, O31.**

1 Introduction

Patent-holders are not always best placed to exploit their own technology in the market . In particular, while the patent-holder might be quite competitive within its home market, it might not have the necessary local expertise to perform well in other geographic markets. When local expertise matters much, it is common for patent-holders to license their technology to a local firm and earn revenues from royalty payments. Indeed, Zuniga and Guellec (2009) find that, in a recent survey of the European Union and Japan conducted in the second half of 2007, 20% of firms in Europe and 27% in Japan grant license to non-affiliated entities. Such licensing is generally seen as welfare increasing both because it ensures that local production is done efficiently and because it ensures that the technology diffuses to several markets as well as to severall firms.

Licensing contracts can be quite complex as they often involve non-linear royalty schemes, territotial restrictions, transfer of related know-how and additional clauses such as termination clauses and grantback clauses. The focus of this paper is on grantback clauses. These clauses specify that any innovation by the licensee that relates to the licensed technology must be given back to the original licensor. Such causes are not unusual. For example, Cockburn (2007) finds that 43% of licensing contracts contain grant-back clauses. Interestingly, Moreira et al. (2012), find that grantbacks tend to be more commonly-used in licensing contracts between firms that are in the same product market and are familiar with the relevant technologies.

Despite the widespread use of grantbacks, their legal status has remained unclear.[4] The basic concern is that, by depriving licensee from a reward that is conditional on their further innovation, grantback clauses are liable to decrease their incentives to engage into further related research. Under current European Union rules, however, the seriousness of this concern depends on the nature of the licensee's innovation. More precisely, grantbacks involving *severable* innovation – innovations that can be used without infringing upon the

[4] In the US, the Transwarp case established that the provision of grantbacks was not *per se* illegal. In subsequent cases, it was similarly judged that grantbacks were not necessarily inconsistent with competition policies unless they were part of a more general pattern of anticompetitive behaviors. See Régibeau-Rockett (2011) for a more extensive review.

licensed technology – are viewed as more harmful than those that apply to *non*-severable innovations, especially when the grantbacks are exclusive.[5] There is however no well-articulated economics rationale for this position. The usual defence of grantback clauses is what one can call the "but for" argument: if it were not for grantback clauses, the patent-holder would prefer not to license rather than take the risk that the licensee might come up with improvements that would make the basic technology obsolete. Since grant-back clauses would tend to decrease the innovation incentives of licensees for both the severable and non-severable innovation cases, it seems that any difference in treatment should then be justified by how effective this "but for" argument is in each of the two cases. This is the main question that we investigate.

Our results question the current anitrust treatment of grantback clauses. We find that when we consider a licensing contract with a single licensee, the "but for..." argument is actually stronger for severable innovation than for non-severable innovation suggesting that, contrary to current practice, grantback of severable innovations might need to be treated more leniently than those involving non-seversable innovations. The intuition for this result is straightforward. Because non-severable innovations cannot be used without a license for the basic technology, the territorial restrictions that were part of the initial licensing contract still apply and the licensor can factor in the effects of such innovation into the terms of the initial licensing contract. By contrast, severable innovation essentially renders the initial licensing contract ineffective and leaves the licensor at the merci of the licensee. Overall, then, since grantback clauses do reduce the incentives to innovate of the licensee, such clauses are harmful when applied to non-severable innovations but might be justified for severable innovations.

As just mentioned, territorial restrictions are an important factor in explaining why the "but for" defence does not apply to the case of non-severable innovation. It therefore makes sense to ask how our conclusions would change if such territorial restrictions could not be be legally enforced. Not only does such an analysis help us understand the relationship between grantback clauses and territotial restrictions in licensing contracts, it is also of direct policy relevance as the European Commission is considering taking a tougher stance on territorial restraints**.** In particular we find that, for severable innovations, the original

[5] In contrast to *severable* innovation, *non-severable* innovation is defined such that it cannot be exploited by a licensee without a licensor's permission.

licensor might actually be better off without a grantback clause. Intuitively, a licensing agreement with a grantback clause only involves a single royalty: the payment from the licensee to the licensor agreed to in the initial licensing agreement. By contrast, an initial licensing contract without grant-back ends up giving rise to two royalty payments: one from the licensee to the original licensor and then one from the innovating licensor to the innovating licensee. These two royalties allow the firm to "segment" the two markets much more effectively so that competition between the two firms does not erode profits. In that sense then, for severable innovation at least, grantback clauses and territorial restrictions are complements. For non-severable innovation, licensing of the basic technology still occurs regardless of whether or not a grantback clause is used. However, in contrast to the situation with territorial restraints, the owner of the basic technology is strictly better off with a grant-back clause. This actually suggest a form of substitutibility between grantback clauses and territorial restraints.

There is not much economics literature on grantback clauses. Moreover, the focus of the few existing papers is quite different from our own. Van Dijk (2000) argues that the use of grant-back clauses can be socially desirable because precisely because they are likely to slow down the rate of innovation and there might be socially excessive incentives to innovate. While correct, this analysis is difficult to square with the fact that, although excessive innovation is theoretically possible, policy makers seem mostly concerned with encouraging further innovation. Indeed, as we have seen, antitrus authorities appear to equate a decrease in the licensee's incentive to innovate with social harm[6].

Choi (2002) takes a very different perspective, asking whether there are conditions under which grantback clauses would make licensing contracts more efficient. Like us, he proposes model where a licensor faces the risk that a licensee might use a transferred technology to make the original technology obsolete. However, Choi's focus is on the role of asymmetric information: whether a licensee could or not innovate is only known to the licensee. In this framework, grantbacks help to ensure that a licensor still has an incentive to transfer the best technology at a lower royalty rate than it would charge without grantbacks. As mentioned earlier, grant-back clauses are often observed between firms that are familiar with the relevant technologies, which suggest that the type of asymmetric information that

[6] Ambashi (2013) examines the over incentive problem in the context of technology competition and cumulative innovation. This study focuses on the role of a grantback that can make the investment in first innovation more close to the socially optimal level.

drives Choi's analysis might not always be a significant factor, especially when licensing takes place between equally sophisticated entities. It seems therefore useful to study the potential efficiency effects of grantbacks in a framework that does not involve any such asymmetric information. In a sense then our analysis is complementary to Choi's. One might think that the kind of effects that we study might be more important in the markets of developped economices, while the adverse selection mechanism emphasised by Choi would be of greater importance when firms from developped economies license their technology to local LDC companies.

The rest of this paper is organized as follows. Section 2 outlines the model structure in the multistage game. Section 3 examines the case of a single licensee according to the attributes of innovation. In section 4, we re-examine the effects of grantback clauses when territorial restraints cannot be imposed. Section 5 extends the model to the case of two heterogeneous licensees. Section 6 concludes followed by a full reference and appendix.

2 Model structure

A licensor (denoted by firm L) has patents covering a basic technology (denoted by BT). There are two markets: the patent-holder's home market and a foreign market. In each market the demand for the product that can be manufactured thanks to the technology has a perfectly inelastic demand curve: all consumers have a reservation price equal to 1 and there is a mass 1 of consumers.[7] The patent-holder can serve his home market at no cost. By contrast, serving the foreign market involves a per unit cost requal to $c > 0$. We will refer to this cost as the level of "trade barriers". This covers both actual trade barriers such as transportation costs or tariffs and any other advantage that might accrue to the local firm. It follows immediately that a patent-holder commercialising his own technology in both markets would earn total profits equal to $2 - c$. Alternatively, the patent-holder could serve his home market himself but license a local firm – called firm A – to serve the foreign market. If each firm can be sure to enjoy exclusive use of the technology in its respective market, then the joint surplus that they can obtain is equal to 2. Licensing therefore leads to an increaase in joint surplus equal to the efficiency gain c]. It is straightforward to check that if the licensor and licensee bargain over a per unit royalty r, the solution of the corresponding

[7] We have also solved the model for asymmetric market size with a mass of consumers m in the licensee's market. This does not affect the nature of the results.

Nash Bargaining solution splits this increase in surplus evenly between the two parties, i.e. $r = c/2$.

The rest of the model is set up to investigate the properties of the optimal licensing contract when territorial restraints and further innovation by the licensee are considered. For now, we will assume, as above, that the licensing contract specifies that the licensor is the only firm authorised to sell an infringing product in its home-market while the licensee is given exclusivity in its own market. This assumption seems justified both by actual practice and the current state of the Law. Bleeke and Rahl (1979), for example, observe that the vast majority of firms include some form of territorial restrictions in licensing contracts.[8] From a legal perspective, territorial restrictions in licensing contracts are usually allowed in the US, Europe, and Japan.[9]

Because grant-back clauses are often justified as a way of protecting the licensor from the harmful consequences of follow-up innovation by the licensee, we ignore further research efforts by the patent-holder and focus our attention on the innovation activities of the licensee. In order to focus on the "but for" defence of grant-back clauses, we also ignore the licensee's own incentibves to innovate: the harmful effect of grant-back clauses on these incentives is simply taken as given. The key assumption of the "but for" defence is that the very fact that firm A receives a licence for the basic technology and does therefore get to practice this technology increases the probability that it might come up with *improvements* to this technology. We push this to the extreme by assuming that firm A cannot innovate in the absence of a license but innovates with certainty and immediately if a license is granted. The certainty of innovation and its immediacy are both designed to "load the dice" in favour of grantback clauses by maximising the potential damage that the licensor might suffer from the licensee's innovation.

If it receives a license for the basic technology, firm A innovates. This innovation improves the consumers' willingness to pay from 1 to $1 + \theta$, where $\theta \geq 0$. The innovation can be of two types. If the improved technology can be implemented without infringing the initial BT

[8] Bleeke and Rahl (1979) draw a conclusion that "The response to this question strongly indicates that most corporations are not willing to compensate for the absence of restrictive [territorial] provisions by charging a higher royalty rate." We can understand that, where patents are present, territorial restrictions could be sought as a prerequisite to licensing contracts.

[9] See the summary of Delrahim (2004) who describes the positions of the US and EU.

patent, then the innovation will be referred to as "severable". If, on the other hand, the improvement can only be used in conjunction with the BT and hence requires a license for the BT before it can be implemented, then we will say that the innovation is "non-severable". This is the terminology used by antitrust authorities. When an innovation is severable, firm A can sell the product of quality $1+\theta$, without relying on the basic technology transferred from firm the licensor. This also means that A no longer owes any royalty payment to the owner of the BT patents. On the other hand, when the innovation is non-severalbe, the improved technology (IT) cannot be applied without infringing upon BT. Hence, the licensing contract is still fully effective and firm A still owes a royalty payment to the licensor.
For most of our analysis, we will focus on the case where $c<1$, so that "barriers to trade"are not prohibitive even in the absence of follow-on innovation. At times, howevr, we will also investigate the situation where the follow-on innovation makes it possible to overcome what were prohibitive barriers, i.e. $1 \leq c < 1+\theta$.

The licensing game is structured ast follows. In Stage 1, the licensor decides whether or not to enter into a licensing contract with firm A. In that stage, the licensor also decides whether or not the contract should include a grantback clause. A grant-back clause simply specifies that the improved technology developped by the licensee must be made available to the licensor. More precisely, under our assumptions about territorial restrictions, the licensee is still free to use its improvement in its own market but the licensor is free to use it in his own home market. Critically, we assume that the grantback clause does not specify any payment from the licensor in exchange for the improved technology. More precisely, what matters is that the parties cannot agree any payment that is conditional on the development of the follow-on innovation and its effective transfer. This reflects the fact that the parties would find it difficult to specify a payment that would depend on the yet unknown – and hard to verify – "quality" of the licensee's future improvement.

If the patent-holder decides to offer a licensing contract with or without grantback, then, in stage 2, the two parties negotiate the terms of the licensing contract, i.e. the per unit royalty r_1 that firm A commits to pay to the licensor for as long as it uses his basic technology. Once the licensing agreement is reached, then, in stage 3, firm A innovates. We assume that the additional value created by the innovation is θ and that whether or not this innovation would be severable is already known to all in stages 1 and two. If the initial contract included a grant-back clause, then the licensor also has access to the improved technology, otherwise, the licensee negotiates with the licensor the terms under which this improved technology

can be made available to him. The outcome of this negotiation is a second royalty r_2 paid by the initial licensor to firm A. Finaly, in stage 4, both firms set prices and profits are realised.

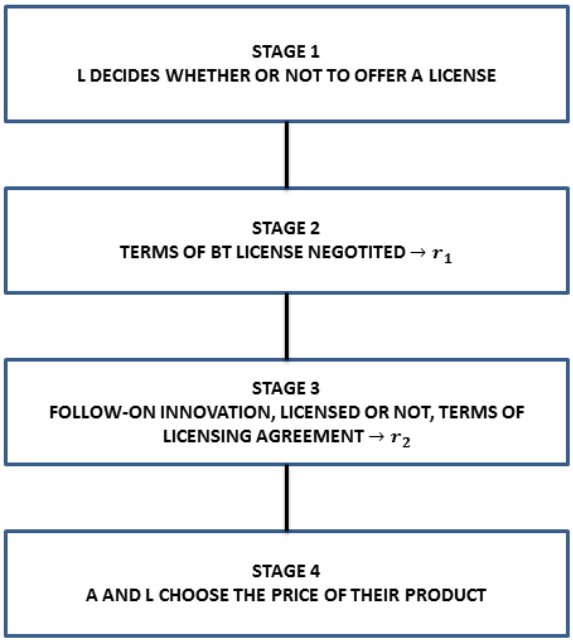

Figure 1 Timing of the game (single licensee)

3 Grant-backclauses with Territorial Restraints

3.1 Non-severable innovation

No Grant-back clause

We first consider the case where the parties agree on a licensing contract without grantback. Assuming that, in stage 1, the licensor decided to license his technology and that, in stage 2, the parties agreed on a royalty rate r_1, we determine the royalty rate, r_2 that is paid by the licensor to firm A in order to get access to the improvement. By purchasing the license of IT, firm L can increase the value of its own market from 1 to $1+\theta$. Hence, we obtain the NBS in Stage 2 by maximizing the following Nash product with respect to r_2:

$$\max_{r_2}[(1+\theta+r_1-r_2)-(1+r_1)][(1+\theta-r_1+r_2)-(1+\theta-r_1)]$$

$$\leftrightarrow \max_{r_2}(\theta-r_2)r_2, \tag{1}$$

Notice that, because a non-severable innovation always infringes upon BT, the royalty, r_1, must still be paid by firm A to firm L. The solution to the bargaining problem is:

$$r_2^{NN}=\frac{\theta}{2}.$$

We can now move back to Stage 2. The equilibrium royalty, r_1 is the solution of the following problem:

$$\max_{r_1}[(1+\theta+r_1-r_2^{NN})-\pi_L^R][(1+\theta-r_1+r_2^{NN})-\pi_A^R] \tag{2}$$

where $\pi_L^R=2-c$ and $\pi_A^R=0$ represent the "reservation" profits of firms L and A when no agreement is reached. Solving this bargaining problem, we get

$$r_1^{NN}=1+\frac{\theta}{2}-\frac{c}{2},$$

So that the patent-owner earns a net royalty equal to $r_1^{NN}-r_2^{NN}=1-\frac{c}{2}$. The equilibrium profits are $\pi_L^{NN}=2+\theta-\frac{c}{2}>\pi_L^R$ and $\pi_A^{NN}=\theta+\frac{c}{2}>\pi_A^R$, respectively. Therefore, tracking back to stage 1, the patent-owner is indeed better off if he decides to license its technology to firm A. The intuition is again simple. Since the benefits from the anticipated innovation by the licensee form part of the expected joint surplus, the licensor's own pay-offs increase with the prospect and size of this innovation. In our setting, the initial negotiation anticipates the outcome of the second negotiation so that the future payment from the licensor to the licensee is incorporated in the initial royalty.

Grant-back clause

The licensing agreement considerd now includes a grant-back clause. This means that firm A can no longer demand a royalty in return for IT in Stage 3. The NBS for the bargaining problem is stage 2 is:

$$\max_{r_1}[(1+\theta+r_1)-(2-c)](1+\theta-r_1)=\max_{r_1}(-1+\theta+c+r_1)(1+\theta-r_1). \qquad (3)$$

This maximisation problem implies

$r_1^{NG}=1-\frac{c}{2}$, which is equivalent to the *net* royalty earned by firm L without grantbacks. This of course means that the profits of firms L and A are exactly as for a license without a grant-back clause, i.e. $\pi_L^{NG}=2+\theta-\frac{c}{2}$ and $\pi_A^{NG}=\theta+\frac{c}{2}$. We can therefore summarise the analysis of non-severable innovation in the following proposition

Proposition 1 (Non-severable innovation,single licensee, no cost of innovation) *) A grant-back clause has no effect on the profits nor on social welfare. The licensee always undertakes the follow-on innovation and the patent-holder always licenses the basic technology.*

Our conclusion should not be surprising. Because the innovation is non-severable, the licensee can only exploit its follow-on innovation in its own territory, whether or not there is a grant-back clause. The only difference is that, in the absence of grantback clause, the licensee can extract its own royalty payment from the initial licensor once the follow-on innovation is obtained. Since this is fully anticipated by both parties, this ex post payment is counted as part of the licensee's share of the total surplus in stage 2 negotiations.

Notice that, because an agreement with no grant-back allows the licensee to receive an additional revenue equal to $\frac{\theta}{2}$ once the follow on innovation is realised, the licensee has incentives to incur costs in order to obtain that innovation. Moreover, these incentives increase with the expected significance of the innovation. There are no such incentives with grant-back. Since the two regimes lead to exactly the same profit levels but the licensee's

incentives to innovate are drastically curtailed by a grant-back clause, we must conclude that *for non-severable innovations, the "but for" defence fails and grant-back clauses are anticompetitive*.

There is one caveat to this conclusion. Because we have assumed that demand is inelastic, the actual level of royalties that firms A and B charge to each other has no effect on consumer welfare. With any degree of elasticity, higher royalties would lead to higher prices. In the absence of grant-back, L's marginal cost in its home market is equal to $r_2 = \frac{\theta}{2}$ while firm A's marginal cost is $r_1^{NN} = 1 + \frac{\theta}{2} - \frac{c}{2}$. With a grant-back clause, L ' s marginal cost is zero and A's marginal cost is $r_1^{NG} = 1 - \frac{c}{2}$. This means that, with elastic demands, a grant-back clause woud improve consumer welfare in both markets. Our analysis does therefore provide some support for a weaker version of the "but for" argument: while a grant-back clause adversely affects the licensee's incentives to innovate, it does lead to lower levels of royaties *in both markets*.

3.2 Severable innovation

In the case of severable innovation, and in the absence of grantback clause, firm L cannot extract any royalty payment from firm A in return for transferring BT in Stage 1. This is because of our stark assumptions that innovation occurs immediately, making BT obsolete and that the royalty payments are linked to the actual use of the innovation. Although firm A uses BT as a tool to innovate, firm A does not actually employ it in production. As discussed earlier on, these assumptions were chosen to bring the "but for" argument in favour of grantback clauses in the sharpest possible relief. Assuming that innovation only occurs after a period of actual use of the basic technology or that part of the royalty payment is independent of the actual use of that technoloy would not modify our qualitative results.

The situation is less clear when the initial agreement actually includes a grant-back clause. One could reasonably take any of two different views. In the first view, the initial agreement that includes the grant-back clause is "wholistic" in the sense that it can also include a royalty still due to firm L even after the licensor's innovation has made the basic technology

obsolete. The view there is that the initial agreement, including the grant-back clause is enforceable as a single package. Alternatively one could argue that, because the follow-on innovation is severable, L simply cannot legally keep collecting royalties on a BT technology that is no longer in use. We believe that this second interpretation is more in line with the spirit of the Law. It also has the advantage of isolating the role of the grantback clause, without linking such a clause to a continued ability to collect royalties on the obsolete BT. We wil therefore retain this interpretation for the rest of the paper. The analysis under the alternative interpretation can be found in Appendix 2.

Finally, we need to make some assumptions about territorial restrictions. Clearly, the territorial restrictions included the initial licensing contract apply to all products that rely on the basic technology. But what happens once the improved technology is obtained? In the absence of grant-back it seems natural to assume that – if A does not license the IT back to L – then A is no longer subject to any territorial restrictions. By contrast, if A chooses to license the IT to L, then it is in both parties' interest to also include territorial restrictions in this new contract. Now consider the situation where the initial agreement contains a grant-back clause. We assume that this agreement, including the territoria restraints that it includes, remins valid even after the follow-on innovation since the follow-on innovation is itself part of the initial contract.

Grantback

If the initial licensing agreement contains a grantback clause, then the situation with severable innovation is indistinguishable from the situation with non-severable innovation: the licensor gets access to the improvement for free and the territorial restrictions remain in place. Hence each firm gets a profit of $1+\theta$ in their respective home markets. With a grantback clause, then, the initisal patent-holder find it optimal to license its basic technology as long as $1+\theta \geq 2-c$, which is equivalent to $\theta \geq 1-c$.

Lemma 1: *If the follow-on innovation is severable and the initial licensing contract includes a grant-back clause then the initial patent-holder finds it optimal to license its basic technology if the size of the follow-on innovation is sufficiently large.*

No Grantback

If firm A gets a license for the basic technology, it can then choose whether to exploit the severable innovation on its own in both markets or whether it prefers to reach a licensing agreement with the BT patent-owner. If such an agreement is reached, it contains the same territorial restrictions as the initial licensing agreement. Whether firm A actually gets a license from the patent-holderdepends on the value of innovation relative to the market entry cost c.

Let us first consider the situation where firm A does not license its improvement to firm L. Firm A stil enjoys a monopoly in its own market: firm L relies on BT and must therefore abide with the territorial restrictions spelled out in that contract. By contrast, firm A is now free to compete in firm L's own market with the improved technology. If the innovation is large, i.e. if $\theta \geq c$, then A would make all sales in L's market by charging a price equal to the value of the improvement θ, giving it a profit in that market equal to $\theta - c$. If the innovation is small, i.e. if $\theta \geq c$, then it is firm L that makes all sales by charging a price equal to $c - \theta$.

If a licensing agreement for the IT is reached, then each firm gets revenues equal to $1 + \theta$ in their respective home markets and A receivess a royalty r_2 from L. If $\theta \geq c$, tage 3 bargaining is then described by the folowing NBS:

$$\max_{r_2}[(1 + \theta - r_2) - 0][(1 + \theta + r_2) - (1 + \theta + \theta - c)]$$

$$= \max_{r_2}(1 + \theta - r_2)(-\theta + c + r_2). \qquad (4)$$

Therefore

$$r_2^{SN} = \theta + \frac{1-c}{2}.$$

Thus, the profits are as follows: $\pi_L^{SN} = \frac{1+c}{2}$, $\pi_A^{SN} = 2\theta + \frac{3-c}{2}$, Stages 1 and 2 are then straightforward. Since whatever royalty would be agreed in stage 2 would never be paid, this stage becomes irrelevant. The only question then is whether the patent-holder would actually want to enter into a licensing agreement on BT that would enable future innovation by the licensee. Since we have just seen that licensing leads to profits for the patent-holder that do not increase with the subsequent innovation one can already guess that the patent-owner will prefer not to license at all: why license if it brings on competition without allowing firm L to share in the benefits of further developments? This intuition is

confirmed by comparing the L profits with and without licensing:

$$\frac{1+c}{2} > Max[2-c, 1]$$

Which cannot be satisfied for $c \leq 1$. So, as long as the barriers between the two markets are not prohibitive, then the patent-owner prefers not to license than license without a grantback clause.

We can now turn to the situation where the improvement in technology is less than the size of the barriers between the two markets, i.e. $\theta < c$. The relevant NBS is :

$$\max_{r_2}[(1+\theta-r_2)-(\mathrm{c}-\theta)][(1+\theta+r_2)-(1+\theta)]$$

$$= \max_{r_2}(1+2\theta-r_2-\mathrm{c})(r_2).$$

This implies

$$r_2 = \frac{1-c}{2} + \theta$$

So that the resulting net profits from licensing the basic technology are $\pi_A^{SN} = 2\theta + \frac{3-c}{2}$ and $\pi_L^{SN} = \frac{1+c}{2}$. These are the exact same profits as when $\theta \geq c$, which means that, as in the previous case firm L will not find it advantageous to license its basic technology in the first place as long as trade barriers are not prohibitive ($c < 1$) when the BT is used

$$\frac{1+c}{2} > Max[2-c, 1] \; \forall \; c < 1$$

We can briefly extend our analysis to the case where trade barriers that would be prohibitive under the basic technology no longer are with the improved technology, i.e. $1 \leq c < 1+\theta$. Over this range, L's pay-off without initial licensing of BT is equal to 1, which is lower than its pay-off of $\frac{1+c}{2}$ obtained by licensing BT and then obtaining a license fro IT from A.

We can now compare the situations with and without grantback. The corresponding profits are displayed in table 1. The profits should be compared between π_L^{SG} and π_L^{SN} as summarized in Table 2. Then, we can demonstrate that, if firm L has a total control to include a grant-back clause into the licensing contract, it will always prefer to do so irrespective of the relation between θ and c.

Table 1 Profits and consumer surplus: severable innovation

	No License	**Grantback**	**No Grantback**	
			$c < 1$	$1 \leq c < 1 + \theta$
π_L	$2 - c$	$1 + \theta$	$2 - c$	$\frac{1 + c}{2}$
π_A	0	$1 + \theta$	0	$2\theta + \frac{3 - c}{2}$
$\pi_L + \pi_A$	$2 - c$	$2 + 2\theta$	$2 - c$	$2 + 2\theta$
CS	0	0	0	0

Comparing these profits, we see that the patent-holder licenses its technology if a grantback-clause is available and the value of the follow-on innovation is sufficiently high. If the licensing agreement cannot include a grant-back clause, then licensing of the basic technology only occurs if the barriers to trade are sufficiently high to be prohibitive in the absence of the follow-on innovation. This is illustrated in Figure XX and summarised in

proposition 2

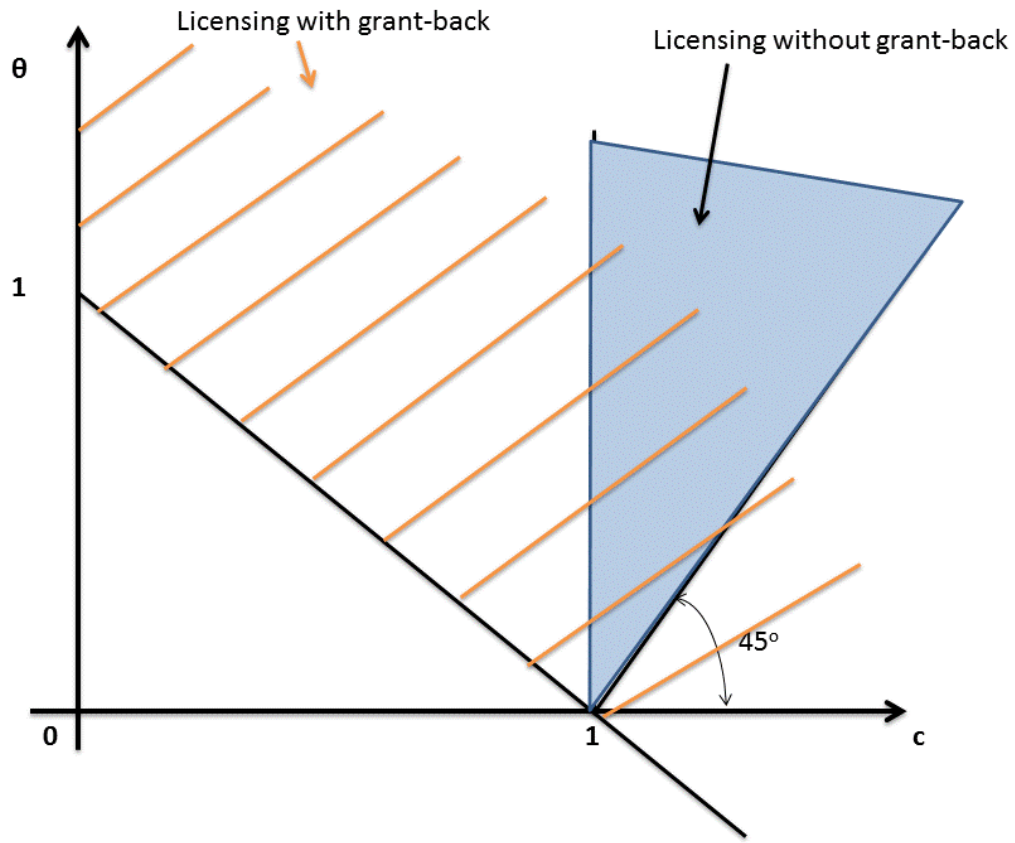

Figure 2

Proposition 2 (Severable innovation and a single licensee)*The patent-holder always a license with a grantbackto a license without grantback And prefers a license with a grantback to no license if the follow-on innovation is significant enough. A license with no grantback is only preferred to no license if the barriers to trade would be prohibitiveonly in the absence of follow-on innovations.*

Comparing propositions 1 and 2 we see that, while the strong version of the "but for" justification for grantback clauses had no traction when the expected follow-on innovation was non-severable, it has considerable relevance in the case of severable innovations since, for a significant range of parameter, licensing would not happen without grantback clauses. So far, then our results do not support the current legal presumption that grantbacks

involving non-seversable innovations should be seen as less likely to be harmful than grantbacks of severable innovations. Of course, just as for non-severable innovations, a grant-back clause would have a drastic effect on the licensee's incentives to innovate.

The "weaker" version of the "but for" defence is also valid with severable innovation since, foir the range of parameters where licensing would occur both with and without a grantback clause, the marginal cost of the initial patent-holder are lower with a grant-back clause (since no royalty is paid) than without it.

4 Prohibition of territorial restrictions

Competition rules apply both to grantback clauses and to territorial restraints. Until recently, the European Union's attitude towards territorial restraints in licensing contracts was fairly relaxed. In a nutshell, European antitrust law generally tolerates agreements that prevent the licensee from competing in the home market of the licensor as well as agreements that prevent the licensor from competing in the market of its licensee. Matters are more complex when it comes to competition between the licensees of of a given licensor: prohibition of "active" sales into another licensee's territory are acceptable for a limited period of time. This period is longer than for so called" "passive" sales. However, the European Commission has recently become more concerned about territorial restrictions. It is therefore worth examining what the potential interaction between such restrictions and grantback clauses might be. We therefore go through the same analysis as in the previous section but under the assumption that neither L nor A can be contractually kept out of either of the two markets.

The profits in the absence of any licensing agreement remain the same as with territorial restrictions. Let us now consider the situation with non-severable innovation.

(1) Non-severable innovation and no grantbacks

Let us start at stage 3 where L has granted a license to A for a royalty of r_1. Assume that A does not license the improvement back to L. We must first determine the equilibrium prices in each market. As we will see, this is not completely straightforward. We will therefore present the derivations for this case in the text. For other derivations below, the reasoning can be found in appendix 1

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In A's market, firm A offers a product of value $1+\theta$ and has unit costs equal to r_1. The situation of firm L in market A is more subtle. Firm L offers a product of value 1 and has unit costs equal to c. However, L must also consider the opportunity cost of making a sale in market A, which is equal to the foregone royalty income that it would have received from A. So, for pricing purpose, L has unit costs equal to $c+r_1$. This means that this is also the minimum price that L is willing to set in order to win market A. Given this minimum price, A will prevail if it can profitably offer greater value to consumers, i.e. if $1+\theta-p_A \geq 1-(c+r_1)$ at a price p_A which covers firm A's cost, i.e. $p_A \geq r_1$. Putting the two conditions together, this implies that A prevails if $1+\theta-r_1 \geq 1-(c+r_1) \leftrightarrow \theta+c \geq 0$, a condition that must be satisfied. In equilibrium A will charge the price that gives consumers exactly the same value as they would get from L when L sets its minimium price, i.e. $p_A=\theta+c+r_1$, i.e. $p_A=1+\theta+c$. Of course we have to satisfy the consumers' participation constraint so that the correct formula for the equilibrium price is $p_A=Min[1+\theta,\theta+c+r_1]$. Which one of the two terms within the bracket applies depend on whether the royalty r_1 is higher or lower than $1-c$. If $r_1<1-c$ then A makes profits of $\theta+c$ and L gets r_1. If $r_1 \geq 1-c$ then A makes profits equal to $1+\theta-r_1$ and L gets r_1.

We now turn to market L. Following the same reasoning, we need to distinguish between two cases. If $\theta>c$ then A is able to offer better value to consumers even if L sets its lowest possible price (equal to r_1. Given that L charges that minimum price, A wins the market by charging $p_A=Min[\theta+r_1,1+\theta]$. If $\theta \leq c$, then L prevails in its home market by setting a price $p_L=Min[r_1+c-\theta,1]$. So, if $\theta>c$ and $r_1<1$ then A makes a profit of $\theta-c$ and L gets the royalty r_1. If $r_1 \geq 1$ then A charges the consumers' willingness to pay and gets profits of $1+(\theta-c)-r_1$ with L still getting r_1. If $\theta<c$, and $r_1<1+\theta-c$ then L gest a profit of $r_1+c-\theta$ while A gets nothing. If $r_1 \geq 1+\theta-c$ then L gets a profit of 1 and A gets nothing.

We must now determine the market equilibria when A decides to license its improvement to L for a royalty r_2. We start with market A. In this market, firm A has an effective marginal cost equal to r_2+r_1. This is because it still has to pay r_1 (since the improvement is non-severable) but it also foregoes a payment of r_2 if it prevails. In a similar vein, firm L has a marginal cost equal to r_1+r_2+c. So, in order to prevail A must charge $p_A=r_1+r_2+c$ or, more exactly $p_A=Min[r_1+r_2+c,1+\theta]$. Hence, if $r_1+r_2<1-c+\theta$ then firm A makes profits equal to r_2+c and L gets r_1. If $r_1+r_2 \geq 1-c+\theta$ then A gets

profits of $1+\theta-r_1$ while L still gets r_1. The situation in market L is a mirror image of the situation in market A, so, if $r_1+r_2<1-c+\theta$ then firm L makes profits equal to r_1+c and A gets r_2. If $r_1+r_2\geq 1-c+\theta$ then L gets profits of $1+\theta-r_2$ while L still gets r_2.

We now have all the elements to solve for the NBS in stage 3, where r_2 is determined and then move back to the NBS in stage 2, where r_1 is determined. The detailed derivations can be found in the appendix. The main difficulty is that the NBS takes a different form depending on the range of royalties considered.

Lemma 2: *In the absence of territorial restrictions and with a non-severable follow-on innovation, licensing the basic technology without a grant-back clause would lead the licensee to license its follow on-technolgy back to the initial patent-holder at a royalty rate given by:*

if $\theta\geq c$, *then* $r_2=1+\theta-c-r_1$ *if* $r_1\leq 1-c$; $r_2=\theta+\frac{1-c-r_1}{2}$ *if* $1-c\leq$

$r_1\leq 1$ *and* $r_2=1+\theta-\frac{c}{2}-r_1$ *if* $r_1\geq 1$.*If* $\theta<c$, *then* $r_2=1+\theta-c-r_1$ *if*

$r_1\leq 1-c$; $r_2=\theta+\frac{1-c-r_1}{2}$

If $1-c\leq r_1\leq 1+\theta-c$ and $r_2=\frac{\theta}{2}$ if $r_1\geq 1+\theta-c$

Proof: Appendix 1

Lemma 3: *In the absence of territorial restrictions and with a non-severable follow-on innovation, the initial patent-holder always licenses its basic technology. If* $\theta\geq c$, *we have*

$r_1^*=1$, $r_2^*=\theta-\frac{c}{2}$, $\pi_L^{NN}=2+\frac{c}{2}$ *and* $\pi_A^{NN}=2\theta-\frac{c}{2}$. *If* $\theta<c$, *then* $r_1^*=1+\theta-c$,

$r_2^*=\frac{\theta}{2}$, $\pi_L^{NN}=2+\frac{3\theta}{2}-c$ *and* $\pi_A^{NN}=c+\frac{\theta}{2}$.

So we see, that, *in spite of the absence of territorial restraints,* licensing of the basic technology still occurs. This might seem counter-intuitive. After all, in the absence of territorial restrictions, competition betweem two firms that have access to exactly the same technology would be expected to dissipate all profits, unless the firms do not have the same

costs. Hence, for example, if A and L both had free access to the BT only, each firm would be able to make a home market profit equal to *c*, the level of the trade barriers between the two markets. The same outcome would be expected if both firms had free access to IT. How then can initial licensing of BT followed by a licensing of IT from A to L lead to higher total profits than *2c*? The answer lies in the fact that the technologies are not available for free. A must pay r_1 in order to get access to BT and L must pay r_2 in order to get access to IT. These royalties effectively increase the effective marginal cost of both firms. Each royalty rate does double duty. On the one hand, it increases both firm's costs in a given maket, leading to higher prices and hence limiting rent dissipation (it makes the "pie" larger). On the other hand, royalty rates also divide surplus between the two parties: the higher r_1 and the lower r_2, the larger the share of surplus appropriated by firm L

(2) Non-Severable Innovation and Grantback

The main difference between the case with and without grant-back lies in the number of relevant contracts and hence in the number of tools at the parties' disposal to de-facto "segment" the market even if territorial restraints are not available. As we discussed abovea royalty payment from A to L, for example, increases the marginal cost of A, but it also increaases the marginal oportunity cost of L since selling an additional unit would come at A's expense and hence at the cost of lost royalty income. Such a royalty can therefore be used to ensure that firm A still extracts all possible surplus from consumers in its own market in spite of the fact that there are no territotial restrictions to protect A from L's competition. With a grantback clause, the only royalty goes from A to L. Without grantback, there is both a royalty from A to L and a royalty from L to A. This, in principles, should further facilitate the de facto segmentation of the two markets.

Accordingly, with grantback, we might expect that licensing of BT would occur for a more restricted set of parameters. However, as stated in Lemma 4 and proved in appendix 1, it turns out that the sole initial licensing contract between the two parties suffices to control competition effectively so that, as without grantback, the IT is always licensed.

Lemma 4: *In the absence of territorial restrictions and with a non-severable follow-on innovation, the initial patent-holderalways prefers to license its basic technology with a*

grantback clause to not licensing it at all. If $\theta \geq \frac{c}{2}$ *then* $r_1^* = 1 + \theta - c$, $\pi_L^{NG} = 2 + 2\theta - c$ *and* $\pi_N^{NG} = c$. *If* $\theta < \frac{c}{2}$ *then* $r_1^* = 1 - \frac{c}{2}$, $\pi_L^{NG} = 2 + \theta - \frac{c}{2}$ *and* $\pi_A^{NG} = \theta + \frac{c}{2}$

Notice that, as in the situation without grantback, the profits of the two parties add up to the full consumer surplus available, i.e. $2 + 2\theta$. So we see that, in spite of the fact that licensing agreements only offer one instrument (r_1) to dull competition between the parties, this instrument is sufficient to ensure that no surplus gets dissipated by ex post competition between A and L.

Proposition 3: *In the absence of territorial restraints, and with a non-severable innovation, the initial technology is always licensed, whether or not grantback clauses included in the licensing contract.*

So just as in the case with territorial restraints, we do not find any support for the strong version of the " but for" defence. There is a difference between the two situations though. With territorial restraints, both firms had exactly the same profits with and without grantback. This is no longer the case once territorial restraints are banned. Clearly, since the parties are always able to jointly extract the whole consumer surplus anyway, they can only have opposite preferences with respect to grantback clauses. If grantback caluses make the patent-holder better off, then they must make the licensee worse off. A straightforward comparison of the profit levels given in Lemma 3 and Lemma 4 show that, as stated in propostition 4, the patent-holder always prefers to include a grantback clause in the licensing contract.

Proposition 4: *If the follo-on innovation is non-severable and the patent-holder can choose whether or not to include a grantback clause in the contract then, it will choose to include it.*

The intuition for this result is simple. In the absence of territorial restraints, royalties do double duty. On the one hand, they are used to preserve surplus by dulling competition between the party but, on the other hand, they also help determine how this surplus is split between licensor and licensee. With grantback, the royalty that the licensee owes to the patent-holder is the only instrument available. There is therefore a direct link between ensuring efficiency by dampening competition and increasing the payment due by the licensee. With grant-backs, the two royalties can be used, which means that it is possible to

dampen competition equally without at the same time implying a distribution of profits away from the licensee.

(3) Severable Innovation and No Grantback

Lemma 5: *With severable Innovation and no grantback, there is ex-post licensing of the improved technology at a royalty rate equal to* $r_2^{SN} = 1 + \theta - c$. *At this rate, each firm serves its home market. Firm A makes total profits of* $\pi_A^{SN} = 2(1 + \theta) - c$ *and firm L makes total profits equal to* $\pi_L^{SN} = c$.

Proof: Appendix

Lemma 6: *With severable innovation and no grantback, the patent-holder only licenses the basic technology if trade barriers would be prohibitive in the absence of follow on innovation and this follow on innovation is large enough (1 < c < 1 + ϑ)*

Proof: The pay-offs from licensing are equal to *c*, while the patent-holder can earn *2-c* by exploiting the patent in both markets. So, if$c < 1$ (i.e. markets are not insulated), this second pay-off must be larger.

These results are not surprising, competition between L and A ensures that L can only capture the benefits that correspond to the amount of home market protection that it gets from trade barriers. Licensing will therefore only occur if these trade barriers are high enough. The upper bound on c only arises because we have assumed that trade-barriers were not so high as to make trade prohibitive in all states of the world.

(4) Severable Innovation and Grantback

This case is rather trivial. Both firms have access to the improved technology. Again, as the technology is severable, firm A does not owe any royalty to firm L. Also, because of the grantback clause, L does not owe any royalty to A for using IT. Trade barriers are therefore the only element that mitigates competition between the two firms. The two markets are now mirror-images of each other. In market A, firm A charges a price equal to c, which is the

marginal cost of firm L. Similarly L charges a price equal to c and makes all sales in its home market. Overall then, each firm makes a profit equal to *c*. Since $c \leq 2 - c$, the patent-holder
prefers not to license in the first place.

Lemma 7: *With severable innovation and grantback, each firm makes profits equal to c*

Proposition 4*: With severable innovation and grantback, the patent-holder never licenses the basic technology.*

We can now determine the effect of grantback clauses in the absence of territorial restrictions and compare them to their effect when territorial restrictions are imposed. In the absence of territorial restrictions, licensing is more likely without a grantback clause than without it. This directly contradicts the "but for " defence. When territorial restrictions were imposed, we saw that licensing could only occur if the licensing agreement included a grantback clause. This suggests some form of complementarity between territorial restrains and grantback clauses.

Proposition 5: *Grantback clauses and territorial restrictions are (weak) complements in the sense that the patent-holder only prefers to use such clauses if the licensing contract can also include territorial restrictions. If territorial restrictions are banned, then the patent-holder strictly prefers not to include a grantback clause in the licensing contract.*

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5. Robustness and Extensions

Our results were obtained in a model with specific assumptions. Many of them do not really matter. For example, the same type of results would obtain if we assumed that follow-on innovation was uncertain or occurred with a time lag. Introducing such features would only add one more parameter to an analysis that is already sufficiently complex. Also, as we argued at the beginning, assuming that follow-on innovation occurs immediately and for sure seems to give the best chance to the "but for defence". The fact that we only find limited support for this defence should therefore be rather robust.

A related point is that, given our assumptions, we do not treat follow-on innovation as an endogenous decision. As explained at the beginning, we take it as given that incentives to invest in follow-on innovation is weaken by grantback clauses so that, in the absence of a strong "but for" defence, the social desirability of such clauses should be questioned. As long as one agrees that the licensor cannot credibly commit ex ante to pay to the licensee an ex post reward that depends on the value of the follow-on innovation, our basic assumption holds as a grantback clause would undoubtedly curtail the licensee's ability to get a reward that depends on the success of his innovation efforts.

In this paper, we have focussed on territorial restrictions between the licensor and a single licensee. Territorial restrictions also typically apply with respect to the relationships between multiple licensees. In particualr, current EU Law still allow for the granting of exclusive territories to each licensing with a (temporary) prohibition on active sales into another licensee's territory. Prohibition of passive sales are also still allowed albeit for a shorter period of time. However, the trend seems to be towards a growing intolerance of such restrictions on sales. The interaction between grant-back clauses and territorial restrictions *between licensees* raises issues that are somewhat different from those examined in the current paper. For example, it is not a priori clear how the innovation incentives of licensees would be affected by grant-back clauses. In particular, one cannot trule out that an optimal pattern of folllow-on innovation would not require imposing grantback clauses in some contracts but not in others. Moreover, in this setting, there is a greater variety of clauses to consider. For example, one would need to distinguish between a clause that automatically gives the patent-holder the right to exploit the follow-on innovation in his homw market – leaving the follow-on innovator free to license it to other licensees – and clauses that grant the initial licensor the right to exploit the follow-on innovation in his home market and to license it to its own initial set of licensees. Furthermore, the legality of each type of grant-back clause may well depend on whether or not the follow-on innovation is severable. These issues seem different enough to warrant a separate investigation and hence another paper.

Another feature of our analysis is that we assumed that all parties knew ex ante whether the follow-on innovation would be severable or not. We took this approach to emphasise the differences betweeb the two types of innovation and evaluate the different legal treatment that they received under the 2004 (?) *Technology Transfer* Guidelines. Still, in practice, any given licensing agreement implies the possibility that follow-on innovation might be of either

type. Moreover, it is entirely possible that the type of follow-on innovation would itself depend on the licensee's R&D efforts.

Once the type of innovation becomes endogenous, one can address another reason for the more evere legal treatment of severable innovations. As we have seen, a follow-on innovation is deemed to be "severable" if it can be used without infringing the initial technology. This means that whether or not an innovation is indeed severable will depend on the "scope" of patent protection. One reason for opposing grantback clauses that apply to severable innovation is therefore that such a clause would allow for the de facto "extension" of the scope of the patent granted under IP Law. To further investigate this issuem It would seem desirable to analyse the impact of grant-back clauses in a framework where the socially optimal scope/breadth of patent protection can also be meaningfully determined. This would involve introducing grant-back clause in the type of models considered by Scotchmer and Green (1990), Green and Scotchmer (1995) or De Nicolo (2000). This is an approach on which we are currently working.

6. Conclusion

It is widely acknowledged that Grantback clauses decrease the innovation incentives of the licensee. A traditional defence for the inclusion of such clauses is to argue that they are necessary for licensing to occur in the first place. The idea is that access to the basic technology that is being licensed increass the probability that the licensee might come up with a follow-on innovation that would make the basic technology obsolete. We investigate the validity of this defence. In doing so, we follow EU Law and distinguish between "severable" follow-on innovations, which can be used without infringing the patents on the basic technology and non-severable innovaitons, which cannot.

We first consider a situation where licensing agreements include restraints that allocate markets between licensor and licensee. We find that the parties' profits – and hence the incentives to licens the basic technology – do not depend on whether or not the licensing agreement includes a grant-back clause. There is however some support for the claim that a grantback clause might lead to lower consumer prices. For severable innovations, we find that licensing does noit necessarily occur and that it can only occur if the agreement includes a grantback clause. In this sense then, the "but for" defence is more valid for severable

innovation than for severble innovation. This seems to contradict the EU's past approach, where grantback clauses on severable innovations were treated more severely than those on non-severable innovations.

We then revisit the issue under the assumption that territorial restraints are not allowed. This is of interest for two reasons. Firstly, it helps us understand how grantback-clauses work "on their own" and, secondly, it helps us understand what might happen as EU Law grows tougher with respect to territorial restraints. For non-severable innovations, we find that licensing still occurs whether or not the agreement includes a grantback clause. Now, however, the owner of the basic technology strictly prefers to include such a clause. For sevrable innovation, we find that licensing can only occur if the agreement does *not* include a grantback clause. This casts further doubt on the general validity of the "but for defence". Our results also suggest that grantback clauses and territorial restraints are complements when the follow-on innovation is severable but are substitutes if the follow-on innovation is non-severable.

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APPENDIX 1

I. Determination of stage 3 royalty with non-severable innovation and no grantback

There are many cases to consider.

a. $\theta \geq c$

Within this case, there are a number of subcases, depending on the value of r_1. We first assume that $r_1 \leq 1 - c$. Over the range of r_2 such that $r_2 \leq 1 - c + \theta - r_1$, the NBS is

$$\max_{r_2}[2r_2 + \mathrm{c} - (\theta + \mathrm{c} + \theta - \mathrm{c})][\mathrm{c} + 2r_1 - 2r_1]$$

$$\leftrightarrow \max_{r_2}[2r_2 + \mathrm{c} - 2\theta][\mathrm{c}]$$

Over the relevant range, this expression is increasing in r_2 so that it is maximised at the corner solution $r_2 = 1 - c + \theta - r_1$. We now consider the range where $r_2 \geq 1 - c + \theta - r_1$. The corresponding NBS is:

$$\max_{r_2}[1 + \theta + r_2 - r_1 - (\theta + \mathrm{c} + \theta - \mathrm{c})][1 + \theta + r_1 - r_2 - 2r_1]$$

$$\leftrightarrow \max_{r_2}[1 - \theta + r_2 - r_1][1 + \theta - r_1 - r_2]$$

This implies that, over this range the expression is maximised at

$$r_2 = \theta$$

However, under our assumption that $r_1 < 1 - c$, we have $\theta < 1 - c + \theta - r_1$. Hence overall, the agreed upon stage 3 royalty is

$$r_2^* = 1 - c + \theta - r_1$$

We now assume that $1 - c < r_1 \leq 1 \leq 1 - c + \theta$

This only changes A's pay-offs in market A in the absence of licence from $\theta + c$ to $1 + \theta - r_1$. The NBS over the first range of r_2 is then

$$\max_{r_2}[2r_2 + \mathrm{c} - (1 + \theta - r_1 + \theta - \mathrm{c})][\mathrm{c} + 2r_1 - 2r_1]$$

$$\leftrightarrow \max_{r_2}[2r_2 + 2\mathrm{c} - 2\theta - 1 + r_1][\mathrm{c}]$$

The expression is still increasing in r_2 over the relevant range so that $r_2 = 1 - c + \theta - r_1$. Over the next range of values for r_2, the relevant NBS is now

$$\max_{r_2}[1 + \theta + r_2 - r_1 - (1 + \theta - r_1 + \theta - c)][1 + \theta + r_1 - r_2 - 2r_1]$$

$$\leftrightarrow \max_{r_2}[r_2 + c - \theta][1 + \theta - r_1 - r_2]$$

Which gives us $r_2 = \theta + \frac{1-c-r_1}{2}$. For $r_1 > 1 - c$, this value is larger than $1 - c + \theta - r_1$. The value of the royalty that sloves the overall NBS problem is therefore interior, i.e.

$$r_2^* = \theta + \frac{1 - c - r_1}{2}$$

This royalty is positive as long as $r_1 < 1 + 2\theta + c$, which is satisfied for the range of $r_1$considered.

Now we consider $1 \leq r_1$. We look first at the range $r_2 \leq 1 - c + \theta - r_1$

$$\max_{r_2}[2r_2 + c - (1 + \theta - r_1 + 1 + \theta - c - r_1)][c + 2r_1 - 2r_1]$$

$$\leftrightarrow \max_{r_2}[2r_2 + 2c - 2\theta - 2 + 2r_1][c]$$

As this expression is increasing in r_2, then, over the original range of values the maximum is reached at the corner $r_2^* = 1 + \theta - c - r_1$. Moving to the range where $r_2 \geq 1 - c + \theta - r_1$, we have

$$\max_{r_2}[1 + \theta - r_1 + r_2 - (1 + \theta - r_1 + 1 + \theta - c - r_1)][1 + \theta + r_1 - r_2 - 2r_1]$$

$$\leftrightarrow \max_{r_2}[r_2 + r_1 - 1 - \theta + c][1 + \theta - r_1 - r_2]$$

This gives us

$$r_2^* = 1 + \theta - r_1 - \frac{c}{2}$$

Since this is range than $1 - c + \theta - r_1$, the value of r_2 that solves the NBS over the whole range is either $r_2^* = 1 - c + \theta - r_1$ or $r_2^* = 1 + \theta - r_1 - \frac{c}{2}$. Since the first value was actually feasible over the seconde range, the overall NBS must be maximised at

$$r_2^* = 1 + \theta - r_1 - \frac{c}{2}$$

b. $\theta < c$

We begin with the case where $r_1 \leq 1 - c$. We further assume that $r_2 \leq 1 + \theta - c - r_1$. The corresponding NBS is:

$$\max_{r_2}[2r_2 + \mathrm{c} - (\theta + \mathrm{c})][2r_1 + \mathrm{c} - (2r_1 + \mathrm{c} - \theta)]$$

$$\leftrightarrow \max_{r_2}[2r_2 - \theta][\theta]$$

As this expression is increasing in r_2, then, over this range of r_2, we have:

$$\mathrm{r}_2^* = 1 + \theta - \mathrm{c} - \mathrm{r}_1$$

We now assume that $r_2 \geq 1 + \theta - c - r_1$, so that the NBS becomes:

$$\max_{r_2}[1 + \theta + r_2 - r_1 - (\theta + \mathrm{c})][1 + \theta + r_1 - r_2 - (2r_1 + \mathrm{c} - \theta)]$$

$$\leftrightarrow \max_{r_2}[1 + r_2 - r_1 - \mathrm{c}][1 + 2\theta - \mathrm{c} - r_1 - r_2]$$

This gives us

$$r_2^* = \theta$$

Under the assumption that $r_1 \leq 1 - c$, this solution is smaller than the lower bound of the corresponding range. We therefore conclude that, for $r_1 \leq 1 - c$, the value of r_2 that solves the Nash Bargaining problem is

$$\mathrm{r}_2^* = 1 + \theta - \mathrm{c} - \mathrm{r}_1$$

We now turn to the next range of r_1, i.e. $1 - c \leq r_1 \leq 1 + \theta - c$

Again, we need to consider two ranges of values for r_2. We begin by assuming that $r_2 \leq 1 + \theta - c - r_1$. The corresponding NBS is:

$$\max_{r_2}[2r_2 + \mathrm{c} - (1 + \theta - r_1)][2r_1 + \mathrm{c} - (2r_1 + \mathrm{c} - \theta)]$$

$$\leftrightarrow \max_{r_2}[2r_2 + \mathrm{c} - r_1 - \theta - 1][\theta]$$

Since this expression is increasing in r_2, we have:

$$r_2^* = 1 + \theta - c - r_1$$

Considering the range $r_2 \geq 1 + \theta - c - r_1$, the NBS is:

$$\max_{r_2}[1 + \theta + r_2 - r_1 - (1 + \theta - r_1)][1 + \theta + r_1 - r_2 - (2r_1 + \mathrm{c} - \theta)]$$

$$\leftrightarrow \max_{r_2}[r_2][1 + 2\theta - \mathrm{c} - r_1 - r_2]$$

Which gives us:

$$r_2^* = \frac{1 - c - r_1}{2} + \theta$$

For $r_1 > 1 - c$, this value is larger than the lower bound of the relevant range. Therefore, we conclude that, for $1 - c \leq r_1 \leq 1 + \theta - c$, we have

$$r_2^* = \frac{1 - c - r_1}{2} + \theta$$

The third case to consider is $1 + \theta - c \leq r_1$. The first range of values of r_2 is $r_2 \leq 1 + \theta - c - r_1$. The corresponding NBS is

$$\max_{r_2}[2r_2 + \mathrm{c} - (1 + \theta - r_1)][2r_1 + \mathrm{c} - (1 + r_1)]$$

$$\leftrightarrow \max_{r_2}[2r_2 + \mathrm{c} + r_1 - 1 - \theta][r_1 + \mathrm{c} - 1]$$

As this expression is increasing in r_2, we have

$$r_2^* = 1 + \theta - c - r_1$$

For the range $r_2 \geq 1 + \theta - c - r_1$, the NBS is:

$$\max_{r_2}[1 + \theta + r_2 - r_1 - (1 + \theta - r_1)][1 + \theta + r_1 - r_2 - (1 + r_1)]$$

$$\leftrightarrow \max_{r_2}[r_2][\theta - r_2]$$

Giving us:

$$r_2^* = \frac{\theta}{2}$$

This value is greater than the lower bound of the r_2 interval if $\frac{\theta}{2} > 1 + \theta - c - r_1$., which must be true for $r_1 > 1 = \theta - c$. Hence, over the full range of values for r_2, we have

$$r_2^* = \frac{\theta}{2}$$

II. Determination of Stage 2 Royalty with Non-Severable Innovation and No Grantback.

a. $\theta \geq c$

We first assume that $r_1 \leq 1 - c$. This means that $r_2 = 1 + \theta - c - r_1$. The NBS is therefore:

$$\max_{r_1}[2 + 2\theta - c - 2r_1 - 0][c + 2r_1 - (2 - c)]$$

$$\leftrightarrow \max_{r_1}[2 + 2\theta - c - 2r_1][2c + 2r_1 - 2]$$

This gives us

$$r_1^* = 1 - \frac{3c}{4} + \frac{\theta}{2}$$

This is within range if

$$r_1^* = 1 - \frac{3c}{4} + \frac{\theta}{2} \leq 1 - c \;\leftrightarrow \frac{c}{4} + \frac{\theta}{2} \leq 0$$

This condition cannot hold. So, over this range, we are at a corner, i.e.

$$r_1^* = 1 - c$$

We now assume that $1 - c < r_1 \leq 1 \leq 1 - c + \theta$, so that $r_2^* = 1 - c + \theta - r_1$. Notice that over this range and for this value of r_2, we have $r_2 > 1 + \theta - c - r_1$. Hence the NBS is

$$\max_{r_1}[1 + \theta + r_2 - r_1] - 0][1 + \theta + r_1 - r_2 - (2 - c)]$$

$$\leftrightarrow \max_{r_1} \frac{3}{2}[\frac{3}{2} + 2\theta - \frac{c}{2} - \frac{3}{2}r_1][c - 1 + r_1]$$

So that

$$r_1^* = 1 + \frac{2(\theta - c)}{3}$$

Clearly, this value is larger than 1 and is therefore not within range. Hence, over this range of r_1 we have

$$r_1^* = 1$$

Now we consider $1 \leq r_1$, so that $r_2^* = 1 + \theta - r_1 - \frac{c}{2}$. Again, this implies that $r_2 > 1 + \theta - c - r_1$. We can then write the NBS as:

$$\max_{r_1}[2 + 2\theta - 2r_1 - \frac{c}{2} - 0)][2 + 2\theta + 2r_1 + \frac{c}{2} - (2 - c)]$$

$$\leftrightarrow \max_{r_1}[2 + 2\theta - 2r_1 - \frac{c}{2}][2\theta + \frac{3c}{2} + 2r_1]$$

So that

$$r_1^* = \frac{1-c}{2}$$

Which is outside the assumed range. This means that, overall, for $r_1 \geq 11$ the equilibrium royalty must be $r_1^* = 1$

Over the whole range of values of r_1 then, the equilibrium royalties are

$$r_1^* = 1$$

$$r_2^* = 1 + \theta - r_1 - \frac{c}{2} = \theta - \frac{c}{2}$$

We can now determine the equilibrium profits of the two firms. From A's sales in market A, firm l collect the royalty r_1^*. In its home market, it gets $1 + \theta - r_2^* = r_1^* + \frac{c}{2}$. This gives us a total equal to

$$\pi_L^{NN} = 2 + \frac{c}{2}$$

Which implies that firm L always licenses the initial technology. For firm A, the profits are made up of r_2^*, earned in market L and $1 + \theta - r_1^* = \theta$, earned in market A. This gives us a total of

$$\pi_A^{NN} = 2\theta - \frac{c}{2} > 0$$

Note thatthe two firms jointly appropriate the total available surplus $2 + 2\theta$

b. $\theta \leq c$

We begin with the case where $r_1 \leq 1 - c$, so that $\mathrm{r}_2^* = 1 + \theta - \mathrm{c} - \mathrm{r}_1$ and the NBS is

$$\max_{r_1}[2+2\theta - c - 2r_1 - 0][2r_1 + \mathrm{c} - (2 - \mathrm{c})]$$

$$\leftrightarrow \max_{r_1}[2 + 2\theta - \mathrm{c} - 2r_1][2r_1 + 2\mathrm{c} - 2]$$

This gives us

$$r_1^* = 1 + \frac{\theta}{2} - \frac{3c}{4}$$

As this is out of range, we actually have

$$r_1^* = 1 - c$$

We now turn to the next range of r_1, i.e. $1 - c \leq r_1 \leq 1 + \theta - c$ so that $r_2^* = \theta + \frac{1-c-r_1}{2}$. This value is larger than $1 + \theta - c - r_1$ so that the NBS is

$$\max_{r_1}[1 + \theta + r_2 - r_1 - 0][1 + \theta + r_1 - r_2 + -(2 - c)]$$

$$\leftrightarrow \max_{r_1}[\frac{3}{2} + 2\theta - \frac{c}{2} - \frac{3}{2}r_1][\frac{3}{2}r_1 + \frac{3}{2}c - \frac{3}{2}]$$

Giving us

$$r_1^* = 1 + \frac{2}{3}(\theta - c)$$

But, for $\theta \leq c$, this value is greater than the upper bound of the range so that

$$r_1^* = 1 + \theta - c$$

The third case to consider is $1 + \theta - c \leq r_1$ so that $r_2^* = \frac{\theta}{2}$ and the NBS is

$$\max_{r_1}[1 + \theta + r_2 - r_1 - 0][1 + \theta + r_1 - r_2 - (2 - c)]$$

$$\leftrightarrow \max_{r_1}[1 + \frac{3\theta}{2} - r_1][r_1 + c + \frac{\theta}{2} - 1]$$

This gives us

$$r_1^* = 1 + \frac{\theta - c}{2}$$

This expression is outside of the assumed range. Hence, over the whole range of values for r_1, the equilibrium value is

$$r_1^* = 1 + \theta - c$$

We can now determine the equilibrium profits of firms A and L. In market A, firm L makes profits equal to r_1^*, while, in its home market, it makes profits of $1 + \theta - r_2$. This gives us a total of

$$\pi_L^{NN} = 2 + \frac{3\theta}{2} - c > 2 - c$$

So that the initial technology is always licensed. Firm A makes profits equal to $r_2^* = \frac{\theta}{2}$ in market L and profits of $1 + \theta - r_1 = c$ in its home market, for a total equal to

$$\pi_A^{NN} = c + \frac{\theta}{2}$$

III. Determination of stage 2 royalty with non-severable innovation and grant back

Because the innovation is non-severable, the royalty r_1 set is stage 2 is still due. This means that both firms have effective marginal costs equal to r_1 in their home country and $r_1 + c$ in the other market. Because of the grant-back, both firm can offer a product valued at $1 + \theta$ by the consumers. Let us first consider the price equilibrium in markets A and L. In this market, as long as the consumer's reservation price is not binding, firm A makes all sales at a price of $c + r_1$, making a profit of *c* and paying r_1 to firm L. If $c + r_1 > 1 + \theta$, then A makes all sales at a price $1 + \theta$ and gets profits of $1 + \theta - r_1$, which is non-negative as long as $r_1 \leq 1 + \theta$. In market L, if the consumer's reservation price is not binding, L makes all sales at the same price of $c + r_1$, making a profit of $c + r_1$. If $r_1 \geq 1 + \theta - c$, then the price and profits of firm L are equal to $1 + \theta$.

Assuming that $r_1 \leq 1 + \theta$, we have therefore two forms for the NBS, depending on the range of r_1.

If $r_1 \leq 1 + \theta - c$ then the NBS is

$$\max_{r_1}[\mathrm{c}-0][2r_1+\mathrm{c}-(2-\mathrm{c})]$$

$$\leftrightarrow \max_{r_1}[\mathrm{c}][2\mathrm{c}+2r_1-2]$$

As this condition is increasing in r_1, we have

$$r_1^* = 1+\theta-c$$

If $r_1 \geq 1+\theta-c$, then the NBS is

$$\max_{r_1}[1+\theta-r_1-0][r_1+1+\theta-(2-\mathrm{c})]$$

$$\leftrightarrow \max_{r_1}[1+\theta-r_1][r_1+\mathrm{c}+\theta-1]$$

This gives us:

$$r_1^* = 1-\frac{c}{2}$$

We must distinguish between two cases.

If $c \leq 2\theta$, then the solution above is smaller than the lower bound of the relevant range. Overall then, the NBS is solved by

$$r_1^* = 1+\theta-c$$

This gives profits of *c* to firm A and profits of $2+2\theta-c$ to firm L. For firm L, this is better than not licensing. If $c \geq 2\theta$ then we are within range so that the overall NBS is solved by

$$r_1^* = 1-\frac{c}{2}$$

This gives profits of $\theta+\frac{c}{2}$ to A and profits of $2+\theta-\frac{c}{2}$ for L. For L, this is better than not Licensing.

IV. Determination of Stage 3 royalty with severable innovation and no grant-back

We begin with the pay-offs in the absence of licensing. Since the innovation is severable, r_1 is irrelevant. Firm A makes profits of $\theta + c$ in its home market. If $\theta \geq c$ then A also makes profits equal to $\theta - c - r_1$ in market L and L earns no profit. If $\theta \leq c$, then L makes profits of $c - \theta$ in its home market while A makes no profit in L.

Now, assume that A licenses its technology to L at a royalty rate r_2. In market A, L cannot profitably charge a price lower than $c + r_2$. If A undercuts , it gets profits equal to $c + r_2$. If it does not it just gets r_2. So in equilibrium, A gets $Min[1 + \theta, c + r_2]$. In market L, assume that L charges a price P_L. The minimum such price that L could charge is $P_L = r_2$. Would A be better off undercuting that price? By doing so A would get profits of $r_2 - c$, so the answer is no? In fact, the minimum price that A would undercut is $P_L = r_2 + c$. In equilibrium then, provided that $r_2 + c \leq 1 + \theta$, L charges $P_L = r_2 + c$, making a profit of *c* and A gets profits equal to the royalty payment r_2. If $r_2 + c \geq 1 + \theta$ then $P_L = 1 + \theta$ and firm L makes profits of $Min[0, 1 + \theta - r_2]$, while A still gets r_2. We can now solve for the relevant NBS.

a. $\theta \geq c$

Over the range $r_2 \leq 1 + \theta - c$, we have

$$\max_{r_2}[2r_2 + c - 2\theta][\mathrm{c}]$$

Since this expression is increasing in r_2, we have, over this range

$$r_2^* = 1 + \theta - c$$

Now we consider the range $r_2 \geq 1 + \theta - c$. The corresponding NBS is

$$\max_{r_2}[1 + \theta + r_2 - 2\theta][1 + \theta - r_2]$$

$$\leftrightarrow \max_{r_2}[1 - \theta + r_2][1 + \theta - r_2]$$

This gives us

$$r_2^* = \theta$$

As we have assumed that $c < 1$, this valure of r_2 is actually smaller than the lower limit

of the range. Hence overall, for $\theta \geq c$, we have

$$r_2^* = 1 + \theta - c$$

b. $\theta \leq c$

For $r_2 \leq 1 + \theta - c$, the NBS is

$$\max_{r_2}[2r_2 + c - \theta - c][\mathrm{c} - (\mathrm{c} - \theta)]]$$

$$\leftrightarrow \max_{r_2}[2r_2 - \theta][\theta]$$

Since this expression is increasing in r_2, we have, over this range:

$$r_2^* = 1 + \theta - c$$

For $r_2 \geq 1 + \theta - c$, the NBS is

$$\max_{r_2}[1 + \theta + r_2 - \theta - c][1 + \theta - r_2 - (\mathrm{c} - \theta)]]$$

$$\leftrightarrow \max_{r_2}[1 + r_2 - \mathrm{c}][1 + 2\theta - \mathrm{c} - r_2]$$

Giving us:

$$r_2^* = \theta$$

This expression is larger than the lower limit of the range if and only if $c > 1$, which we have ruled out by assumption. Therefore, for $\theta \leq c$, we have

$$r_2^* = 1 + \theta - c$$

V. Determination of Stage 2 royalty with Severable Innovation and Grantback

Both firms have access to the improved technology. Again, as the technology is severable, firm A does not owe any royalty to firm L. The two markets are now mirror-images of each other. In market A, firm A charges a price equal to c, which is the marginal cost of firm L. Similarly L charges a price equal to c and makes all sales in its home market. Overall then, each firm makes a profit equal to *c*. Since $c \leq 2 - c$, the patent-holder

prefers not to license in the first place.