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Economic Implications of Intellectual Property Rights for the Biotechnology Sector: A Comparative Analysis of the European – Japanese Situations[1]

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Abstract

Under the assumption of similar general legal environments, the following analysis suggests that a strategy of confidential secrecy in R&D is less significant for Japanese enterprises as it is for European enterprises. Founded upon this difference the amount of patent induced information disclosure effects for Japan is not as essential as it is for Europe. Consequently, the blockade effect in Japan is comparatively dominant, i.e. in Japan the negative aspects of patent protection effect the system more immediately. Thus, one might argue that less patent protection is more fruitful for Japan. Given this analysis, the current endeavours of the USA, the European Union and Japan to harmonize patent legislation for the biotechnology sector appears to be flawed.

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1 Introduction

The main objective of this paper is to analyse the welfare effects of national specific differences given by the definitions of intellectual property rights for biotechnological inventor's discoveries in Japan and Europe. Different various forms of intellectual property rights and means of economic protection for discoveries or innovations within the biotechnology sector are conceivable. In fact, however, at the moment only the instrument *patent* is being politically discussed.

From the economist's point of view patents have two main functions: An incentive function and an information dissemination function. The newer theory of patents mostly argues on the basis of the incentive function although in the biotech sector the information dissemination function is the most important one as we will show in section 3.1. Consequently the following analysis will focus on this second function. We concentrate on the question if patents encourage the R&D process in the field of modern biotechnological and genetic engineering, thereby increasing social welfare because they help to inform additional researchers about new basic knowledge and different ways to use it. In general, our model exhibits a positive effect of patents on social welfare along the lines of the postulated information dissemination function.

The following analysis shows that differences between Japan and Europe exist with regard to the patent granting and patent claims processes in the biotechnology sector within the legal environment as well as with regard to cultural and traditional aspects of society in general. From an aggregate welfare analysis perspective, the analysis presented suggests that these differences in cultural and traditional prerequisites within the two different national patent systems leads to the necessity of diverse degrees of

patent exclusivity in economic policy implementation. As a result the current endeavours of the "Triad" to harmonize patent laws in the USA, the European Union and Japan appears questionable.

We will proceed as follows. Section 2 presents a brief survey of the legal situation in Europe and the current global undertakings to eliminate regional specific variations in national patent laws. Section 3.1 discusses the research and development system present in the biotechnology sector. After focusing on and identifying the relevant economic characteristics of genetic technological research, observed strategies of enterprises active in the biotechnology sector are discussed. In the following, two major strategies are observed and examined: researching and developing biotechnological innovations and having them patented; researching and developing biotechnological innovations and keeping the corresponding technological knowledge secret in order to capture the appropriation of the respective economic rents generated. In addition to these two strategies three further strategies exist: imitating, licensing, and cooperating. We abstract here from an explicit analysis of these strategies since we are mainly interested in the primary welfare effects of patent protection. Once the legal environment has been defined with regard to the manner and extent of patent protection, a researcher must first make a decision as to whether or not patent protection is economically sensible. Only in the second instance does the researcher consider the question of possible combinations with the other strategies. Based upon these considerations, Section 3.4 presents the formal model structure of such situations. The legal environment and the regional patent efficiencies play a major role hereby. Section 4 summarizes the major conclusions and results derived.

2 Legal Background

One of the basic fundamentals of patent law is the principle of territory. The bestowing of a patent is a deed of territorial sovereignty. As a consequence, patents (for the same discovery or innovation) that are registered in various national states may be judged differently due to differences in the legal statutes of the standards of protection given. This can even go as far as having a patent granted in one country and the same government right being denied in another country. Today, especially in the area of genetic engineering, regional specific differences are common with regard to questions pertaining to the permissibility and the scope of patent protection based upon the application of traditionally more technically oriented patent laws. A variety of new questions are thus emerging, which demand the establishment of new standards, without which these questions can not be appropriately addressed. Recognizing the need to reduce transaction costs due to variations in country-specific patent protection levels and standards when applying for a patent grant, it has for a long time been a goal of the international community to harmonize existing national patent legislations. It is commonly argued that there is a need for a commitment to some form of minimum standards, as well as procedural principles (compare [SB02], p. 3).

Indeed within the European Union such activities are meanwhile so highly developed that it is already possible to speak of homogeneous standards. The administrative authority in charge of granting patents within the European Union is the European Patent Office located in Munich. The decisive statutory provision of the European Union for patent protection of genetic engineering inventions and the harmonization of relevant legal aspects is the *directive on biotechnological patents* (DBP). In addition to

the DBP further agreements exist which focus upon harmonizing industrial legislation in general. In this respect, for example, the *European Patent Convention* (EPC) or the *Luxemburger Vereinbarung ber Gemeinschaftspatente* may be mentioned. However, the key legal foundation for patent protection in the field of genetic engineering in the European Union is still the *Directive 98/44/EC on the legal protection of biotechnological inventions* (DBP). Since deficits even now persist in the DBP statutes, much room for controversy with regard to an optimal patent system for biotechnological inventions in Europe remains (compare [GV02], p. 155). The final establishment of binding legal standards in Europe is yet to be obtained (compare [SB02], p. 5).

On the other hand, respective similar ambitions at a global level are still in their infancy. Indeed, a few international agreements have been signed with the goal of harmonizing the granting of patents according to a unified global structure such as the *Pariser Uebereinkommen zum Schutz des gewerblichen Eigentums* or the agreement on *Trade-Related Intellectual Property Rights* (TRIPS). These Agreements, however, are based upon very general requirements and do not explicitly deal with the scope of legal protection for biotechnological inventions per se.

Because genetic inventions have long been among the most challenging areas of technology for patent offices, efforts have been made through the trilateral cooperation of the USA, the European Union and Japan to harmonize their approach to the examination of patent applications in the field of biotechnology. The appropriate scope of claims has been one of the most contentious issues, but still some differences among national patent offices remain. Patent authorities of the three regions still try to clarify the circumstances under which genetic inventions are patentable (compare [OEC02], p. 30).

3 Theoretical Foundations

3.1 Elements of the Research Process

The following analysis is founded upon elements of the simple model originally suggested by Bessen and Maskin (2000) and characterizes the expected social welfare effects of patent protection for the individual succession of steps for the genetic technical research and development (R & D) - sequence. Two general attributes of genetic engineering technology are central to the analysis.

First of all, it must be noted that innovations in the biotechnology and genetic engineering sector occur *sequentially.* That is, each individual innovation represents a relatively small technological advancement. Each new advancement is founded upon the current frontier of technology, as such each new technological advancement may be conceived of as being directly derived from the previous incremental technological improvement. More generally stated the existent knowledge set is successively enlarged through a process of many small successions of steps.[3] Different steps may be passed through by various enterprises. The aggressiveness of the competitive environment in which biotechnological companies are confronted with requires them to permanently attempt to uphold their technological edge. This implies that they have to continuously monitor and master the newest developments of their field.

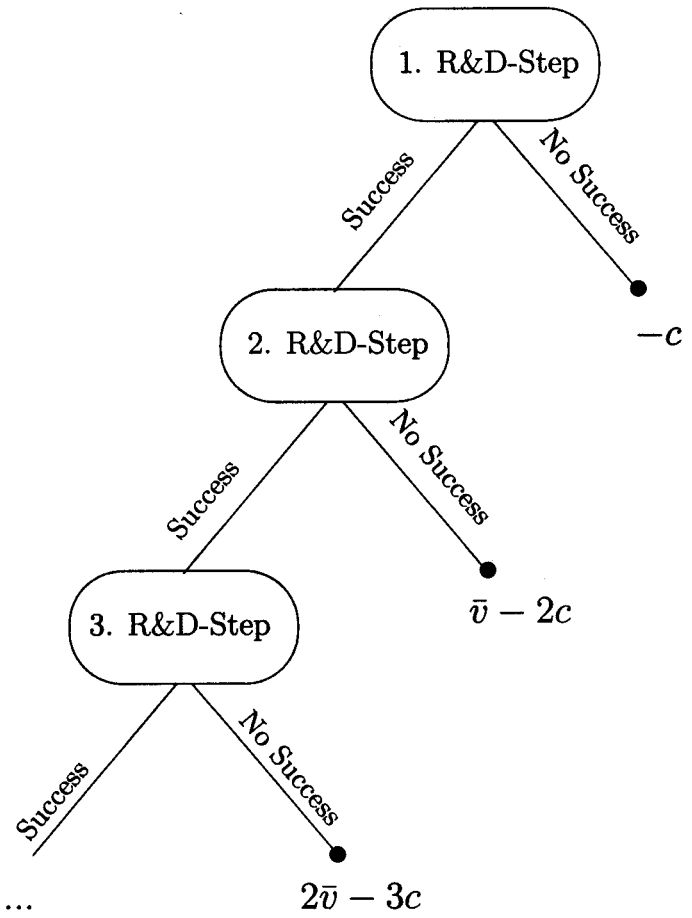
Secondly, one must consider that innovations are often *complementary.* The various solution approaches of different research teams of different enterprises for some corresponding problem of interest are in conjunction with one another, enhancing the probability that a particular research target will be achieved within some given time

[3] We use the terms "innovation steps" and "steps of the innovation process" synonymously.

span. This assumption is quite contrary to the standard patent theory case whereby one argues that double research efforts represent a waste of scarce resources. Here, complementary research efforts do naturally induce additional costs, however, at the same time they may lead to information-spillovers which enhance the probability of obtaining an adequate solution to some problem at hand. A current practical example of such effects is e.g. the various approaches taken by diverse software companies to develop spoken language-guided software packages. The variety of approaches taken were complementary to each other in the sense of mutually enhancing one another's approach, which eventually lead to a much quicker introduction of a user friendly new market product (compare [BM00]). In the following illustration below this complementary aspect is reflected in the probability p of the research and development efforts being successful.

Figure 1 illustrates the given proposed incremental process within a biotechnological development sequence. A higher stage of development can first be obtained, given that the previous stage was successful. The costs of R&D for each stage are designated as c, whereby v represents the economic aggregate expected (social) value given that R&D leads to the discovery and development of a successful innovation. In each stage of development the costs c materialize, b e f o r e the aggregate expected social value v (assuming success) can be determined. The sequence will be terminated, given that in Stage t the R&D-expenditures were non-successful. Up to this point in time benefit yields amounting to $(t-1)v$ are realized. Costs incurred amount to tc. The expected economic benefit for society G founded upon such a R&D-sequence can be formulated

Figure 1: A Stylized Biotechnology Research and Development Sequence



as:

$$G = -c(1-p) + \sum_{t=1}^{t_{max}} (p^t(1-p)(tv-(t+1)c)) = \sum_{t=0}^{t_{max}} (p^t(1-p)(tv-(t+1)c)) \quad . \quad (1)$$

The variable t represents the i-th iteration of the biotechnology R&D sequence. Since the innovation step $t+1$ can only be realized given that t was successfully completed, t also symbolizes the amount of successfully executed innovations. t may also be interpreted as designating a time point within a R&D-sequence, since throughout time $t+1$ always occurs following t.

Generally, the sequential nature of R&D processes in various fields of technology is not contested as being unreal. All the same, the assumption that such a process

may continue infinitely does appear to be unrealistic. As such, t_{max} designates some maximum amount of iterations permissible within an observed R&D- sequence. Consequently, the research process is contended to be bounded ex ante with regard to time duration as well as with regard to technological advancement capabilities. For example, on various occasions it has been observed that so-called back-stop technologies and killer-applications have repeatedly made certain technological developments prematurely obsolete. Also, as a new technology matures through its life-cycle the probability of technological enhancement decreases throughout time as one observes decreasing returns to investment in R&D-activities. Finally, it may be argued that in the international competitive arena biotechnological research and development processes will gradually become more globalized so that domestic advancements may be replaced by imitation from foreigners and further development by foreign competitors will become commonplace.

Observing the entire chain of sequences necessary to develop and produce a medication product or treatment based upon fundamental genetic information - that is, from the decoding of the genetic sequences passing through the clinical tests and onto the final production and product marketing aspects whose results are patentable and lead to effective benefits (revenues). As stated above, the number of iterations in such a sequence is unequivocally determined. All the same, the contention here is that biotechnological sequences exhibit the preliminary assumed characteristics mentioned above. In the following it will, however, be alleged - manifold steps of the innovation process must be worked through. In the model structure presented here, however, only those development steps will be explicitly regarded that $t_{max} = 10$ (for a detailed account of potential R&D-steps compare e.g. [Art97]).

3.2 R&D-System Strategies

Throughout the patent theory literature the assessment can be found that patent protection within R&D-sequence analysis does not inherently lead to positive economic welfare benefits for society (compare e.g. [BM00]). The main reason being the possibility that legal patent protection may be (mis-)used to impede and inhibit further innovations by third parties. If R&D is sequential and additional research efforts of competitors act complementary with regard to the quality and quantity of societies' total research productivity, then one may constitute that a negative patent blockade effect may emerge. In fact, it has been observed for the biotechnology sector that patents have already been granted with very widely defined property rights for the patent holder, and that such blockade effects are to be observed (compare [OEC02], p. 30).

On the other hand, the absence of patents in a specific step t or period does not necessarily mean that a blockade effect will not occur given that the technological informational advantage remains confidential, i.e. the inventor is capable of enduring secrecy. Usually in the literature, the possibility of securing informational secrecy is not adequately regarded. It is much more often the case that the literature on patent processes commonly argues along the lines that once a stage of development has been achieved by some enterprise, all other competitors unlimitedly discover the new application and apply it. If this were the case, an inventor without a legal patent right granted to him or her would dispose over no advantages relative to their rivals.

Looking through the relevant literature on innovation processes as well as empirical observations within the current praxis of the biotechnology sector, it may be contended

that this situation represents a special case and is not commonly observed to be valid in general (compare e.g. [Hul01], p. 123; [Spa01], p. 10, and [ZDB98], p. 290). If, however, one may assume that the informational content of a new innovation diffuses very slowly, or perhaps special additional knowledge capacities are required to implement the new technology, or if efficient secrecy mechanisms exist to protect the technology, then an inventor would have a competitive advantage in the next stage of the R&D process. A strategy of confidential secrecy would thus be lucrative and economically attractive in such a competitive environment. If the innovator decides to keep his discovery secret, then it may come to similar blockade effects such as those discussed above for patents. In other words, less patent protection does not inherently mean enhanced research results based upon additional research efforts, but rather confidential secrecy strategies become economically more attractive.

Significant for the following argumentation is the fact that a confidential secrecy strategy can only be successfully implemented given that a patent grant application is n o t filed. This is due to the situation that once a patent has been registered for filing the private information becomes public and public disclosure of the know how is given. Certainly, from an aggregate economic perspective this transparency is exactly one of the main benefits of a functioning patent system, that is private information is made public and nothing is held to be secret. As such, an inventor can only choose between the two strategies, *confidential secrecy without patent protection* or *patent protection with information and know how disclosure.* A strategy of *confidential secrecy and patent protection*, which for obvious reasons would be a preferred strategy, therefore does not exist.

Tilman (2001) (see [Spa01]) describes the circumstances such that new knowledge

in the modern biotechnology sector exhibits a natural exclusiveness. Traditionally knowledge is observed to be characterized by its public good nature, which makes it impossible for the creator of new knowledge to exclude usage by others. This conception of a perfect spillover effect is not valid for the modern molecular biotechnology sector. Numerous patent registrations and the high level of attractiveness for the strategy patent protection leads to an improved diffusion of frontier technology know how. As a result, the choice of the patent protection strategy in the modern biotechnology sector countervails and mitigates the natural exclusiveness principle .

Summarizing, on the one hand patents with elements of vast property rights may lower society's innovation rate. For example, some researcher B will not be able to follow through the innovation step $t+1$, if this requires the fundamental knowledge contained in the exclusive patent rights granted to researcher A for innovation step t if researcher A blocks or prohibits its usage (often referred to as "sleeping patents" in the literature). As such, patents may cause a negative blockade effect or barrier to entry for newcomers within R&D-sequences of the biotechnology chain. The consequence being that less researchers will be active in the field of the observed sequence due to the legal patent environment and the probability p of a successful R&D innovation will be reduced. On the other hand, the complementary nature of the circumstances has the effect that a single researcher A alone will never be as successful as researcher A and B together. However, in order that researcher B does not forfeit in the R&D process, he must have access to the knowledge developed by researcher A in stage t. Without a patent, researcher A has the possibility of keeping his know how secret, which gives him the opportunity to sustain his competitive advantage over researcher B. At the same time patents thus also guarantee a positive information effect. More researchers

will now be active in the field of the observed biotechnological sequence due to the simple access to a fundamental technology base. This enhances the total probability p of success of research and development efforts due to the existing complementary effects.

3.3 Decisive Variables

In the molecular biotechnology sector the welfare effect G of patents depends upon the R&D probability of success p and the degree of patent exclusiveness ε, which represents the legal environment and the various dimensions of patent systems. In addition, the welfare effect will also be determined by the regional specific cultural and traditional elements of society with regard to the practice of granting and implementation of property rights. We now discuss briefly both of these facets.

3.3.1 The Legal Environment

An important determinant of the aggregate economic value of patent protection in the R&D system described here is the degree of patent exclusiveness ε (with $0 \leq \varepsilon \leq 1$), which a research team can apply for after a successful cessation of a new R&D step. The degree of patent exclusiveness ε results from a combination of the individual dimensions of the patent system institutionalized, which may be regulated by government policy (for an interesting survey of relevant dimensions of the patent system consult e.g. [DL97]). An invention commonly opens up a variety of potential revenue options. This is especially the case for so-called basic science innovations with development potential. All the same, even individual innovations, for example, in the form of diverse product variants may be successfully differentiated and can

still offer profitable opportunities given densely populated competitive segments of a market. The degree of patent exclusiveness ε indicates the share of all potential revenue - and product variant combinations that may be solely appropriated by an individual researcher or research team. In view of the fact that revenue opportunities are commonly not only dependent upon optimal timing of innovations, one must also take the legal patent duration into account as a major significant constituting element of ε.[4] The situation characterized by a degree of exclusiveness equal to zero ($\varepsilon = 0$) exemplifies the case of no patent protection. $\varepsilon = 1$ marks the patent protection case, which gives a researcher an absolute monopoly and the potential power to set up a full legally protected information blockade. Of course an exact measurement of ε in reality will be rather difficult. Just the same, it may be reasonably argued that a specific degree of exclusiveness with the prescribed attributes exists. In addition, for the following analysis it is not necessary to specify ε further.

3.3.2 Regional Patent Behaviour and Productivity

If one compares the number of submitted and granted patents of Japanese and European enterprises, it is observed that R&D departments of Japanese enterprises have a much higher propensity to claim legal patent protection. This stylized fact is nothing new and is usually explained based upon differences in the respective legal environments of these two countries. It is often contended that the Japanese system is more significantly founded upon public information disclosure and collective information creation, whereas patent systems of western countries such as Europe appear to be more

[4] ε is hereby distinguished from the common concepts of patent scope or patent width found in the literature. Although these concepts are similarly defined (compare e.g. [GS90] or [Kle90]), they usually are analysed separately from the patent duration.

restrictive and emphasize the private character of intellectual property. The patent system and property rights in general, are embedded in the defined framework of the national innovation systems present and the cultural heredity of society. This implies that culture and tradition strongly affect the legal patent environment given (compare [Hul01], p. 123).

If regional specific differences founded upon cultural and traditional values with respect to property rights and the indigenous innovation system exist, the question emerges whether such differences also directly affect the patent behaviour of economic agents within the R&D process. In order to make a comparison, it would be necessary to exclude the effects of the legal environment upon the respective regional patent behaviour. In the following it is thus assumed that Japan and Europe may be regarded as being within the same institutional patent regime.

Patent registrations for genetically engineered innovations of significant magnitudes are only to be observed at the United States Patent and Trademark Office (USPTO), the European Patent Office (EPO), as well as the Japanese Patent Office (JPO). Basically, one would expect to find that modern biotechnology enterprises desire to obtain patents worldwide. Just the same, it should not be overlooked that commonly first the avenue of the national patent office is preferred. Such local effects must also be eliminated from the investigation. Consequently, only the patent behaviour statistics as registered by the USPTO are considered here. Table 1 below compares patent productivity in Asia, Europe and the USA. Patent productivity is defined here as the number of patents granted per 1 million dollars of R&D expenditures in the field of molecular biotechnology.

Table 1: A Comparison of Regional Patent Productivity in 2000

	Asia/Pacific	Europe	USA
granted patents*	470	1050	3700
R+D expense** ($m)	175	4244	11532
Patent Productivity ***	2,69	0,25	0,32

Sources: OECD 2002, S. 36; Ernst and Young 2002, S.10; own calculations
* Patents granted by USPTO in the area of biotechnology which consist of class 435 (Molecular biology and microbiology) of the USPTO classification system.
** in the area of Biotechnology
*** granted patents per 1 m $

Table 1 illustrates that the patent productivity of Asian enterprises is actually significantly larger then their European or American counterparts. It may also be observed from Table 1 that the patent productivity for Europe and America is of similar magnitude. Analogous results are obtained if one examines the situation based upon patents submitted and patents granted by the EPO (compare [OEC02], p. 37).

Accepting the underlying assumption of one proposed legal environment, the observed differences in regional patent productivities suggest evidently that over and beyond ε further additional influences are at work in determining the patent behaviour in the considered regions. These alternative influences may represent e.g. differences in cultural and traditional aspects affecting the demand for patent protection, which will be designated by k in the following. Which specific factors exactly influence k will not be discussed in this paper. It is simply postulated here that $k_J > k_D$ and that with increasing magnitudes of k the incentive to apply for a patent increases.

3.4 Theoretical Aspects of Blockade- and Information Effects

The attractiveness of the two proposed basic strategies *confidential secrecy* and *patent protection* from the perspective of a researching enterprise is fundamentally dependent upon how intensive the potential patent protection is, i.e. how large ε is. Given $\varepsilon = 1$, there is no reason for an enterprise to forgo patent registration or to attempt to implement secrecy. Despite the information effect which is 100 percent given $\varepsilon = 1$, it is legally possible for an enterprise to prohibit any leakage of patented know how to competitors. If $\varepsilon = 1$ competition does not emerge. As ε decreases, a confidential secrecy strategy becomes increasingly attractive since researchers must assume that potential competitors – based upon the legal opportunities and the respective profit yields given – will expand their activities. As $\varepsilon \rightarrow 0$ patents basically lose their protective effect and a patent protection strategy turns out to be ineffective and the information effect is lost. The alternative strategy to patent protection is a confidential secrecy strategy. Given an increasing ε the incentive to have an innovation patented increases and the corresponding information effect also increases as the inclination to sustain secrecy decreases and vice versa.

Now we introduce l , with $0 \leq l \leq 1$, which represents a function of the variables ε and k and reflects the incentives for the choice of the strategy patent protection. Thus two general cases are obtained: $l(\varepsilon = 0, k) = 0$ and $l(\varepsilon = 1, k) = 1$. In the first case, the implication is that independent of cultural elements k a patent strategy will not evolve because of the fact that patent protection is ineffective due to a lack of sufficient incentives. In the second case, there exists an optimal patent protection and consequently there is no reason not to go for the patent protection strategy. Within

the interval $\varepsilon \in [0,1]$ the function l may be plausibly assumed to be monotonic and increasing, however, the functions exact path remains unspecified. This relationship is valid independent of cultural effects k , which determine the manner and degree of increase and curvature of the function l. Given these prerequisites the following is valid for the incentive function l :

$$l = l(\varepsilon, k) = \varepsilon^{\frac{1}{k}} \quad . \tag{2}$$

Further, it is postulated that for the cultural effect (k) and the legal environment effect (ε) on the function l it holds that:

$$l_k > 0 \quad \text{und} \quad l_\varepsilon > 0 \quad . \tag{3}$$

Without explicitly modelling the concrete path of l, we postulate here a general form of a first-order polynom $(ax + b)$ with $a = 1$ and $b = 0$. Thus, $l(\varepsilon, k)$ fulfils all above stated conditions. Now looking at the exponent $1/k$, the concrete path of the function may be plotted for different k as in figure 2.

In order to examine the features of the function l more closely it is necessary to introduce an exponential connexion of ε and k. In so doing, when deriving the maximal economic benefit for society G dependent upon the magnitude of the legal environment exclusiveness ε the variable k is still observed. Consequently, one immediately observes that an optimal degree of exclusiveness is not independent from the cultural and traditional heritage aspects k.

Both the blockade - and the information effects mentioned above have an important effect on the number of actively working research teams in the biotechnology R&D-system present. This in turn also strongly influences the resulting degree of complementary properties given in the R&D-system and the scale of the probability

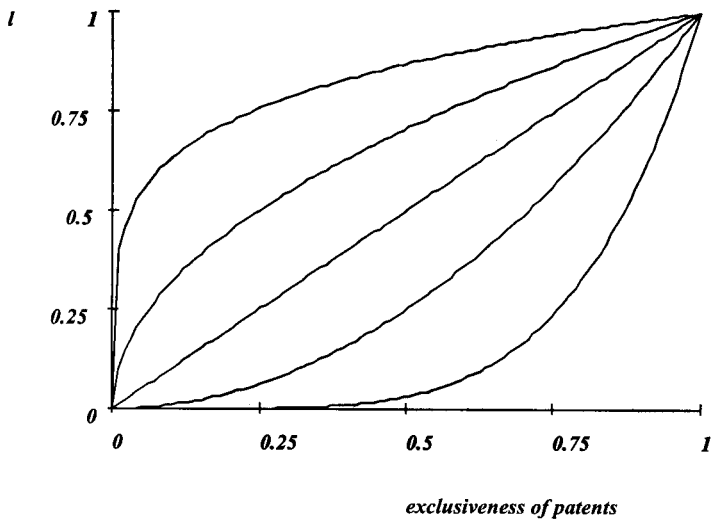


Figure 2: The function $l(\varepsilon)$ for different k

p for determining the level of success in a specifically observed stage t of the research sequence. As the information effect becomes stronger the probability p of achieving a successful new innovation increases. Contrarily, as the blockade effect increases the probability p of success sinks. l represents the relevant R&D strategy decision-making process for enterprises active in the biotechnology sector regarding the two strategies patent protection and confidential secrecy. As the function l increases more research teams on average choose to follow a patent protection strategy. This enhances the information effect, which improves also the complementary advantages inherent in the biotechnology R&D-system. Simultaneously, however, as the information effect grasps throughout the R&D-system the force of the blockade effect emerges and reduces the positive features of an effective patent protection from the viewpoint of society in general. Assuming for simplicity a linear blockade effect, then it follows that the aggregate

probability of R&D success p is:

$$p = p(\varepsilon, l) = (1 - \varepsilon) l \hat{p} \tag{4}$$

respectively,

$$p = p(\varepsilon, k) = (1 - \varepsilon) \varepsilon^{\frac{1}{k}} \hat{p} \quad , \tag{5}$$

with $\hat{p}$ designating the maximum R&D probability of success observing the realisation of all conceivable elements of complementary effects given. Consequently, the positive social benefit effect G exemplifying the respective introduction of the corresponding legal patent protection environment present for the individual steps of the innovation process observed may be calculated as follows:

$$G = \sum_{t=0}^{t_{max}} \left[\left((1 - \varepsilon) \varepsilon^{\frac{1}{k}} \hat{p} \right)^t \left(1 - (1 - \varepsilon) \varepsilon^{\frac{1}{k}} \hat{p} \right) (tv - (t+1)c) \right] \quad . \tag{6}$$

3.5 Results

It is assumed here that $k_J > k_D$ and that the relevant parameters of the model reflect the actual situation given for the respective Japanese and European patent systems. Then we may graph the social benefit functions for Europe (G_E) and Japan (G_J) respectively as illustrated below in Figure 3.

Observation of Figure 3 portrays the following results: Given $\varepsilon = 0$, the value of the function l is also zero ($l = 0$). Furthermore, the probability of R&D success is also zero ($p = 0$) and thus the value for the social patent protection benefit function is also zero ($G = 0$). This means that without patent protection there will be no aggregate social benefit to be obtained and biotechnological research will be relinquished. It must be noted here that the function G represents solely the additional benefits for society of

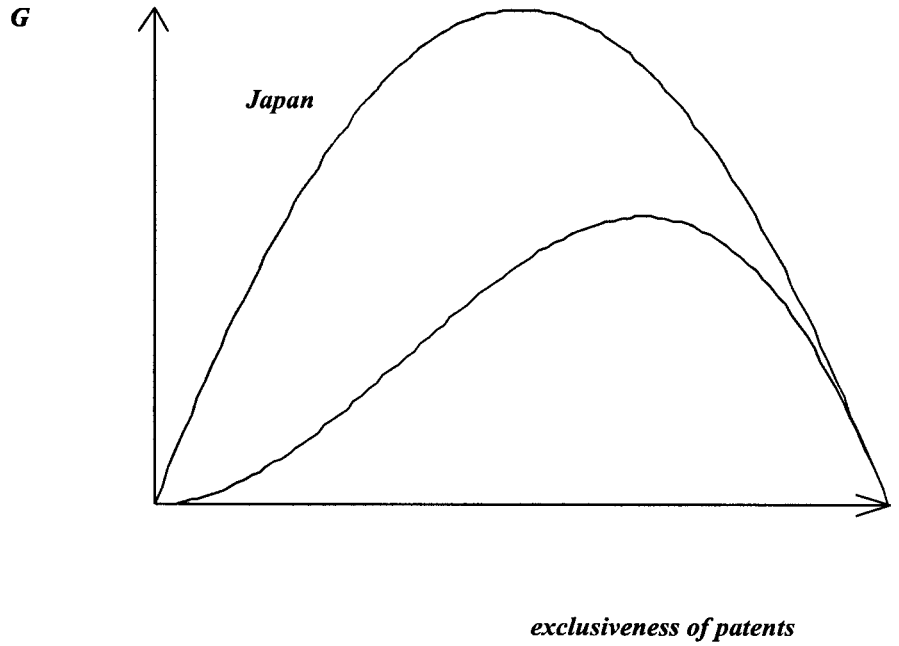


Figure 3: The Social Patent Protection Benefit Functions of Europe and Japan

patent protection per se and does n o t reflect the total conceivable social net benefits of genetic engineering as such.

In addition, Figure 3 above illustrates that the social benefit returns are greater in Japan than in Europe, due to the fact that the established Japanese property rights environment is characterized by a higher level of information disclosure of the patent system. As described above in Section 3.2, the natural exclusiveness principle is fundamentally less severe in Japan and as a result there exists a lesser amount of impediments to the sequential innovation process as compared to the European patent system. This is valid for the situation with patents, as well as the situation without patent protection.

Along the increasing part of the G function the information effect dominates the

total effect of patent protection obtained and takes precedence over potential blockade effects. Starting from a point of very weak patent protection (i.e. a low value of ε) the information effect will first dominate and as patent protection laws become more stringent (increasing values of ε) the blockade effect will predominate the situation. This is because even a weak patent law environment induces a small information effect. Is a situation without patent protection better than a situation with weak patent protection? In attempting to answer this question, one must observe that in a situation with weak patent laws the blockade effect does not hold. On the other hand, one must account for the possibility of the implementation of the confidential secrecy strategy by enterprises which may result in even higher levels of the blockade effect than in a patent regime characterized by a small ε.

The optimal degree of exclusiveness ε for biotechnological patents in Europe is greater for Europe as compared to Japan. This suggests that at an earlier stage in Japan, as ε increases the blockade effect will dominate the information effect. At first observation, this may appear to be less plausible since the information effect in Japan is founded upon a greater value of the variable k. However, since $k_J > k_D$, the level of the social benefit welfare effect is greater in Japan than is the case for Europe. At this higher level consequently the scale of the positive information effect is fragile and less stabile. As such, despite the earlier dominance of the blockade effect in Japan, the total Japanese level of G is higher than for Europe.

Since $G \geq 0$ is always valid, patent protection always has a positive economic welfare effect. As such patent protection is in principle never detrimental. This observation may easily be falsely evaluated if one presupposes as an alternative to following a patent protection strategy that a perfect confidential secrecy strategy is permissible.

Under such a no patent protection scenario an absolute confidential secrecy leads to a total knowledge blockade effect. However, realistically if the degree of sustainable secrecy is indeed limited throughout time, patent protection may create negative effects. Namely, then when given a scenario of R&D activities in spite of no patent protection insufficient means of preventing information disclosure effects abound. Under such circumstances additional patent protection may create a negative blockade effect, however, without creating a supplemental information effect. Since in reality it is commonly observed that only limited levels of confidential secrecy exist, the above statement must be reconsidered. One may state that a certain degree of patent protection is definitely beneficial for society, however, a very strong patent regime may create negative economic welfare effects.

4 Conclusions and Summary

Under the assumption of similar general legal environments, the above analysis and comparison of the relative patent productivities of European and Japanese enterprises in the field of molecular biotechnology and genetic engineering suggests that a strategy of confidential secrecy is less significant for Japanese enterprises as it is for European enterprises. This result is independent of the institutionalized legal patent prerequisites such as ε. This phenomenon can be explained by the differences in the cultural and traditional heritage with regard to the granting and claims to property rights inherent in patents as exhibited in the variable k of our model structure. Naturally, other reasonable additional explanations for the observed stylized facts may exist such as differences in the size and organization structures of European and Japanese enterprises

and their respective propensities to cooperate which has not been analysed here. The Japanese biotechnology sector is dominated by a few large enterprises, whereas in Europe typically biotechnology companies are rather small and usually employ less than 10 employees. All the same, independent of which explanation one might prefer, the formal analysis suggested here given the situation $l_J > l_D$ always results in $\varepsilon_J^{opt} < \varepsilon_D^{opt}$

This result is due to the fact that the information effect induced by patents is less significant in the Japanese patent regime as compared to the European patent regime. Founded upon a greater value of k (representing cultural and traditional heritage aspects) in Japan the amount of patent induced information disclosure effects is not as essential as it is for Europe. Due to Japanese cultural and traditional heritage aspects, the level of information disclosure regarding basic genetic knowledge appears to be more open than in Europe. It may be concluded that patent protection in Japan has a stimulating effect on the amount of information diffusion in Japan, however, not as strong as is the case for Europe. Consequently, the blockade effect in Japan is comparatively dominant, i.e. in Japan the negative aspects of patent protection effect the system more immediately. Thus, one might argue that less patent protection is more fruitful for Japan.

Given the above analysis presented in this paper, the current endeavours of the USA, the European Union and Japan to harmonize patent legislation for the biotechnology sector appears to be flawed. If the analysis above is correct, then the implementation of a future harmonization of patent legislation laws leading to a greater magnitude of ε (legal environment exclusiveness) will negatively affect Japan's biotechnology sector. On the other hand, if regulation of the patent policy regime results in a smaller ε, then Europe will have to make a sacrifice. It should be briefly commented here that the

analysis presented here does not take account of current attempts within the harmonization debate to eliminate additional administrative transaction costs of applying for patent status, since these efforts appear generally non-disputable.

A further conclusion of the analysis presented may be stated as follows: A confidential secrecy strategy will be followed if patent protection is not given or such a strategy may not be ensued if an inventor perceives the parameter constellation of the combination of ε and k to be such that it appears non-economical. This contrasts to the general assumption often found in recent literature that an inventor basically always desires to patent his innovation. An economic agent may prefer not to patent his new knowledge given that a sequential research and development process path under a confidential secrecy strategy could lead to higher returns and sustainable dynamic competitive advantages. At this point, one may observe the limitations of an exogeneously defined patent policy. The patent policy regime no longer necessarily has the entrepreneurial behaviour effects desired once a confidential secrecy strategy becomes the dominant behaviour observed. In the model structure presented here, this effect would occur sooner, the smaller k is. Only a very high level of ε would result in a noticeable influence on the respective patent productivities.

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