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Intangible Assets in the European Health Industry: the Case of the Pharmaceutical Sector

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Abstract

Intangible assets are raising increasing interests among scholars, policy-makers and firms themselves. Companies across countries and sectors stress the increasing importance of human resources, organisational learning and building of capabilities as factors for competitiveness. Some firms are attempting to include measures of their intangible assets into their annual report. Studies of intangibles are developing in both the management and economics literature. The European Commission is stressing the need to formulate policies that favour the development of intangible assets.

Yet the nature, determinants and effects of intangible assets are not clear. Sometimes examples of intangible assets are given as innovation, organisational practices or human resources. Sometimes there are considered as generators of intangible assets and not intangible assets as such. The confusion probably derives from the fact that some assets are simultaneously assets and generator of assets (e.g. knowledge); in addition, intangible assets may be created by a combination of generators: for example, a patent, i.e. an innovation, results from both R&D activity and organisational assets, R&D activities being more effective in certain organisational environments.

In this paper, we analyse intangible assets in the pharmaceutical industry, in order to derive insights as to their nature and their determinants, as well as implications for the health industry model.

We define intangible assets as knowledge and capabilities that, combined together and with tangible assets, generate innovation, increase productivity and value. This definition implies an emphasis on complementarities between assets and activities.

The major implication of the analysis is to provide a deeper rationale for the health industry model. The latter model considers health as a system, between health care providers, financing organisations and health care producers (i.e. producers of drugs, medical apparels, etc.), because their separate consideration leads to the ignorance of important spillovers between the various parts. We show that the major source of spillovers appears to be the complementarity between tangible and intangible assets, and the rise of intangible assets observed in most industrialised countries over the last decades is the reason for the rise in spillovers in the health industry, hence the need to consider it as a system. Policy implications in terms of the competitiveness of the European pharmaceutical industry are also drawn.

1. Introduction

A report to the European Commission (Gambardella et al., 2000) argues that the European drug industry is loosing competitiveness in the face of the USA, although there are differences among EU countries. In particular, the EU is lagging behind in its ability to generate, organise and sustain innovative processes and appears less able to translate R&D into commercial success, partly due to a strategy of reliance on external inputs such as licences from international companies, pricing policies or peculiarities of the public regulatory and health care systems, rather than a strategy of reliance on own R&D and innovation. The European market is more fragmented and less competitive (prices do not fall after patent expiry) than the US one, European firms having to rely more on their domestic market to sell their products than on the whole European one.

Parallel to this, a report to the European Commission by the High Level Expert Group on the Intangible Economy (2000) argues that a key element of competitiveness has become the exploitation of intangible investments such as R&D, proprietary know-how, employees' skills, world networks and brands, and especially the capacity to combine external and internal sources of knowledge. Buigues, Jacquemin and Dewatripont (2000) stress that intangibles such as R&D, marketing, advertising software and training, are growing in importance and have transformed the sources of competitiveness, so much so that public policies should change. They claim that public policies should shift focus towards sustaining intangible investments rather than tangible ones, in particular sustaining R&D and training.

Therefore, intangible assets are being pointed by some scholars as sources of competitiveness and differentials in economic performance. Given that both innovation is about the creation of knowledge and the capacity to commercialise innovation is determined by intangible resources such as organisation (coordination between researchers, between researchers and marketers, motivation, etc.), we ask in this paper whether the source of the difference in competitiveness between European and American pharmaceutical firms lies in intangible assets.

We first analyse intangible assets, in order to provide new evidence on their nature and their effects on competitiveness, apply the analysis to the case of the pharmaceutical industry and conclude on both general policy implications and implications for the health industry model. We analyse the nature and effects of intangibles in the second section, from the point of view of economics. We see them as capabilities resulting from complementary investments in both tangible and intangible resources. For instance, the development of human capital, innovation, the organisation of production is complementary strategies aiming at enhancing the firm's major capability (producing the right product at the right moment, which is the intangible asset of the

firm). Given this preliminary reflection, we analyse in the subsequent section intangibles in the pharmaceutical industry. We show that the difference in competitiveness between the US and Europe can be explained by a difference in intangible assets and a lack of exploitation of complementarities between assets. Policy implications are discussed in the conclusion. The major implication is to provide a rationale for the rise in spillovers between the various components of the health industry, and the resulting need for an integrated view, as proposed by Di Tommaso – Schweitzer (2000).

2 The nature and effects of intangible assets

The increasing interest towards intangibles as factors for competitiveness in the "new" or "information" or "knowledge" economy is now quite obvious (Buigues et al., 2000; Lev, 2000). Just as obvious is the fact that intangible assets are not new. What is new is the importance taken in recent years by intangibles. Most often quoted factors are first, the steep rise in the market-to-book value of many firms parallel to the small rise in the value of their physical assets; the difference is claimed to result from intangible assets. Second, globalisation (hence more intense competition) and the diffusion of information and communication technologies favour the rising importance of intangible assets in that the former implies the increasing use by firms of non-price strategies (differentiation, product innovation), while the latter favours directly the development of intangible activities (higher skilled personnel and services). Third, the diffusion of new organisational practices; firms are reducing the number of hierarchical layers, redefining jobs towards multitasking and team work, more interactions among employees. Communication within and between firms is increasing (in the latter case because of the process of outsourcing and collaboration with other firms, including competitors). This raises the issue of whether the diffusion of new organisational forms is the result of the rise in intangible assets or the cause?

2.1. Intangibles in economics

Such a rise in interest is paralleled by a surprising lack of economic theoretical framework that defines intangibles and their properties. Economics has considered intangible assets, such as innovation, knowledge, human capital and organisation, but all rather separately.

Traditionally, innovation studies have focused mainly on R&D activities and on process innovation, with the expenditure on R&D assumed to determine the rate of innovation, and on the

determination of optimal patent (see Ulph, 1995, Malerba, 2000, chapter 14, for a review; Gilbert – Shapiro, 1990). The basis of the economics of innovation is the analysis of the market failures associated with the market for ideas. Geroski (1995) outlines three main market failures associated with the market for ideas. First, spillovers (externality) arise because of the public good character of knowledge. Thus knowledge is in many respects both non-rival (the use by one agent does not impede the use by another agent) and non-excludable (the producer of a new knowledge cannot prevent other agents to use the knowledge although they do not pay for it). This creates the problem of appropriability, in that it is difficult to prevent other agents from taking advantage of a given innovation. The evolutionary theory disagrees with the non-excludability of knowledge, arguing that some knowledge (tacit) is difficult to imitate (Pavitt, 1995). The second market failure is non-convexity due to increasing returns (innovation has large fixed costs but low or zero marginal costs): marginal cost is then lower than average costs, and marginal cost pricing is not viable (firms therefore try to monopolise the market). Third, risk and uncertainty inherent in the innovation process which may lead to underinvestment in innovation. There are three types of uncertainties in R&D: technological (is it possible to do what we would like to do?), commercial (will there be a market for this new product?) and competitive (will competitors produce better innovation?).

A resulting problem is that it is difficult to price ideas: it is difficult to give a price to an idea before knowing it. However, once one knows the idea, there is no need to buy it any longer (Arrow, 1974). Hence the market tends to undervalue innovation, which leads to low returns to innovation and therefore reduces this incentives to innovate. Arrow (1962) made the first steps in formalising the economic incentives to innovate within an equilibrium framework. He showed that incentives to innovate are higher under competition than under monopoly.

The public policy problem is that it is efficient to have maximum diffusion of knowledge, since marginal costs are nil, but maximum diffusion means low incentives to innovate (trade-off). The problem of spillovers has been at the heart of policy recommendation by economists: suggested policies have been subsidies (in order to maintain incentives to innovate and ensure diffusion), R&D cooperation and patents. Patents provide legal protection of the innovation. However, they have been shown in the empirical literature (Griliches, 1990, Pavitt, 1995) to be undervalued and imperfect since, in particular, they do not protect process innovation, the latter being better protected by lead time, secrecy and first-mover advantages.

In formal models (see Katsoulacos – Ulph, 1995, De Bondt, 1999, for reviews), spillovers are assumed to be a parameter that allow innovation by one firm to have effects (via cost reduction) on other firms. The parameter is generally exogenously given and there is no clear story on its determinants. Empirical research has attempted to measure spillovers but without much success.

Generally R&D by other firms in the industry is added in the productivity equation (that measures the productivity effects of R&D). If the variable turns out to have a significant coefficient, there is spillover (defined as knowledge flow not accounted for in transactions, i.e. externalities). Such a procedure is imperfect in that it incurs problems of aggregation (the spillovers may arise between two firms only and not between all firms in the industry), and it excludes some spillovers, such as the spillovers arising between industries and between the firm and its suppliers. In addition, some knowledge flow can be unintentional and not external and therefore there is no problem for the return to innovation. In fact, in order to measure spillovers one would need to evaluate the importance of different channels through which information flows: publications, employees changing firm, reverse engineering, and so on. The extent to which knowledge flows through these channels depends on the capacity of the receiver, the nature of knowledge, the incentives of individuals. Levin et al. (1987) have provided empirical evidence on the efficacy of a number of knowledge flows in their survey of the conditions for appropriability. They found that independent R&D is often cited as an effective way to learn knowledge from rivals, as well as licences. Other studies show that such channels are numerous and varied and differ according to the sector and the dimension of the firms.

Regarding organisation, its consideration as a factor for differential performance across firms has recently experienced renewed interests, due to increasing evidence of diffusing organisational changes in firms of most countries. The evidence results from surveys asking firms' managers about various aspects of organisational and technological changes. For instance, the COI survey in France was a conducted on a sample of 5,000 firms (Greenan – Mairesse, 1999). Other evidence include Black – Lynch, 1997, 1999, Ichniowski et al., 1997, 1999, for the US (although these surveys are more focused on human resources management systems, i.e. internal labour markets); Coriat (1999) reviews the results of a number of surveys conducted in the EU on organisational changes.

Firms are becoming more decentralised, hierarchies are flattering, employees are involved in teams, job rotation and have increasing responsibility in problem-solving that used to be performed by superiors. Communication within and between firms is increasing. Hence the traditional model of the multidivisional firm, a large, integrated and centralised firm is no longer the dominant model, and this has attracted increasing interests among economists. However, the theory of the firm is made of different approaches which do not provide a complete framework to study organisational changes, in that no theory predicts why organisational changes occur, why they are made of different organisational practices (for instance, team work, together with higher communication, flatter hierarchy, job rotation and not team work with lower communication and fixed job

positions). There is growing evidence that organisational changes are related to innovation and technological changes (Labory, 2000).

One interesting theory is that of complementarities, developed by Milgrom and Roberts (1995). According to them, firms adopt different but specific organisational practices together because those practices are complementary, in the sense of combining to produce positive profit effects. This is formalised in the supermodular properties of the profit function, the idea being that a practice is adopted jointly with other practices if this raises the marginal profit generated by the other practices. Complementarity is an interesting concept; as we will see below, it might the piece of the puzzle, which is missing in order to analyse intangible assets.

In terms of measurement of value and effects, there are also imperfections. Innovation is a creation of ideas and is difficult to measure; as outlined above, a firm's innovative activity has been proxied in economics by R&D expenditure and patents. Organisational change is difficult to measure, yet it might be an important determinant of firm's performance (as outlined by Leibenstein already in 1966); many scholars have shown in case studies that the way the firm organises production and the research team affects its performance in terms of efficiency of production and product innovation (for instance, the famous case of the Japanese car industry in the 1970s and 1980s; see Clark and Fujimoto, 1991, Nonaka, 1991, Labory, 1997). Human capital has generally been proxied by the education level, thereby excluding competencies gained during the working life through working experience and training within the firm.

In reality, one might argue that all these intangible assets (innovation, organisation and human capital) combine to create a firm's value: innovation (a new knowledge) does not have value unless it is transformed into a product that is sold on the market. In other words, innovation, the organisation of production, the organisation of commercial activities and employees (with their human capital) all contribute to the value created by this innovation. The organisation of the firm does not have value unless combined with human capital and tangible capital (such as machines and equipment). Hence it might be argued that the growing emphasis put by firms on their intangible assets (in audit, reporting, …) is due to a strategy of development of complementarities between intangibles and tangible resources, in order to increase value. Whereas in the past such complementarities were fixed (in particular product definition, technology, the organisational structure, job definition and skills of personnel, …), they tend to constitute now a strategic variable (Bianchi-Labory, 2002).

2.2. Intangibles for firms

Intangibles can be usefully defined as "sources of probable future economic profits lacking physical substance, which are controlled, or at least influenced, by a firm as a result of previous events and transactions (self-production, purchase or any other type of acquisition) and may or may not be sold separately from other corporate assets" (Garcia-Ayuso, 2001, p5). In this management literature, the concept of intellectual capital is argued to be composed of three components:

- human capital, defined as the knowledge, skills, experience and abilities that employees have and that the firm does not own (and looses of the employee leaves the firm); examples are innovative capacity, creativity, know-how, professional experience, employee flexibility, motivation, satisfaction, learning capacity, loyalty;
- structural capital, i.e. the pool of knowledge that stays in the firm when employees leave (organisational routines and procedures, systems, culture, etc.); examples are innovation capacity, organisation flexibility;
- relational capital, which consists in the resources related to the external relationships of the firm, such as those with customers, suppliers and R&D partners; examples include image, alliances, customer loyalty, customer satisfaction, market power, environmental activities.

The intellectual capital and the intangible capital are equivalent concepts. The set of intangible resources (stock, static notion) constitutes the intangible capital, while intangible investments (flow, dynamic notion) allow to increase the intangible capital of a firm, through the acquisition of new intangible resources (e.g. new technology) or the improvement in the existing intangible capital (e.g. organisational restructuring that improve communication flows within the company). Intangible investments may give rise to new intangible resources or may improve the value of existing ones.

Lev has proposed a measure of the long-term expected returns on knowledge assets. Knowledge capital is defined as the ratio between normalised earnings (several years of historical year-end results) minus earnings from tangible and financial assets and the knowledge capital discount rate. Table 1 in the appendix shows estimated values of the knowledge capital of major US pharmaceutical firms.

However, this measure does not say about how do intangible resources and investment create value. What is the role of each component of intangible capital, namely human resources, structural capital and relational capital? Part of the sociology literature (the "fit" approach: Aldridge and Pfeffer, 1976; Hannan and Freeman, 1977; Hannan, 1991) supports the view that all

components create value only if they are jointly adopted (more than the sum of the parts). Such literature even refers to Milgrom and Roberts (1995) complementarity concept.

The strategic management literature also agrees on the relationship between organisational and human resources management choices and the firm's main strategies. Thus for instance Arthur (1992, 1994) shows the correlation between industrial relation system (more or less participative) and the market strategy of the firm (homogenous good or not). Garcia-Ayuso (2001) argues that a firm's reporting on intangible assets starts with the definition of its main strategies, from which relevant intangible resources and investment (intellectual capital) result. Abernethy and Thomson (2001) try to find empirical evidence of the association between a strategy based on product innovation, organisational flexibility (the adoption of an organic structure, characterised by flat hierarchy, intense communication and decentralisation of decisions), the importance of training and selection in human resource management and a lower use of management control systems. Contrary to expectations, they find that innovative firms do use management control systems, together with organic structure, training and selection. They also find evidence of an association between strategy and intangible resources and investments. However, their results have to be interpreted with care because they use a small sample, of only innovative firms with 200 employees and more.

2.3. A firm's value and its intangible determinants

Overall, it seems that what has changed in the last decades and has led to the focus on firms' intangible assets is the firms' value. The tangible capital appears no longer sufficient to explain a firm's value. Both tangible and intangible assets determine the latter. All such resources combine to determine the firm's capabilities: capability to innovate, to forecast consumers' future needs, to organise production in an efficient manner, to commercialise the product, and so on. Those capabilities constitute the firm's intangible asset, which in turn determine the firm's value. The problem is that such capabilities are very difficult to measure and therefore to compare across firms. When information is imperfect or incomplete, economic agents holding the information have to use signals in order to convey the information to other agents (Spence, 1974). The firm signals the level of its intangible capital by building a reputation for it: advertising campaigns, sponsorship of social events, as well as reporting on innovative activities, training of personnel, etc., all contribute to convey information on the firms' intangible capital.

When firms renew products infrequently and rarely change strategy and organisation, their value can be summarised by what they have achieved up to now: current market shares, products,

investments, and so on. Hence the traditional measure of performance, profits and revenues that come out of the traditional balance sheet are good indicators. In contrast, when the firm renews products frequently and regularly innovate, the current achievements do not summarise well the firm's value: what is in the pipeline is as important. This means that the future expected value should be taken into account when valuing a firm. However, such future value is by definition difficult to measure, and the best approximation is a probability distribution of future profits. In order to influence such probabilistic valuation, the firm has to build a reputation, a reputation for competence, so that market analysts and other stakeholders perceive better the intangible capital (the capabilities) of the firm.

Table 1. A taxonomy of the determinants of a firm's value

Tangible resources
- Machines and equipment
- Buildings
- Labour (number of hours worked)
- existing products
- patents
- brand name
- distribution channels
- licensing agreements
Intangible resources
- human capital: competencies of employees
- internal organisational structure
- products in the pipeline
- relationships with other firms: joint ventures, alliances, collaborative agreements, etc.
- relationships with public institutions: universities, local government, etc.
- copyright, design rights, trade secrets
- know-how

If this is true, it means that also at the country level macroeconomic indicators and especially growth measures should account for these intangible assets. A country with high intangible assets has the potential to develop in the future, since its business has products in the pipeline and a capability to develop new products, create or conquer new markets. A country with low intangible capital has limited growth prospects.

Reputation is important to gain and maintain customers; to obtain finance (investors, stock market), to attract good human resources; the ability to innovate is important (in some sectors) to develop new product or new production processes that reduce production costs.

The nature of the intangible capital of the firm lies therefore in its main capability, to develop products, to change the organisation of production in order to adapt to changes in the extent of the market. Intangible assets therefore might be usefully defined as sets of complementary capabilities. For instance, the intangible asset "innovative capability" results from a combination of tangible capital (computers and equipment to carry out R&D) and intangible capital (quality of engineers, organisation and motivation of the research teams, etc.).

The next step is to analyse the pharmaceutical industry in the light of the above analysis; we will analyse the recent evolution of the industry, the relative performance of European firms and American firms in order to derive insights as to the differences in intangible assets and policy implications.

3. Intangible assets in the pharmaceutical industry

Since the beginnings of the industry in the late 19th century, pharmaceutical firms have followed various strategic orientations and built different innovative capabilities. Product innovation has always been the main competitive strategy, allowing monopolistic position during patent life and generics competition afterwards. Market structure has been characterised by a few firms in oligopolistic competition together with a competitive fringe (competing in the generics market). A major change occurred with the development of biotechnologies, allowing new ways of doing R&D and new innovative capabilities. Major changes occurred in the organisation of firms in the industry, although the main established firms maintained their position.

3.1. The pharmaceutical industry before biotechnologies

Until the diffusion of the new biotechnologies, the dominant research technology was "random screening" (whereby "natural and chemically derived compounds are randomly screened in test tube experiments and laboratory animals for potential therapeutic activity", Henderson et al., 1999, p. 272). There were little knowledge spillovers between firms because what was important in the research was the quantity of research (screening) performed (sort of economies of scale in research), and the basic scientific knowledge was shared by all competitors.

The industry developed especially after World War II, where large pharmaceutical firms consolidated their positions: for example, Merck, Eli Lilly, Bristol-Myers and Pfizer in the US, Bayer in Germany, Hoffman- La Roche in Switzerland. R&D was institutionalised in-house, and large firms took advantage of economies of scale in research.

Public policy has always been substantial in the sector. Public research increased substantially after WWII (see table 4). Patent protection has constituted another field of public intervention, as well as product regulation, with the obligation for all producers to submit new products for regulatory approval before being allowed to be commercialised. In the USA, the Food and Drug Administration (FDA) receives applications and decides on market authorisations; in the EU, market authorisations have only recently (in the 1990s) been harmonised, to allow producers to make just one application for market authorisation in the EU, and not one authorisation in each Member States (see Bianchi – Labory, 2002). Another important difference between the US and Europe concerns biomedical research. In continental Europe, the training and careers of scientists has been strongly orientated towards patient care and the application of research, because of the integration of medical schools and hospitals in single entities. In contrast, scientists in the US and the UK have developed more expertise in basic research, since medical schools are separated from hospitals (Henderson et al, 1999). In addition, the links between universities (research institutions) and firms are stronger, in part thanks to a higher flexibility in the career of scientists, who can easily go to work for a firm during a certain time period and come back to teach and do research at university afterwards if they wish. This has probably favoured the commercialisation of innovations, a capacity which seems to be lacking in Europe (Gambardella et al., 2000).

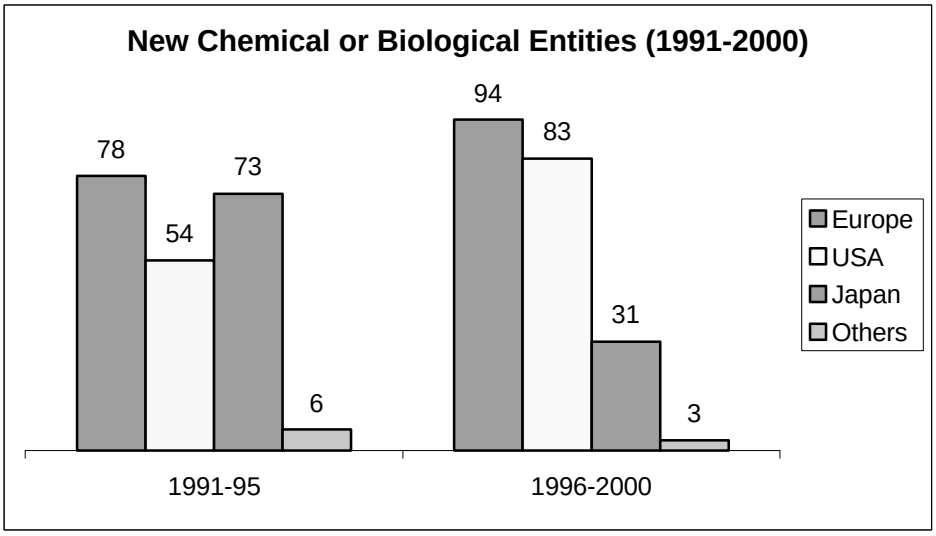
3.2. Biotechnologies and implied changes in industrial organisation

The fundamental discoveries in genetic engineering and recombinant DNA prompted the development of biotechnologies, which opened new drug development opportunities for pharmaceutical companies. Whereas in the past drugs were derived from natural sources or synthesised through organic chemical methods, drugs can now be developed by genetic engineering, so that the compounds which were impossible to derive in the past, such as proteins, can now be produced artificially, allowing a “rational” research method rather than random screening. Such discovery has had important consequences for the drug industry (Henderson et al., 1999, Gambardella et al., 2000), in particular that of the arrival of new entrants, expert and specialised in biotechnologies and the reorganisation of major large established firms to develop a capacity to develop and produce biotech products.

The world pharmaceutical market was worth Euro 393 million (at ex-factory prices) in 2000 (Efpia, 2001). The North American market experienced the fastest growth and remained the world's largest market with 43% share, compared to 22 % for Western Europe. The European

pharmaceutical industry produces Euro 121,4 million worth of products and employs more than 500,000 employees. The main pharmaceutical producers are indicated in table 2 of the appendix.

In terms of R&D, Europe is losing competitiveness relative to the US, although it was a world leader in terms of R&D and innovation until 1990. Between 1990 and 1999, R&D investment in Europe doubled, while in the US it was multiplied by 3.5. In 1990, the major European-based companies spent 73% of their R&D in Europe, while in 1999 they spent only 59% of their R&D expenditure in the EU; the difference went to the US, implying that the US has become a main world R&D centre. The loss in competitiveness concerns primarily biotechnologies.
The graph below shows that in 2000, Europe remained the main provider of new products relative to the USA, if one considers both chemical and biological entities; however, focusing on new biological entities, the US is leading.



Source: EFPIA, 2001.

Table 2 shows that the US is leading in the biopharmaceutical sector, R&D expenditure and turnover of biotech companies being much higher in the US.

Table 2. Biotech Companies - Europe versus USA

Indicators	**Europe**	**USA**
Turnover (Euro Mn)	8,679	23,750
R&D Expenditure (Euro Mn)	4,977	11,400
Number of companies (units)	1,570	1,273
Number of employees (units)	61,104	162,000

Source: EFPIA, 2001.

Table 3. Patent applications at the European Patent Office

	World Patent share (%) 1978-1993	N. Firms 1978-1986	N. Firms 1987-1993	Growth in number of firms
USA	36.5	213	303	+90
Japan	19.5	108	185	+78
UK	5.9	39	64	+25
Germany	12.0	45	58	+13
France	6.0	37	52	+15
Switzerland	4.2	11	19	+8

Source: Henderson et al. (1999).

Table 3 shows the number of firms, which are actively patenting at the European Patent Office. American firms are definitively more active, even more so as the figures exclude patenting activity in the US. Table 4 shows the difference in institutions, which innovate in biotechnology. Newly founded firms are much more numerous in the USA than in Europe, and represent an important source of innovation. Public research plays a more important role in countries like France. Between the two sub periods, the role of established firms has increased everywhere; this shows that the biotechnological sector initially grew by the arrival of new biotech firms (especially) in the US, and progressively large established firms have developed a capacity to innovate in biotechnology. Henderson et al (1999) show that large firms have acquired innovative capacity in biotechnology mainly by signing collaborative agreements, establishing research joint ventures or acquiring new biotech firms. Europe is progressively developing a capacity to innovate in biotechnology, but is a follower relative to the US. In Europe, biotechnology has developed in different ways. Some firms, mainly the British and Swiss ones, have acquired biotechnology via acquisition or collaborative arrangements with the smaller US biotech firms. Firms in other countries have benefited from public research, which has progressively catched up; thus for instance one of the biggest innovator in the EU is a French public institution, the Institut Pasteur.

Table 4. Activity in Genetic Engineering by type of institutions

	% Patents by institution (European Patent Office)		
	NBFs	**Established companies**	**Universities or other public institutions**
	1978-1986		
USA	43.2	34.5	22.3
Japan	0	87.7	12.3
Germany	0.01	81.8	17.7
UK	27.3	49.1	23.6
France	18.7	21.5	59.8
Switzerland	0	92.9	7.1
Italy	0	95.7	4.3
	1987-1993		
USA	40.4	38.1	20.7
Japan	3.1	86.9	10.0
Germany	3.0	80.0	17.0
UK	23.7	44.7	31.6
France	16.7	35.0	48.3
Switzerland	4.7	89.0	6.3

Source: Henderson et al. (1999).

Following the biotechnology "revolution", R&D costs have continuously increased in the industry (see table 5). R&D project for new drugs nowadays last 12 to 14 years and cost up to $ 600 millions (Bottazzi et al., 2000).

One interpretation of the collaborative agreements between established firms and new biotech firms is that large firms therefore have compensated their lack of expertise in the new biotechnology by developing agreements with the new entrants and by focusing on capabilities in the marketing and distribution side. Marketing costs have increased, and distribution strategies have become important determinants of market shares. Therefore, complementary relations have developed between firms: new entrants with expertise on biotechnology gain access to the distribution potential of the large firms, while large firms gain access to the innovative advantage of the smaller firms. The US has become a world R&D centre in biotechnology; the percentage of new patents by new biotech firms (NBFs) has been the highest among OECD countries, with 43.2 % over the period 1978-1986 and 40.4 % over the period 1987-1993, while the respective figures were 34.5% and 38.1% for large, established companies. Over the two subperiods, the percentage of new

patents by large firms has increased, while that by NBFs has decreased. Parallel to this trend, the number of acquisitions of NBFs by large firms, or mergers between the two, has increased in the whole period. As a result, it appears that one way of acquiring biotech capabilities might have been, for large American pharmaceutical firms, the acquisition of innovative NBFs. As table 4 shows, Germany and Japan have continued to rely primarily on large firms for innovation in genetic engineering (measured by patents), although some NBFs have started to innovate in the second subperiod. In the UK, the trend is different since universities and public institutions have increased their contribution to patents in genetic engineering over the period, while both NBFs and large firms have reduced theirs. The French pattern appears to be similar the US one.

An account of the major mergers and acquisitions over the period 1987 to 1997 can be found in Bottazzi et al. (2000). Since then, further developments have taken place, with the creation of Novartis in Switzerland, and the merger of Hoechst and Rhone Poulenc. Mergers and acquisition allow to pool resources and reduce the risks and costs associated with activities like R&D and the launch of new products. Given the large technological and organisational changes made necessary by the development of the biotechnology, mergers and acquisitions among large pharmaceutical firms might be interpreted as a strategy to reduce the costs associated with the development of new complementarities and to control the new intangible assets.

This raises a policy dilemma: mergers and acquisitions may allow to acquire some capabilities in R&D which would be difficult to acquire otherwise, but they also raise the market power of firms; in fact, large incumbent firms threatened by the dynamism of NBFs in terms of innovation might have absorbed them also with a view to maintaining their market power. A deeper examination of such dilemma would be useful, with an empirical study of mergers and acquisition in the sector for instance. At this stage, our discussion of intangible assets leads us to conclude that mergers and acquisitions might not be necessary to get access to intangible assets. What matter are the relationships that are built between organisations, via individuals. Individuals are key to the transfer of knowledge and capabilities because they embody such intangible assets. Networking occurs through various types of contacts that all must make the individuals (and their organisations) dependent on one another; such dependency essentially results from the complementarity of the resources held by the various parties. Hence what may matter with intangibles is control, not ownership. The implication is that large, incumbent pharmaceutical firms the market position of which was threatened might have preferred to acquire NBFs to get more market power, while a collaboration agreement might have been sufficient. At this stage of our reflection and research, we leave the question rather open and will examine it in more details in the future.

Apart from R&D, marketing and distribution costs play an important role in the costs of production. Distribution costs account for about 50% of the expenditure on some products, when retail and wholesale margins are included, and vary up to 10% across Member Sates (Huttin, 1989). Marketing costs are often higher than R&D costs (Jacobzone, 2000). The increase in R&D costs in the 1980s has been lower than the increase in marketing costs over the same period.

Table 5. The changing structure of company costs in the pharmaceutical industry, 1973-89
(% of sales)

	Manufacturing	**Marketing**	**R&D**	**Operating Profit**	**Other**
1973	40	17	10	23	12
1973-80	37	16	11	27	11
1989	25	25	15	29	10

Source: Jacobzone (2000).

3.3. Intangible assets in Europe and the US

Hence we can provide a new key for interpretation of the evolution of the pharmaceutical industry. Following the significant technological change, new firms have entered the market thanks to their mastering of the new research capabilities. However, established firms, although constrained in their ability to adapt to changes, have maintained their dominant positions. In fact, established firms have adopted the new technology and therefore developed a capability to innovate and commercialise biotech products by either setting up collaborative relationships with or acquiring the new firms, as in the US and the UK and Switzerland, or taking advantage from the development of public research, as in France. The former strategy seems to have been the most profitable since the US firms have taken the lead in the introduction of new biotech products. The USA have become the world R&D centre, since many European firms have established new R&D centres in that region.

In particular, large firms derive innovative advantages from their ability to realise economies of scope, in turn resulting from their holding an adequate portfolio of research projects and their building many external and internal relationships (with other firms, with university laboratories, etc.) that allow them to capture and use internal and external knowledge spillovers.

Henderson and Cockburn (1996) show that large firms exploit both economies of scale and of scope and thereby increase research productivity.

The US therefore has had major capabilities to adopt the new technology, to develop and commercialise new biotech products. Although in Europe biotech research is developing, it seems that what is lacking is the capability to commercialise innovation. The difference between the two regions lies therefore in intangible assets, with four main factors explaining the difference:

1. stronger biomedical research (at the beginning), resulting at least in part from the higher commitment of scientists to basic research, since biomedical training was not biased towards applied research and patient care like in continental Europe (capability to innovate);
2. more flexibility in scientists' career, in the sense of ability to move to business and back to universities, which seems to favour the commercialisation of innovations (capability to commercialise innovations or, in the words of Henderson, Cockburn (2000), ability to develop and maintain expertise on particular disease and disciplines);
3. internal organisation: management of research teams, and motivation of researchers in particular. Henderson and Cockburn (2000) show that the use of publication in scientific journals as a criterion for promotion of researchers within the firm is an important determinant of a firms' innovative competence;
4. stronger intellectual property right protection: according to Henderson et al. (1999), the 1980 Bayh-Dole Act gave universities the right to retain property rights from federally funded research, allowing therefore university researchers to get the returns from their innovations, hence higher incentives to innovate. In contrast, patent protection appears more limited in Europe, since for instance no grace period is allowed (allowance of a patent even if the discovery is not published).

These factors are likely to have favoured the creation of university start-ups, i.e. new biotech firms, since researchers had the incentive to innovate (they could get patent hence returns from their innovation) and could more flexibility move from university to business and back. It is often argued that a major factor for the smaller rate of firm creation in Europe is due to the lack of venture capital; in the case of the pharmaceutical industry, this does not appear to be a determinant since governments made large funds available; Merit (1996) shows that financial constraints were not binding.

Of course, such an interpretation needs to be confirmed by a more systematic analysis; other interpretations include that of Thomas (1994), who argues that European firms adopted biotechnology later because of weaker competitive pressures in their domestic market. Such analysis might constitute the subject of future research.

A last point we want to make regards the measurement of intangible assets. Given that most intangibles are not priced, especially if they are considered as capabilities and knowledge that result from combinations of intangible and tangible assets, one way to measure them might lie in the survey methodology. Surveys are increasingly used to measure organisational changes and organisational flexibility (see the review by Bianchi – Labory, 2002). An interesting survey that we wish to mention is a French survey of the capabilities to innovate, which has been carried out by the French Ministry of Industry on a representative sample of the French industry. The survey asked firms to rank a number of broad and detailed competencies, such as "include innovation in the overall strategy of the company", "develop innovations", "manage and defend intellectual property", "follow and forecast market trends". Table 6 below reports the results for the broad competencies, and compares the results for the pharmaceutical industry relative to those for all industries.

Table 6. A measure of Intangible assets; results from the survey of competencies in France, 1998. (% of firms quoting the "competence" as important and very important)

	All industry	**Pharmaceutical**
Ability to incorporate innovation in the overall strategy (evaluate the capacity of the firm to change)	57.7	67.0
Ability to follow, forecast and act on market change (follow competitors' products, find out about the potential demand and opinion of customers on innovations)	38.1	57.6
Ability to innovate (act on organisation and time)	49.5	59.6
Ability to organise and manage knowledge production (favour and channel creativity, evaluate the results of knowledge creation)	49.4	56.9
Ability to acquire external technologies (identify, evaluate and absorb external technologies)	26.1	41.9
Ability to manage and defend intellectual property (patents, design rights, brand)	31.9	53.4
Ability to manage human resources (hire, evaluate, train)	40.1	50.5
Ability to finance innovation (evaluate costs and find investors)	33.8	43.1
Ability to sell innovation (innovative product, innovative firm)	32.6	56.7

Note: all "broad" competencies are summary of different related questions, which are partially indicated in parenthesis besides each competence in the table.

As expected, capabilities related to innovative activities appear to be substantially higher in the pharmaceutical industry than in the average of the whole industry, especially the ability to follow and forecast market changes and to innovate (innovative activity per se, knowledge creation management, and incorporation of innovation in the overall company strategies). The ability to

acquire external technologies does not seem to be perceived as very important, in that less than 50% of firms find it important, although the figure for the average of the whole industry is much lower (about a quarter). This, together with the majority of firms finding the protection of innovation as important, might be a sign that spillovers are not fully exploited and firms prefer protecting their innovation: is it because otherwise they would not get enough return from their innovation, or because they want in this way to preserve market power? This would require further investigation.

4. Conclusive remarks: complementarities in the health industry

We have shown in this paper that intangible assets might be defined as sets of complementary capabilities that result from various combinations of both tangible and intangible resources. Such assets appear to have been key assets for firms to successfully adapt to the new competitive conditions of the 1990s mainly, with biotechnology spurring the creation of new biotech start-ups active in drug development. Established large firms have managed to remain dominant players because of their control of a particular intangible asset: commercialisation and distribution capabilities, which the new start-ups did not have. Among established firms, those who have taken a lead are those who early adopted the strategy to control the new technology, which they achieved by collaborative agreements with or acquisitions of new start-ups.

Our analysis has important policy implications, in particular concerning the creation of SMEs and the favouring of innovation and its diffusion. The paper shows that what mattered for the former was not so much tangible resources, such as venture capital funding, but intangible ones, such as norms and institutional features (i.e. in a way, social capital) favouring the development of intangibles: the different focus of biomedical schools not favouring applied research at the expense of basic research; the flexibility in scientists' career and their possibility to move from university to business and back; property right protection favouring innovation in universities. The absence or minor importance of such features in Europe appears to have lead to both the delays in adopting the new technology and the lack of commercialisation of innovation. European governments and the European Commission are already stressing the need to provide a climate favourable to innovation and to firm creation for the respective policies to have positive effects. The consideration of intangible assets in policy-making might lead to the formulation of policies effective in creating such a climate.

Regarding the health industry model, we have stressed that what matters are not so much the tangible and intangible assets per se, but rather the complementarities, (synergies or cross-fertilisations) that are exploited between them. Thus the US has become a world biotech R&D

centre thanks to a combination of particular assets: university research oriented towards applied research; ease for researchers to set up firms and come back to university after working in the private sector; extensive business-university relationships, and so on. In Europe, the combination of assets is different; for instance, it is not so easy for researchers to start up a business, the training and research orientation do not always favour applied research. In addition, one has to consider the whole health industry in order to understand all the relevant complementarities: for instance in France, the motivation of researchers and the orientation of universities can be understood only if the relationship between medicine universities, that train personnel for medical research, the pharmaceutical sector and patient care and hospital are considered. In the French system, medicine faculties are strongly related to hospitals. In fact, each medicine faculty is associated with a particular hospital. This has the advantage of allowing doctors to train "on-the-job"; however, the drawback is that medicine faculties are strongly oriented towards patient care and not so much towards research.

More generally, the importance of complementarities outlined in this paper implies that restricting attention to a particular sector of health, say the pharmaceutical industry, or hospitals, will lead to the ignorance of important complementarities between the various sectors of the health industry. Thinking about the integrated health system allows seeing the accumulation of intangible assets in the whole system, not as externalities but as internalities. Considering of the whole system, policy will make sure that all actors in the system have access to knowledge, innovation, human capital, which are internal to the system but external to the single actors. In particular, small firms also have access to information and knowledge in an integrated system, not in a disintegrated one.

Therefore, policies in different fields (education, research, industry, …) have interactive effects that should be taken into account, because they might be negative for certain objectives. For instance, a (social) policy of reducing the prices for drugs combined with strong patent protection of new medicines might not be compatible. Another example is the case of the lack of transformation of innovation into commercial success in the EU; the policies that should be combined, because they jointly have positive effects, by creating appropriate intangible assets, might be education (teaching at medicine universities), RTD (favour the links between universities and business, by allowing more mobility of researchers between the private and the public sector) and intellectual property rights (allow university researchers to take patents, so that they might have incentives to create new firms exploiting their innovation). The independent consideration of the policies does not resolve the problems: for instance, the ageing of the population would lead governments to take measures to increase the number of doctors, at the expense of researchers, while research and new and more efficient cures are also a solution.

Therefore, what is needed is to create the intangible assets relevant and appropriate to the situation of the country (or supra or infra-national region), and for this purpose the integrated vision of the health industry model is key. In a way, the explicit consideration of intangible assets provides the rationale and theoretical background for a health industry model.

This paper has constituted a first reflection on intangible assets in the health industry, and we hope to have shown that the consideration of intangible assets provides new insights on important issues and open interesting avenues for future research.

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Appendix

Table 1. Lev's estimation of knowledge capital (in $ millions)

Pharmaceutical companies	Knowledge capital	Book Value	Knowledge capital / book value	Market value	Mkt/book value	Knowledge capital earnings / sales
Merck	48 038	12 614	3.81	139 910	11.09	22%
Bristol-Myers Squibb	30 470	7 219	4.22	106 994	14.82	19%
Johnson & Johnson	28 965	12 359	2.40	92 884	7.52	14%
Pfizer	23 890	7 933	3.01	136 846	17.25	20%
American Home Prod.	22 822	8 175	2.79	63 392	7.75	17%
Abbott Labs	19 558	4 999	3.91	56 631	11.33	17%
Eli Lilly	16 505	4 646	3.55	67 968	14.63	21%
Warner Lambert	12 099	2 836	4.27	52 237	18.42	16%
Pharmacia & Upjohn	4 725	5 538	0.85	22 447	4.05	7%
ICN Pharmaceuticals	1 158	796	1.45	3 092	3.88	16%
Watson Pharmaceuticals	1 110	565	1.96	3 899	6.90	35%
Allergan	1 053	841	1.25	2 753	3.27	10%
Mylan Labs	972	744	1.31	3 666	4.92	19%
Rexall Sundown	766	192	4.00	2 392	12.48	31%
Alza	622	301	2.07	4 181	13.88	14%
Forest Labs	553	614	0.90	2 653	4.32	14%
NBTY	386	117	3.30	976	8.34	15%
Barr Labs	376	156	2.41	909	5.83	11%
Perrigo	254	426	0.60	821	1.93	3%
Agouron Pharmaceut.	152	236	0.64	1 049	4.44	3%

Table 2. Top ranking companies in the health industry (ordered by amount of R&D spending)

	R&D per employee ($'000)	Country of origin
Chemicals		
Bayer	12.6	Germany
Du Pont de Nemours	12.8	USA
BASF	9.2	Germany
Dow Chemical	14.3	USA
AKZO Nobel	7.3	Netherlands
Mitsubishi Chemical	11.7	Japan
Sumitomo Chemical	19.9	Japan
Toray Industries	6.4	Japan
Solvay	8.4	Belgium
Mitsui Chemicals	19.1	Japan
Asahi Chemical Industry	8.4	Japan
PPG Industries	5.7	USA
ICI	3.8	UK
Rohm and Haas	9.4	USA
Clariant	5.4	Switzwerland
Teijin	7.6	Japan
DSM	7.7	Nertherlands
Shin-Etsu Chemical	8.4	Japan
Kyowa Hakko Chemical	19.3	Japan
Dow Corning	13.2	USA
Rhodia	4.1	France
Ciba Speciality Chemical	6	Switzerland
Health		
Abott Laboratories	14.9	USA
Warner Lambert	19.2	USA
Medtronic	14.2	USA
Baxter International	5.9	USA
Guidant	25.6	USA
Applera	37.8	USA
Becton Dickinson	6	USA
Nycomed Amersham	17	UK
Boston Scientific	9.7	USA
Allergan	21.2	USA
Beckman Coulter	12.8	USA

Pharmaceuticals		
Pfizer	33	USA
GlaxoSmithKline	23.3	UK
Johnson & Johnson	19.9	USA
AstraZeneca	34	UK
Novartis	23.2	Switzerland
Pharmacia	31.2	USA
Roche	25.2	Switzerland
Merck	22.6	USA
Eli Lilly	37.9	USA
Bristol-Myers Squibb	29.5	USA
American Home Products	23.5	USA
Aventis	9.8	France
Schering-Plough	31.8	USA
Boehringer Ingelheim	22.3	Germany
Sanofi-Synthelabo	20.3	France
Amgen	77.2	USA
Schering	21.8	Germany
Takeda Chemical	27.9	Japan
Sankyo	33.3	Japan
E Merck	10.2	Germany
Yamanouchi Pharmaceutical	35.9	Japan
Novo Nordisk	22.5	Denmark
Eisai	39.1	Japan
Fujisawa Pharmaceutical	33.4	Japan
Chugai Pharmaceutical	48.1	Japan
Daiichi Pharmaceutical	30.6	Japan
Elan	61	Ireland
Biogen	137.4	USA
Chiron	57.3	USA
Millenium Pharmaceutical	135.3	USA
Serono	41.3	Switzerland
Shionogi	na	Japan
Altana	16.1	Germany
Taisho Pharmaceutical	27.2	Japan
Incyte Genomics	97.5	USA
Lundbeck	39.7	Denmark
Ono Pharmaceutical	na	Japan
UCB	12	Belgium

Source: Financial Times
Na: not available.