ON THE NEED OF NEW MECHANISMS FOR THE PROTECTION OF INTELLECTUAL PROPERTY OF RESEARCH UNIVERSITIES

by

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Av Rovisco Pais, 1096 Lisboa Codex, Portugal

published in:

TECHNOLOGY TRANSFER: FROM INVENTION TO INNOVATION

editors: A. Inzelt, J. Hilton

Kluwer Academic Publishers

1998

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ABSTRACT

This paper discusses the need of reforming the current systems of intellectual property protection, aiming at reflecting the challenges created by the advent of the knowledge-based economy. In a previous paper we argued that the rationale for undertaking intellectual property protection in 'research universities' is the strengthening of the institutional integrity of universities (Conceição et al, 1998). In the present paper, we briefly analyse the economic impact of the American and European systems of intellectual property protection, which were designed to meet the needs of the industrial era. In particular, we observe that the nature of today's inventions is rapidly turning the current system inadequate and ineffective, in particularly in the areas of life sciences and information technologies. Today's technologies and inventions have created new potential forms of intellectual property that cannot be handled using the current system. We focus our analysis in the university sector, and discuss four main challenges research universities are currently facing.

1. INTRODUCTION

In a previous paper we argued that technology transfer, including the protection of intellectual property, should be explicitly acknowledged in the context of the university function (figure 1) as a way to achieve the requirements of preserving the university's institutional integrity (Conceição et al., 1998). By institutional integrity of the university we refer to the idea based on Rosenberg and Nelson (1996), Dasgupta and David (1994), David (1993) and Pavitt (1990), in that universities have developed over the centuries an institutional specialisation by which they perform a unique societal role, by virtue of leaving largely public the results of their research and teaching activities. This specialisation has been accompanied by the emergence of other institutions, such as firms, that have developed their own features, namely the fact that they strive for profit by privatising the outcomes of their production processes. Although universities are important in creating technology, they are crucial in creating science, the non-excludable portion of software, as discussed in section 3. A threat to the institutional integrity of the university would mean, for example, that there would be fewer incentives to produce non-excludable software, and that there would be a lack of investment of other institutions in producing this type of valuable knowledge.

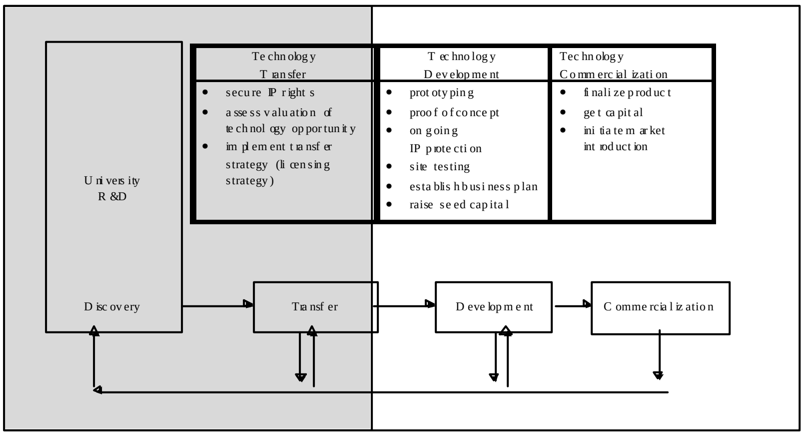
The analysis above should be considered in terms of the current understanding of innovation, in that the challenge of technology innovation requires the consideration of the entire process from research and development (R&D) in the laboratory to successful commercialisation in the marketplace. Traditionally, successful commercialisation of R&D was the result of an automatic process that began with scientific research and then moved to development, financing, manufacturing, marketing and subsequent internationalisation, without sustaining connections among academic business and government leaders. Today, the relationships between technological innovation and economic wealth generation, markets, and job creation involves more than capital investments. It demands an integrated and interactive approach that blends scientific, technological, socio-economic and cultural aspects in rapidly moving environments.

Kline and Rosenberg (1986) argued that there are complex links and feed back relations between firms (where the innovation takes place) and the Science and Technology system, and proposed the interactive model of innovation. Myers and Rosenbloom (1996) extended this model to explicitly express organisational capabilities and the special characteristics of innovations. In this model, organisational capabilities are considered as the foundations of competitive advantage in innovation, and include: firm-specific knowledge, communities of practice, and technology platforms. Firm-specific knowledge, represents the accumulated learning of the organisation, which is pertinent to the business. This shall be distinguished from the body of generally accessible knowledge. The specific knowledge of a firm is embodied in the firm's people and its technology platforms, products, and processes. Communities of practice are ensembles of skilled technical people with expertise on working across the organisation. These communities span organisational divisions and provide both a repository for the firm's expertise and a medium for communication and application of new knowledge. Technology platforms are an output of the design process, which provide a common framework on which families of specific products and services can be created over time. A platform comprises an ensemble of technologies configured in a system or subsystem that creates opportunities for a variety of outputs.

In the context of this model, the question which does arise is how research (namely, at the university level) contributes most effectively to the profitable execution of the chains of innovation. Using the terminology of Myers and Rosenbloom (1996), "effective" research will contribute to the base of general knowledge, but "productive" research requires the corporation to build the organisational capabilities (i.e. firm-specific knowledge, communities of practice, and technology platforms). At the university level, it is clear that it is research, not commercial design and development, the field in which academia, are expected to excel. Technology transfer activities are valued in order to secure intellectual property rights, to assess the valuation of technological opportunities and to implement transfer strategies.

Figure 1: A Framework for the Interaction of University R&D and Technology Transfer in the Context of Innovation

(the shadow area includes the priority activities on which a *research university* should concentrate)



Source: Conceição, P., Heitor, M., Oliveira, P. (1998)

The aim of this paper is to present the motivations and to discuss the challenges, for the development of a new system of intellectual property protection for universities, considering the relation between R&D and economic growth, and the challenges created by the advent of the knowledge based economy.

In this context, the following section presents the reasons that motivate the development of intellectual property policies for universities, and gives experiences of American and European universities. In section 3 we briefly introduce aspects of the economics of knowledge and intellectual capital, namely by classifying knowledge according to the degree of rivalry and exclusion, and discussing some of the elements considered in the decision of protecting intellectual property. Section 4 discusses the main challenges universities are facing in the context of the current socio-economic context, and discusses the need of reforming the actual systems of intellectual property protection. Finally, a summary of the main findings is presented.

2. THE CONTEXT FOR INTELLECTUAL PROPERTY PROTECTION

The important strategic role that universities can play in helping nations to meet public policy goals has been extensively recognised, including public safety, quality of life, health care, environmental protection and economic competitiveness (e.g. Mowery and Rosenberg, 1989; Readings, 1996; Lucas, 1996; Ehrenberg, 1997). This has been achieved by the creation and distribution of knowledge, improving the competencies and skills of the labour force, and contributing to the development and commercialisation of new technologies. In this context, the protection of the intellectual property is a key institutional mechanism, since it provides incentives for the private production of R&D. Research universities, in particular in the US, have taken advantage of this mechanism by deriving financial benefits from the creativity of academic scientists.

However, successful technology transfer depends on a complex web of interactions, and is highly contingent on the specificity of the place where the transfer occurs (Kim et al, 1997). The particular institutional history, geographic context, legal setting, and other factors, demand customised policies and practices. It is within this context that we present in section 2.1. the experience of American universities in protecting their intellectual property, and then, in section 2.2., discuss the European context.

2.1. Intellectual Property Protection and Technology Licensing in American Universities

American universities have been particularly successful at contributing to the accomplishment of commercial opportunities, whilst related actions in Europe have been erratic in quality and scarce in quantity. In the United States, new innovations have benefited from a close interaction between universities and the community, as recently discussed extensively by Rosenberg and Nelson (1986). In the context of the complex web of relationships between universities and firms, intellectual property by universities represents a small portion. Nonetheless, it is worthwhile to look in further detail at the impact of intellectual property actions by US universities in order to make two points: first, that the existence of explicit strategies for intellectual property protection in the US has provided the generation of sizeable aggregate level of income. On the other hand, the impact of the income at the institutional level is negligible on average.

A economic impact model developed by the Association of University Technology Managers (AUTM, 1998; AUTM, 1998) shows that more than $24,8 billion of US economy activity can be attributed to the results of academic licensing. This figure includes both pre-production investments ($4 billion per year) and post-production sales of products by licensees (17$ billion per year). The increasing value of new academic discoveries is illustrated in table 1, which shows that academic institutions, hospitals, and research institutes earned more that $415 million in royalties in 1995.

Table 2 shows the evolution during the last years of the research expenditures in American universities. There is an increasing rate of growth of royalties received in comparison with R&D expenditure, which reflects the growing importance of intellectual property rights.

Some American universities have been particularly benefited from R&D income and royalty. As a point in case, MIT has received $38 million in license revenues. At Stanford University since 1969, when the Office of Technology Licensing was founded, royalties have surpassed $111 million, capitalising from inventions such as Recombinant DNA ($53.4 million) and FM Sound ($13.9 million). Other universities have also benefited from significant funding from licensing fees, normally associated with a particular invention. Besides MIT and Stanford, "big-winners" include University of Wisconsin (with Warfarin and Vitamin D), Michigan State (CIS Platinum), University of Rochester (Hemphilus Vaccine).

Table 1: Gross royalties received by US Universities, Hospitals and Research Institutes

Royalties received	US Universities ($ million)	% change	US hospitals & research institutes ($ million)	% change
1991	$122.9	-	$32.0	-
1992	$159.0	29	$45.4	20
1993	$212.7	34	$62.1	0
1994	$236.7	11	$71.7	9

1995	$270.8	14	$83.0	85

Source: AUTM Licensing Survey 1991-1995

Table 2: Total research expenditures in US Universities, Hospitals and Research Institutes

Total research expend.	**US Universities ($ million)**	**% change**	**US hospitals & research institutes ($ million)**	**% change**
1991	$10,264.9	-	$776.7	-
1992	$11,033.0	7	$858.9	11
1993	$11,655.6	6	$1,014.0	18
1994	$12,801.4	10	$1,063.0	5
1995	$13,297.4	4	$1,180.9	11

Source: AUTM Licensing Survey 1991-1995

Despite the impact of patents income at a few American universities and the overall growth illustrated in tables 1 and 2, we should stress that, on average, the share of royalties in the total research expenditures remains small, and below 0,2%. In addition the analysis of table 3, considering the value of the patents listed, shows that the number of universities in which the protection of intellectual property is relevant, is very small.

Table 3: Number of patents in some US universities

University	Patents in 1995
University of California	219
Massachusetts Institute of Technology	107
University of Texas	90
Stanford University	55
University of Wisconsin	47
Cornell University	41
California Institute of Technology	38
Iowa State University	37
University of Florida	33
North Carolina State University	31
State University of New York	31
University of Michigan	29
Virginia Polytechnic Inst. & State University	29
Johns Hopkins University	28
University of Minnesota	27
Duke University	26
University of Pennsylvania	26

Source: AUTM Licensing Survey 1991-1995

A recent profit/loss analysis of technology transfer programs in U.S. universities, hospitals, and research centres (Trune and Goslin, 1998) concluded that only 40,5% of all institutions generated enough royalties to offset the cost of maintaining the administrative office (technology transfer office costs, patent fees, and legal expenses). This was estimated by taking one-third of the royalties less the cost of maintaining the technology transfer offices. The most profitable offices appeared to be those within technological institutes, universities with medical schools and hospitals/research centres (table 4).

Table 4: Profit and Loss Calculations for Technology Transfer Offices

Loss/Profit	Medical Schools	Technological Institutes	Universities with medical schools	Universities without medical schools	Hospitals and research centres
Loss					
> 200	1	-	12	5	4
100-200	6	2	8	9	6
0-100	3	1	13	24	4
Profit					
0-100	2	1	7	7	4
100-200	-	-	6	1	-
200-300	-	-	2	2	1
300-400	1	1	-	-	-
400-500	-	-	1	1	1
500-1,000	1	2	4	2	2
1-5,000	-	-	9	2	3
>5,000	-	-	2	-	3
Number (%) profitable	4/14 (28.6)	4/7 (57.1)	31/64 (48.4)	15/55 (27.3)	14/28 (50.0)
Mean profit ($000)	1.7	176.8	540.6	40.3	1,1135.1
Range of profit and (loss) ($000)	(297)-808	(179)-650	(619)-11,830	(984)-3,233	(501)-10,583

Source: Trune and Goslin, 1998

Concerning the calculations for overall university program, the study concluded that only 48,8% of these institutions operated at a profit (table 5) This figure was estimated by taking two-thirds of the royalties income less all university expenditures required to operate the technology transfer program.

Table 4: Profit and Loss Calculations for Overall University Programs

Loss/Profit	Medical Schools	Technological Institutes	Universities with medical schools	Universities Without medical schools	Hospitals and Research centers
Loss					
> 200	2	1	14	7	2
100-200	1	2	7	12	7
0-100	5	-	7	18	2
Profit					
0-100	1	1	5	7	1
100-200	1	-	2	1	1
200-300	1	-	4	2	3
300-400	-	-	4	-	1
400-500	1	-	3	-	-
500-1,000	1	2	4	3	-
1-5,000	1	1	11	4	8
>5,000	-	-	4	1	3
Number (%) profitable	6/14 (42.9)	4/7 (57.1)	37/64 (57.8)	18/55 (32.7)	17/28 (60,7)
Mean profit ($000)	198.9	405.9	1,310.9	206.6	2,629.3
Range of profit and (loss) ($000)	(376)-2,019	(310)-2,007	(709)-25,200	(1,263)-6,709	(237)-21,340

Source: Trune and Goslin, 1998

Although the figures of the tables do not represent the specific trends of the leading American research universities mentioned above, the expectation is that this share of royalties in the total research expenditures will remain negligible.

2.2. The European Situation

The analysis above shows that the impact of licensing income is, on average, negligible in the American academic system. This is not a reason not to develop a strategy for intellectual protection in universities. In fact, some specific institutions may, indeed, benefit from generous payoffs from patents. However, we argue that there is a deeper and more fundamental rationale for undergoing university policies of intellectual property protection. In this section we discuss briefly how the perceived lag of Europe in terms of producing innovations has led to a sense of urgency in terms of pushing universities, and R&D in general, towards more applied type of research.

In recent years, namely since 1992, the relative weakness of the European industry has been discussed, particularly in terms of the objectives of the Single Act and of the provisions of the Maastricht Treaty. Three major indicators have been mentioned, mainly Europe's competitive edge has been blunted; its research potential is being eroded; and, finally, a weak position with regard to future technology. It is clear that the EU has a relatively much lower level of R&D overall than America and Japan. In 1995 the ratios between total R&D expenditure and gross national product were 2.45% in the USA, 2.9% in Japan and only 1.91% in the European Union.

In addition, whilst the demand for research personnel is constantly growing, the supply can hardly keep up, especially in Europe, where the number of technology students and academia is far less than in the other competing parts of the world. Even more important than the absolute number of researchers, are their qualifications, the ability to meet the needs of developing industries and the extent to which the capital they represent is utilised.

Overall, the lower investments in both financial and human terms give cause for concern, especially in a context where intangible assets and intangible investments are the best guarantees for future wealth formation. Nevertheless, besides the weak European figures, analysis has shown that the problem is based on the European weakness in integrating R&D and innovation in an overall strategy, which both exploits and orients the results achieved. This weakness stems from a combination of factors, namely: the still inadequate links between universities and enterprises; the lack of facilities for business start-ups by researchers; the lack of venture capital to help firms through the development phase and the reluctance of private-sector financiers to invest in new activities; the insufficient account of R&D in business strategies and the lack of co-ordinate strategies between businesses, universities and the public authorities; and the targeting on markets which are too small and the weak capacity to foresee future needs and demand on the market (e.g., European Commission, 1996; Archibugi et Pianta, 1996; Wallmark, 1997).

Despite an outstanding scientific performance, Europe is far behind the US and Japan in terms of its technological and commercial performance. The results indicate that one of Europe's major weaknesses lie in its inferiority in terms of transforming the results of scientific research into innovations and competitive advantages. This has recently led to a shift in the European R&D policy towards seeking economic relevance in science and technology. The evolution towards the definition by the European Commission of the 5th Framework Program, as well as the First Action Plan for Innovation in Europe (which was released in early 1997), confirm this perception.

Additionally, empirical evidence shows that the European system for awarding patents to innovators is too expensive and too atomised, since there is no single European patent system (Schmitt, 1998; Ferné, 1998). Therefore, the cost of securing patent protection in every member state is high and discourages companies from exploiting their innovative potential. As a point in case, a typical European patent giving protection in eight countries costs around 20,000 ECU (including fees charged by the European Patent Office and national patent offices, patent attorneys charges, but not including translations), which in the US would cost 1,500 ECU, and in Japan only 1,100 ECU. The evidence calls for the need of a truly European system free of institutional and national barriers.

The technological and economic changes are making the current system of intellectual property unworkable and ineffective, since it was designed to meet the needs of the industrial era. Nowadays, new technologies and inventions have created new potential forms of intellectual property that cannot be handled in the same way traditional inventions were, in particular in the fields related with life sciences and information technologies (Thurow, 1997).

It is within this context that we discuss the need for a new system of intellectual property for the European universities, a calling that has been made due to the perception that Europe is lagging far behind in terms of innovation. We argue that intellectual property policies are important for universities and society wide, but that the rationale should not be gathering more financial resources, but rather to preserve the institutional integrity of the university. To make our argument clearer it is important, firstly, to understand the economics of knowledge, namely in terms of the impact of the privatisation of research results.

3. THE ECONOMICS OF KNOWLEDGE AND INTELLECTUAL CAPITAL

This section aims at developing a theoretical framework to analyse the issue of intellectual property. In economic terms, intellectual property awards private rights to knowledge. We discuss the economic features of the knowledge and the economic distinction of the private and public knowledge.

Knowledge has very specific characteristics that make it economically different from objects, (Nelson and Romer, 1996). Using the traditional classification utilised in public finance, economic goods can be classified according to the degree of rivalry and exclusion.

Rivalry is associated with scarcity and expandability of a good, and reflects the idea that, if rival, a good can only be used by one person at a time. Objects are typically rival goods. However, the knowledge contained in, say, a book, is non-rival. The fact that I am reading and enjoying a book does not preclude others from reading the exact same book. The same happens with music stored in a CD, or with a software program.

Excludability is associated with the property rights over a good. A good is excludable if the owner has the legal power to prevent others from using it. Knowledge can be made excludable, through intellectual property rights. In the case of a book, the author holds the copyright, and may not wish people to read the book unless they pay a fee for it (buying the book), or that they read at all (taking the book out of print).

Goods with high levels of both excludability and rivalry are designated as private goods. In this case, there are private incentives for production, for the producers can appropriate completely the benefits arising from the use of these goods by others. On the other extreme, goods with low levels of both rivalry and excludability are public goods. For these goods, such a national defence and public roads, there are no private incentives for production. Governments normally intervene in the provision of public goods. There are also non-excludable rival goods, such as fisheries. In this case, there is rivalry in consumption, but difficulty in excluding people from using the good. Fisheries are part of a broader class of such type of goods named common pool resources (CPRs).

Romer and Nelson (1996) consider that all objects are classified as hardware, material things that are non-human. Knowledge, on the other hand, is divided into wetware, the knowledge stored in the brain's wet computer, and software, knowledge that is codified and is stored outside the human brain. The relevant distinction between these two types of knowledge is that wetware (more familiarly referred to as human capital) is a rival good, since it is linked to each individual human being. Software, on the other hand, is non-rival, in the sense described above.

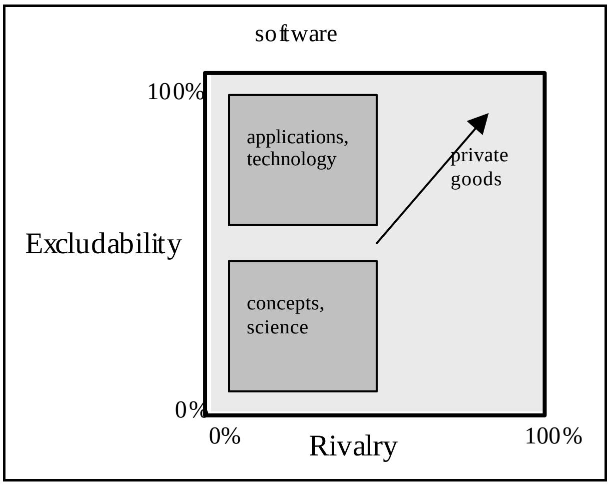
Non-rival software has a low marginal cost of reproduction and distribution (making it difficult to exclude people from its use) and is associated with high fixed costs of original production. These properties have substantial impact in terms of generating economies of increasing returns, as Romer (1990) have argued, leading to the new theories of growth. In the context of this paper, we are interested rather in the mechanisms of production non-rival software, for competitive markets will not allocate resources efficiently in order to produce this type of goods. The reason is, as we argued, the absence of private incentives.

David (1993) proposes three types of alternatives to yield the conditions for the production of non-rival software. The first, patronage, consists on giving direct subsidies to producers, on the condition that the goods must be publicly available at virtually zero costs. The second, procurement, is based on the direct production of the goods by the government, awarding specific contracts to private agents whenever necessary. Finally, the third, property, is associated with the privatisation of the non-rival software, awarding the producer monopolistic rights that yield returns large enough to cover the fixed costs of production. Specific legal instruments include patents, copyrights, and trade secrets.

Both patronage and procurement rely on a direct intervention of the government, by which the non-rival software remains non-excluded, and, therefore, effectively a public good. Property grants private producers on new knowledge exclusive property rights in the use of their creations. This yields the private incentives in which markets operate efficiently. In terms of the matrix of the Figure 2, the issue then is to opt between making software excludable, or non-excludable, since the non-rivalry characteristic is always present.

In the world of science and technology, there is a tendency to consider science as a public good and technology private. Science rests on the publicly available scientific journals and is freely and rapidly disseminated throughout the scientific community and the society at large. Technology is associated with more practical applications exploited by the firms that engaged in its development, and is protected by patents or other instruments of privatising software. Figure 2 illustrates this distinction. Naturally, at the university level there is both science and technology. Indeed, universities often engage in aggressive and effective programs to protect their intellectual property. The motivation is clear: to derive financial benefits from the creativity of academic scientists.

Figure 2: Technology and Science: Two Types of Software



There are several elements that enter into the decision to protect intellectual property, but in this section we should make a note to argue that not often the decision to protect is the most beneficial society wide. In fact, for the common good, it is often more useful to leave the scientific achievements as public goods, especially when they are associated with concepts still in an early phase of development.

4. DISCUSSION: CHALLENGES FOR FUTURE DEVELOPMENTS IN INTELLECTUAL PROPERTY PROTECTION MECHANISMS

The framework established in figure 1, section 1, may theoretically preserve the University's institutional integrity, but brings together a series of questions and challenges for research universities. First, it is clear from the discussion above that the economic impact of protecting the intellectual property protection is expected to be negligible, at least in average terms. In addition, we may select four main challenges universities are currently facing:

1st Challenge: Balancing innovation and diffusion

Establishing intellectual property rights make software excludable yielding private incentives to production. This strategy is often implemented in commercial computer software programs, books, and music CDs. However, there are two difficulties with this strategy. First, it is sometimes difficult to implement and enforce intellectual property rights, especially at the international level, due to the easiness in copying and reproducing software. Secondly, and most importantly, establishing property rights on software may have perverse effects, since if the benefits are given only to an inventor turned monopolist they will not spread society-wide. In other words, too much emphasis may be being given to innovation at the expense of diffusion, which can slow the overall rate of technological change, or knowledge diffusion and adoption. To illustrate this, Nelson and Romer (1996) ask what would have happened if the concept behind a worksheet, first introduced by Lotus, would have been given exclusive rights. The competition between Lotus, Microsoft, and Borland (with their products Lotus 123, and Excel) might never have happened. Therefore, technology policy in general, and University policy in particular, should not only focus on promoting innovation by restricting access to information, so that innovative firms accrue monopolistic profits temporarily.

2nd Challenge: Beyond the excludable/non-excludable dichotomy of software

We have noticed that establishing intellectual property rights makes software excludable, yielding to private incentives to production. This may be appropriate when the software under analysis is, say, a new formula for Coca-Cola. The new software will benefit only one company. When the software under consideration has a potential society wide impact, like, for example, the cure for cancer would have, then this software production should be induced through patronage or procurement. It is in the public interest that the results be society wide available. This is the dichotomy between making software excludable or non-excludable. As Soete (1997) have pointed out, some software may not benefit only a firm, nor the entire society. It can benefit an industry, a region, a group of citizens, a number of countries. In this case, the incentives for collective action should be focused on the subjects affected. To subsidise through general taxation such an effort may not be justifiable. Kyriakou (1997) proposes a couple of instances by which focused mechanisms for collective action within the group of subjects that would benefit from the software may be generated. However, the field here is wide open for innovative institutional settings that need to go beyond the pure public/private approach for giving incentives for software production.

3rd Challenge: Integrating intellectual property protection systems

Empirical evidence shows that the impact of intellectual property policies depends on a variety of factors such as history, endowments, market structure, education, openness to trade and investment, and related business regulations, just to mention a few. On the other hand it is known that the variety of systems, for instance in Europe, creates bureaucracy and inefficiency. The European system for awarding patents to innovators is too expensive and too atomised. Since there is no single European patent system, the cost of securing patent protection in every member state is high and discourages companies from exploiting their innovative potential. This situation contrasts with both the American and Japanese situation, which have a single patent system and legal framework allowing protection in the whole territories. As a point in case, a typical European patent giving protection in eight countries costs around 20,000 ECU (including fees charged by the European Patent Office and national patent offices, patent attorneys charges, but not including translations), which in the US would cost 1,500 ECU, and in Japan only 1,100 ECU. The evidence calls for the need of a truly operational system free of institutional and national barriers.

4th Challenge: Facing new knowledge

The technological and economic changes are making the current system of intellectual property unworkable and ineffective, since it was designed to meet the needs of the industrial era. Nowadays, new technologies and inventions have created new potential forms of intellectual property that cannot be handled in the same way traditional inventions were, in particular in the fields related with life sciences and information technologies. Thurow (1997) illustrate this situation by comparing the invention of a new gene and the invention of a gearbox, concluding that such different inventions can not be handled by the same system of intellectual property protection. Additionally, the recent controversies about laws governing biotechnological innovations, such as cloning of human beings and changing human genes, reinforced the need of a new system of intellectual property, clearly stating how far can elements of the human body constitute patentable inventions.

SUMMARY

This paper discusses the need of reforming the current systems of intellectual property protection, adapting it to the challenges created by the advent of the knowledge based economy. In a previous paper we argued that the rationale for undertaking intellectual property protection in research universities is the strengthening of the institutional integrity of universities. In this present paper, we analyse some facts that turn the current system inadequate and ineffective, and discuss some challenges research universities are currently facing, namely i) the need to balancing innovation and diffusion; ii) the excludable/non-excludable dichotomy of software; iii) the need to integrate intellectual property protection systems; and iv) the challenges created by recent advances in knowledge.

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