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Intellectual Property Marketplaces and How They Work: Evidence from German Pharmaceutical Firms

This article examines a sample of German pharmaceutical firms to highlight the strategic reasons why firms participate in various intellectual property (IP) marketplaces, both proprietary (patents and copyrights) and non-proprietary (open source and non-patented technology). The obstacles that prevent these marketplaces from functioning efficiently are also investigated. The analysis suggests that IP policy must embrace all IP forms and must recognise that IP marketplaces do not work "automatically" but suffer many institutional failures.

The intellectual property rights regime plays a particularly important role for the pharmaceutical industry with its extensive efforts in research and development and for the protection of newly generated knowledge. It is, however, well recognised that firms do not patent or copyright mainly to cover R&D expenditures, as suggested in mainstream intellectual property rights (IPR) theory, but rather that their incentives are related to various types of strategic value they can obtain through licensing markets or via buying and selling such IPR, i.e. by engaging in the marketplaces for intellectual property (IP).[1]

IP marketplaces are the focus of this article. We deal with different kinds of IP marketplaces as institutions and explore the incentives for firms to participate in these marketplaces in terms of the strategic benefits that they seek. We also investigate the IP governance forms that firms employ to realise this value and the problems or obstacles they face in this process.

Despite the existence of research that points to the IPR marketplace as a platform for value creation,[2] the theoretical and empirical IPR literature has focused very little, if at all, on the functioning and efficiency of the IPR marketplace *per se*. Our research intends to contribute to filling this gap by focusing on the pharmaceutical industry as a promising case to research the conditions for IP marketplaces to work efficiently and be sustainable in the long run. While mainstream economics argues that knowledge privatisation is necessary in order to remedy the market failure connected with the inherently public nature of knowledge (what has been termed the "tragedy of the commons"), this article addresses a different kind of market failure: the failure of institutions to ensure the efficient functioning of the markets for knowledge-based goods (what we can term a "tragedy of institutions").

This approach is in line with the tradition of institutional economics, where it is argued that markets are platforms

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1 W. Cohen, R. Nelson, J. Walsh: Protecting Their Intellectual Assets: Approbriability Conditions and Why U.S. Manufacturing Firms Patent (or Not), NBER Working Paper 7552, 2000; R. Levin, A. Klevorick, R. Nelson, S. Winter, R. Gilbert, Z. Griliches: Appropriating the returns from industrial research and development, in: Brookings Papers on Economic Activity, No. 3, 1987; E. Mansfield: Patents and innovation: An empirical study, in: Management Science, Vol. 32, 1986, pp. 173-181.

2 W. Cohen, R. Nelson, J. Walsh: Protecting Their Intellectual..., op. cit.; R. Mazzoleni, R.R. Nelson: The Benefits and Costs of Strong Patent Protection: A Contribution to the Current Debate, in: Research Policy, Vol. 27, No. 3, 1998, pp. 273-284; B. Coriat, F. Orsi: Establishing a New Intellectual Property Rights Regime in the United States. Origins, Content and Problems, in: Research Policy, Vol. 31, 2002, pp. 1491-1507; R. Mergers, R. Nelson: On the complex economics of patent scope, in: Columbia Law Review, Vol. 90, No. 1, 1990, pp. 839-961; R.P. Merges: Institutions for Intellectual Property Transactions: The Case of Patent Pools, in: R. Dreyfuss, D. Zimmerman, H. First (eds.): Expanding the Boundaries of Intellectual Property: Innovation Policy for the Knowledge Society, Oxford (England) 2001, Oxford University Press; C. Shapiro: Navigating the Patent Thicket:Cross Licenses, Patent Pools, and Standard-Setting, in: NBER Conference on Innovation Policy and the Economy, 2001; B. Andersen, S. Konzelmann: In Search of a Useful Theory of The Productive Potential of Intellectual Property Rights, in: Research Policy, Vol. 37, 2008, pp. 12-28.

of social relations and cannot be reduced to simple supply and demand curves. For trade to take place, these social relations need to be underpinned by trust and similar expectations between buyers and sellers in relation to prices, contracts and other aspects.[3] We refer to the notion of "marketplace" to denote the space, actual or metaphorical, in which a market operates, and hence to emphasise the web of social relationships and institutions that are required for processes of exchange to take place.

By researching the functioning and efficiency of IP marketplaces, we are able to look in more detail at markets as institutions for value creation and at the potential sources of institutional failure.

The empirical analysis presented in this article is based upon an original exploratory survey of a sample of pharmaceutical firms based in Germany. The questionnaire concerned the firms' IP exchange activities and the strategic benefits firms seek from them, the obstacles they experience in IP marketplaces, as well as some information on ways in which prices are set in the patent and copyright marketplaces and on the perceived "value vs. price" relationship. Further details on the sample and on the data collection process are presented below.

The article is structured as follows. First, we set the general analytical framework by briefly introducing proprietary and non-proprietary IP marketplaces, covering what they are and how they work. We then broadly review the strategic benefits that firms may seek from trading their IP in various marketplaces, and the institutional obstacles which they may face during these activities and which may affect their individual performance as well as the performance of entire IP systems. After outlining the data on which the empirical analysis is based, we present our results. Finally, we offer conclusions on the performance and efficiency of IP marketplaces as experienced by the set of survey respondents in the German pharmaceutical industry.

The analysis presented in this article expands the existing literature in several ways. First, it builds upon "productive systems" theory, which argues that the requirements for operational and dynamic efficiencies, and hence system performance, depend upon the ability to secure effective cooperation among stakeholders within the system during the processes of creating and distributing value.[4] In doing so, it incorporates the theoretical framework for the productive potential of IPR (set out in Andersen and Konzelmann)[5] where the focus is on the "institutional environment", on the "institutions of governance" and on the interaction of the two in influencing value creation and value distribution from IP.

Second, the article challenges the mainstream view that knowledge privatisation, normally attached to a patent, is necessary in order to remedy the market failure connected to the inherently public nature of knowledge, since it researches value creation processes in marketplaces associated with several forms of IP, both proprietary (patents, copyrights) and non-proprietary (open source, IP with no formal protection).[6] Previously, patent studies have dominated this research field.

Third, the article applies the concept of institutional failure, as introduced by institutional economists,[7] to IP marketplaces, investigating the possible sources of such failures when IP marketplaces do not work or underperform.

Finally, the choice of IP governance forms within each IP marketplace (see Table 1 for an overview) is investigated in relation to the performance of IP markets, a technique that, to our knowledge, has not previously been considered.

The empirical analysis sheds new light on the relationship between the firms' objectives when trading IP and their choice of marketplaces and governance forms, thus enhancing our understanding of the rationale for these institutions to exist. It also focuses on the obstacles that prevent IP marketplaces from functioning smoothly and points to some critical issues that policymakers need to be aware of if such obstacles are to be removed.

3 G. Hodgson: Economics and Institutions: A Manifesto for a Modern Institutional Economics, Oxford 1988, Polity Press; G. Hodgson: Economics and Utopia: Why the Learning Economy is not the End of History, Economics as Social Theory series, London and New York 1999, Routledge.

4 F. Wilkinson: Productive systems, in: Cambridge Journal of Economics, Vol. 7, 1983, pp. 413-429; F. Wilkinson: Productive systems and the structuring role of economic and social theories, in: J. Michie (ed.): Systems of Production: Markets, Organisations and Performance, London 2002, Routledge; A. Birecree, S. Konzelmann, F. Wilkinson: Productive systems, competitive pressures, strategic choices and work organisation: an introduction, in: International Contributions to Labour Studies, Vol. 7, No. 1, 1997, pp. 3-17.

5 B. Andersen, S. Konzelmann, op. cit..

6 The terms "proprietary" and "non-proprietary" become popular in relation to software, but they are now used more broadly across various industries. We define as "proprietary" those forms of IP protection where restrictions on using, sharing, copying and modifying intellectual property are implemented by legal means, while non-proprietary IP is characterised by the relaxation of some or all of these restrictions.

7 Cf. e.g. G. Hodgson: Economics and Institutions, op. cit., G. Hodgson: Economics and Utopia, op. cit.

Proprietary and Non-Proprietary IP Marketplaces as Institutions

The institutional economics literature[8] argues that there is not only one market, as standard textbook theory postulates, but that there are many different types of markets (for example auction markets, price tag markets, medieval-style regional street markets, black or unauthorised markets), and that these markets are enforced by different norms and bargaining forms. This also applies to intellectual property. In this paper we consider several IP marketplaces, which are best distinguished by the character of the knowledge that is exchanged. The various IP marketplaces are underpinned by different social relations, as defined by the IP governance structures (see Table 1). The quality of the social relations are influenced by the different types of institutional failures (see below).

First, in order to understand the performance of the IP marketplaces, it is necessary to identify who the stakeholders are that participate in the various marketplaces, as well as what their respective interests might be. This leads to the first Research Question (denoted as RQ) of the article:

RQ1: In which IP marketplaces do firms participate?

Four main IP marketplaces are considered: patents, open source, copyright and non-patented technology.

With regard to proprietary IP marketplaces – patent and copyright – Andersen and Konzelmann[9] outline different forms of market platforms where IPR can be exchanged. They also explain how these markets are embedded in various social relations as defined by different IPR governance structures, ranging from simple arrangements (buying and selling, licensing in and out) to more complex ones such as cross-licensing and pooling. Such forms of patent and copyright interactions are not expected to be exclusive; rather, most firms would presumably participate in several different forms.

With regard to non-proprietary IP marketplaces, the most common model is open source. Whereas IPR law in its current form provides the right to exclude anyone from using, modifying and redistributing copies of an author's work, as well as a right to withhold the source-code, a "GNU General Public License (GPL)" transfers these rights to the commons in order to ensure access, i.e. to ensure that every person who receives a copy of a work has the same rights to study, use, modify, and redistribute both the work and derived versions of the work. Such a license also requires that the same license terms apply to all redistributed versions of the work. The IPR terms are changed from "All Rights Reserved" to "Some Rights Reserved": the rights which are not reserved move into the "public domain" or commons. Originally developed for software IP, open source is also becoming more common in other sectors, and it is usually linked to a firm's open innovation strategy. Examples include "Creative Commons" in the creative industries; "Wikipedia" and "Wiki" in publishing; open source in education and scientific research (e.g. Science Commons); and open source health care and medicine, such as the Tropical Disease Initiative, and the not-for-profit "virtual pharmas" such as the Institute for One World Health and the Drugs for Neglected Diseases Initiative.[10]

Many firms also exchange non-protected technology in IP marketplaces. An explanation for this could be that the patent system is too resource-demanding in terms of application costs, search costs in order to avoid duplication of an invention and enforcement costs regarding possible court cases. Alternatively, it could be that the technological solution is not at the forefront from a technical point of view (thereby failing to satisfy the novelty criteria for patent protection), but it is still very productive for industry and therefore traded in the market. The reason could also be that the innovation is difficult to understand and imitate, or that it is client-specific and irrelevant to other firms, or that the inventor or innovator enjoys a first-mover advantage, thus rendering moot whether or not the technology is protected. Finally, it could be due to the fact that the technology product life-cycle is short, making it reasonable to launch the unprotected technology on the market, as the patent system is too slow.

Secondly, this article investigates the reasons why firms engage in different types of IP marketplaces and why they use specific IP governance structures. Andersen and Konzelmann[11] suggest that the choice of a governance structure underpinning an IP marketplace is not random; rather, it depends upon the type of financial and non-financial value that the stakeholders seek to realise: in other words, they suggest that there is a relationship between the choice of a certain IP governance institution within a specific IP marketplace and the benefits firms seek to achieve from the transaction. This is investigated through the following research questions:

8 Ibid.
9 B. Andersen, S. Konzelmann, op. cit.
10 B. Andersen: Intellectual Property Rights and "Open Innovation" in Services. Dynamics of Institutions and Markets in Europe (DIME), in: Working Paper series on Intellectual Property Rights, No. 80, June 2008.
11 B. Andersen, S. Konzelmann, op. cit.

RQ2: What are the various types of strategic benefits or the value that firms seek when exchanging IP?

RQ3: Is there a relationship between benefit seeking and the choice of governance forms?

Building upon the relevant literature on the use of IP marketplaces that has been developed in relation to patents, we explore in particular the following four main categories of strategic benefits that can be sought through participation in IP marketplaces and which represent the most widely cited reasons that firms engage in the exchange of IP:

- benefits relating to innovation, in that the trade of IP should facilitate innovation diffusion[12] and enhance innovation processes, often in a social process of interaction with other individuals and organisations, thereby also enabling the development of better technology or enabling standardisation and technological compatibility;[13]
- benefits relating to market positioning, linked to the ability to gain or maintain market share due to the exclusive access to certain IP;[14]
- benefits relating to financial gains in terms of the ability to derive income from transactions in proprietary marketplaces or conversely to cut costs by forsaking IPR protection and even in terms of the increased ability to raise capital;[15]
- benefits relating to the building of strategic relationships with or within industry.[16]

Another objective of this article is to discuss the performance or efficiency of IP marketplaces as experienced by the pharmaceutical firms in our sample, or in other words, to deal with the following research question:

RQ4: What are the various types of obstacles experienced by firms which prevent them from reaching the value they are seeking when exchanging IP in the marketplace?

When discussing the obstacles to the smooth functioning of IP marketplaces, institutional economics tends to focus on asymmetric relationships with respect to bargaining power and information and knowledge.[17] Trust is also an important factor in market interaction.[18] But there are also other institutional aspects of markets as platforms for social relations, which could affect the sustainability of the system. For example, a recent report from the software industry,[19] which focused especially on patent rights, suggested that firms encountered problems relating to (i) inflexibility (impossible to bargain a deal), (ii) a lack of transparency (difficult to identify the owner, uncertainty as to what the right price is, or impossible to make sense of text and diagrams in patent documents), (iii) a lack of integrity (poor behaviour and unjust court cases), and (iv) low quality (too many similar patents with no inventive step), among other obstacles. To understand the problems that firms encounter when engaging in IP marketplaces which can lead to institutional failure, we investigated several main categories of obstacles derived from the literature, namely problems relating to difficulties in search, lack of transparency, contract design and enforcement issues and regulation issues. The range of obstacles investigated by the survey is listed at the end of the data section.

Data

This study draws upon the UKNOW-survey database comprising data collected from German pharmaceutical

12 K. Arrow: Economic Welfare and the Allocation of Resources for Invention, in: R. Nelson (ed.): The Rate and Direction of Inventive Activity, Princeton NJ 1962, Princeton University Press, pp. 609-25; L. Rivera-Batiz, P. Romer: Economic integration and endogenous growth, in: The Quarterly Journal of Economics, May 1991; A. Arora, A. Fosfuri, A. Gambardella: Markets for Technology: Economics of Innovation and Corporate Strategy, Cambridge MA 2001, MIT Press; J. Gans, S. Stern: Incumbency and R&D Incentives: Licensing the Gale of Creative Destruction, in: Journal of Economics and Management Strategy, Vol. 9, 2000.

13 Cf. e.g. R. Merges, R. Nelson, op. cit.; R. Merges, R. Nelson: On limiting or encouraging rivalry in technical progress: The effect of patent scope decisions, in: Journal of Economic Behavior & Organization, Vol. 25, No.1, 1994, pp. 1-24; S. Winter: Patents and Welfare in an Evolutionary Model, in: Industrial and Corporate Change, Vol. 2, 1993, pp. 211-231; A. Plant: The Economic Theory Concerning Patents for Inventions, in: Economica, Vol. 1, New Series, 1934, pp. 30-51.

14 Cf. e.g. K. Rivette, D. Kline: Rembrandts in the Attic: Unlocking the Hidden Value of Patents, Harvard Business School University Press, 2000; W. Cohen et al.: Protecting Their Intellectual Assets..., op. cit.; O. Granstrand: Economics and Management of Intellectual Property, Cheltenham 1999, Edward Elgar.

15 Cf. e.g. B. Coriat, F. Orsi, op. cit.; K. Rivette, D. Kline, op. cit.

16 Cf. e.g. A.B. Jaffe, M. Trajtenberg, R. Henderson: Geographical Localisation of Knowledge Spillovers, as Evidenced by Patent Citations, in: Quarterly Journal of Economics, Vol. 58, No. 3, 1993, pp. 577-598; D. Teece: Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing and Public Policy, in: Research Policy, Vol. 15, 1986, pp. 285-305.

17 G.A. Akerlof: The Market for "Lemons": Quality Uncertainty and the Market Mechanism, in: The Quarterly Journal of Economics, Vol. 84, No. 3, 1970, pp. 488-500.

18 R. Bachmann: Trust, Power and Control in Trans-organizational Relations, in: R. M. Kramer (ed.): Organizational Trust. A Reader, Oxford 2006, Oxford University Press.

19 IBM: Building a New IP Marketplace: A Global Innovation Outlook 2.0, in: Innovation Outlook Report, IP marketplace, 2006.

firms, UK firms in the ICT sector and UK universities[20] and refers to the sample of German firms.

In order to build the German pharmaceutical firms sample, information was drawn from the Amadeus database, which is a comprehensive, pan-European database containing financial information on more than 11 million public and private companies in 41 European countries. Firms were extracted according to geographic location (Germany) and NACE Rev. 1 codes. The code used for this extraction was 244 (Manufacture of pharmaceuticals, med. chemicals, botanical prod.), which comprises codes 2441 (Manufacture of basic pharmaceutical products) and 2442 (Manufacture of pharmaceutical preparations).

From this initial population (size 746), it was established that 164 firms were not part of the pharmaceutical manufacturing industry (for example, pharmaceutical trading companies) and an additional 45 were no longer in business. Thus, the population was reduced to 537 relevant firms. All firms were contacted by telephone and offered the choice of either a telephone interview with the assistance of appropriately trained interviewers or an online questionnaire. The survey was carried out by Zentrum für Sozialforschung Halle e.V. (zsh), a company which belongs to the University of Halle. Field work was carried out between October and December 2008.

The questions in the survey referred separately to four IP marketplaces. In turn, for each marketplace, the questions in the survey referred to different IP governance structures, as detailed in Table 1.

A first set of questions referred to the extent and intensity with which firms participated in each marketplace and each governance structure. Firms were asked about their stock of patents owned and licensed, whether they engaged in each patent governance form, and if so, the number of transactions in the last two years. With respect to open source, non-patented technology and copyright, firms were asked whether they engaged in each governance form, and if so, the number of transactions they had carried out in the last two years.

A second set of questions referred to the benefits that firms seek when trading IP. For each marketplace and governance form, firms were asked to tick up to five strategic benefits that they sought. These include four broad benefit types related to 13 different variables:

- *Benefits relating to financial gains.* Variables include (1) direct income from market transactions; (2) cost cutting, e.g. via savings on royalties or patent administration; (3) increasing the firm's ability to raise venture capital.

- *Benefits relating to innovation.* Variables include (4) being able to use the best inventions, innovations and creative expressions; (5) setting common standards / making or using compatible technology or creative expressions; (6) innovation methodology: developing better technology or creative expressions; (7) benefiting from user or supplier involvement as a development strategy.

Table 1
Marketplaces and Governance Forms Investigated Through the UKNOW Survey

IP marketplaces	Governance structures
Patents as a tool for the protection of novel ideas	Selling patents
	Buying patents
	Out-licensing patents
	In-licensing patents
	Cross-licensing patents
	Participation in patent pools
	Buying university-owned patents
	Licensing university-owned patents
"Open source" IP as a tool for the protection of original ideas and creative expressions	Participating in open source software development
	Participating in open source pharmaceutical projects
	Participating in other open source communities
"Non-patented" ideas	Releasing not-patented product or process innovations to the public
	Releasing not-patented product or process innovations to private firms
	Using not-patented product or process innovations
	Collaborating with universities without patent restrictions
Copyright as a tool for the protection of original creative expressions	Selling copyright
	Buying copyright
	Out-licensing copyright
	In-licensing copyright
	Buying university-owned copyright
	Licensing university-owned copyright

20 The database was developed at Birkbeck College (under the coordination of Birgitte Andersen) as part of the EU 6th Framework Programme project UKNOW (Understanding the Relationship between Knowledge and Competitiveness in the Enlarging EU, contract number CIT 028519), Work Package 3.2 "An IPR Regime in Support of a Knowledge Based Economy".

- *Benefits relating to the building of strategic relationships.* Variables include (8) building informal relationships with industry networks; (9) increasing the firm's ability to enter collaborative agreements, e.g. joint ventures, strategic alliances etc.; (10) giving something to the community.

- *Benefits relating to market positioning.* Variables include (11) increasing market share, e.g. building a broader user base or securing market protection; (12) professional recognition or brand recognition; (13) competitive signalling.

Then, firms were also asked to tick up to five obstacles they encountered when trading IP. These include four broad types of obstacles related to 14 different variables:

- *Obstacles relating to search problems.* Variables include (1) difficulty in locating the owners of IP; (2) difficulty in locating the users of IP; (3) difficulty in finding the best IP.

- *Obstacles relating to a lack of transparency.* Variables include (4) difficulty in assessing the degree of novelty/originality of the IP; (5) a lack of clarity of the IP document; (6) difficulty in assessing the economic value of the IP.

- *Obstacles relating to contract negotiation and enforcement.* Variables include (7) difficulty in negotiating a price for the IP; (8) difficulty in negotiating the non-price-related terms of the contract; (9) the excessive cost of enforcing the contract; (10) non-cost-related problems with enforcing the contract; (11) trust issues, e.g. opportunistic behaviour, free-riding, or similar.

- *Obstacles relating to excessive or too rigid regulation.* Variables include (12) regulations allow overly exclusive rights; (13) international IP regulations do not fit the needs of different local markets; (14) firms have different practices, which are not accommodated by regulations.

Analysis

Pharmaceutical Firms' Involvement in IP Marketplaces

The number of valid responses obtained was 34, resulting in a response rate of 6.3%. The low rate is mainly due to the fact that firms often reported either that they had outsourced the legal aspect of IPR to a specialised lawyer (who was not granted permission to answer our questions) or that they were affiliates of larger foreign investors who deal with IPR issues in their headquarters. As can be seen in Table 2, respondents are overrepresented in the large firms category and underrepresented in the small firms category. This is mainly due to the fact that small firms often reported that they were not formally and constantly engaged in product or process development and hence dealt with IP issues infrequently and sporadically.

Table 2
Size Distribution of Population and Respondents

	Population	Respondents
N firms	537	34
Less than 10 employees	44.7%	17.6%
Between 11 and 50 employees	24.6%	26.5%
Between 51 and 250 employees	17.9%	32.4%
More than 250 employees	12.8%	23.5%

We first assess the patterns of participation in different IP marketplaces (RQ1).

Of the 34 respondents, 10 (29.4%) do not participate in any of the four IP marketplaces, while 24 (70.6%) participate in at least one IP marketplace. Of the respondents that participate in IP marketplaces, only 7 (29.2%) are involved in one marketplace, while most (17, that is 70.8%) are involved in two or more marketplaces (although no organisation participates in all four marketplaces: 10 firms do not participate in any marketplace, 7 participate in one, 13 participate in two, 4 participate in three, and none participate in all four marketplaces). Furthermore, while 4 firms (16.7%) engage only in proprietary IP marketplaces (patents and/or copyrights) and 9 firms (37.5%) engage only in non-proprietary IP marketplaces, the greatest share of respondents that engage in IP marketplaces use a combination of proprietary and non-proprietary forms of protection for their IP (11 firms, or 45.8%). This clearly indicates that participation in these marketplaces represents complementary rather than alternative strategies of knowledge protection and transfer. It is particularly interesting to find that even in the pharmaceutical industry, which is considered one where the use of patents is particularly intensive and warranted,[21] the reliance on non-proprietary IP marketplaces is widespread. The reasons for the strategic use of different types of IP marketplaces (in terms of value seeking) are explored below.

Only two firms in our dataset participate in the proprietary copyright marketplace: one firm that also uses patents

21 E. Mansfield, op.cit.; R. Levin et al., op. cit.; F.M. Scherer: The Economics of Human Gene Patents, in: Academic Medicine, Vol. 77, 2002, p. 1350.

and one firm that also uses open source and non-patented technology. Because of the extremely low number of observations relating to this marketplace and its associated governance forms, we refrain from analysing the copyright marketplace throughout the rest of this article, focusing instead on patents, open source and non-patented technology.

The likelihood of participating in certain marketplaces or combinations of marketplaces is not significantly affected by firm size. In particular, there are no significant differences in terms of turnover or number of employees between the 14 firms that participate in patent marketplaces and those that do not or indeed between these subgroups and the structure of the full sample of 34 firms.

In the patent marketplace, all governance forms are used in almost equal measure, with a slight prevalence of in-licensing. Of the 14 firms that engage in the patent marketplace, most (13 or 93%) engage in in-licensing patents. Buying, selling, out-licensing and cross-licensing patents are each engaged in by 8 firms (57%), and 7 firms (50%) participate in patent pools. Of the 13 firms that in-license patents, 9 in-license from universities, while of the 8 that buy patents, 7 buy patents from universities. Universities are therefore a key source of patented knowledge for German pharmaceutical firms. The substantial impact that university knowledge has on the pharmaceutical industry is well documented.[22]

12 firms are active in open source IP, and all engage in open source pharmaceuticals. Of the 17 firms that engage in markets for non-patented technology, most seem to be active in many governance forms at the same time. 16 firms (94%) use non-patented technology, and there are 13 firms (76%) that are active in each of the following governance forms: releasing non-patented technology to the public, releasing non-patented technology to private firms, and collaborating with universities without patent restrictions.

In the previous two years, firms have, on average, traded about 10% of their total stock of patents. The stock of patents that firms in-license from other organisations is, on average, one third of the stock of patents they own. The number of patents traded in the previous two years is quite low: on average, firms have sold 0.5 patents, bought 1, out-licensed 1.4, in-licensed 2.7, and cross-licensed and pooled 0.5. Firms have, on average, engaged in 0.5 open source projects, released 6.5 non-patented technologies to the public, released 0.5 non-patented technologies to private firms, used 1.6 non-patented technologies and participated in 1.2 collaborations with universities. The intensity of engagement in the various marketplaces is therefore similar, with a higher average number of transactions in non-patented technology, confirming in quantitative terms the importance of this marketplace.

22 W. Cohen, R. Nelson, J. Walsh: Links and Impacts: The Influence of Public Research on Industrial R&D, in: Management Science, Vol. 48, No 1, 2002, pp. 1-23.

Strategic Value Seeking and the Trade of IP

We now move on to address RQ2 and RQ3 by analysing the various types of strategic benefits that firms seek when exchanging IP in different marketplaces. We examine in particular whether there is a link:

- between the various marketplaces in which firms engage and the benefits that they seek;
- between the various governance structures (within the patent, open source and non-patented technology marketplaces) and the benefits that firms seek.

Table 3 summarises the responses given by pharmaceutical firms with respect to the benefits that they derive from engaging in the various IP marketplaces (the columns do not add up to 100% since each firm could choose more than one category of benefits). The 13 variables underpinning the four broad benefits in Table 3 are listed above in the data section.[23]

Pharmaceutical firms seek all kinds of benefits in all marketplaces, but with varying degrees of intensity. The main benefits that firms seek when engaging in the patents marketplace relate to innovation and market positioning. This is in line with findings from the economics of innovation literature, which point to the role of patents in the pharmaceutical industry as a means to prevent imitation and hence maintain market share[24] and with the conventional view that patent protection fosters innovation processes.[25] Firms that engage in open source pharmaceuticals mainly seek benefits relating to innovation and to the building of strategic relationships. This is also quite well known. The literature on open source has often indicated

23 In order to construct the shares presented in Table 3, the firms' responses with respect to each benefit were aggregated into the four main categories ("financial", "innovation", "strategic relationships" and "market"), taking care to avoid double-counting. The shares of firms ticking at least one benefit in each category were computed for each IP governance form, and they were then averaged across all governance forms within each marketplace.

24 R. Levin et al., op. cit.

25 See G. Dosi et al., for an overview of the debate on the relationship between patenting and innovation activity: G. Dosi, L. Marengo, G. Pasquali: How much should society fuel the greed of innovators? On the relations between appropriability, opportunities and rates of innovation, in: Research Policy, Vol. 35, 2006, pp. 1110-1121.

Table 3
Benefits from Participation in IP Marketplaces
(% of Firms Seeking a Certain Benefit Type)

	Patents	Open source	Non-patented technology
Finance	27.2	16.7	39.8
Innovation	44.9	25.0	40.1
Strategic relationships	27.6	25.0	31.3
Market positioning	41.6	8.3	29.3

that firms engage in open source IP in order to develop and use better innovations,[26] especially when user-driven.[27] The literature has also emphasised the importance of standardisation and compatibility, which allow firms to enlarge their user bases.[28] Firms have been known to contribute to open source projects out of individual extrinsic and social motivations,[29] especially when the technology is not crucial to the firm's competitive advantage.[30] However, firms that exchange non-patented technology mainly do so for financial gain and in order to improve their innovation processes.

If we analyse in greater detail the respondents' answers with respect to the specific benefits within each category (these data are not reported), we find that in the context of financial benefits, "direct income" from the transaction is relevant only in the patent marketplace (and only for two patent governance forms, selling and out-licensing patents). This suggests that firms take part in IP marketplaces, proprietary and non-proprietary, for many reasons other than direct financial gain. Cost-cutting is the most important financial benefit in all marketplaces (mentioned by 25% of firms engaging in open source and by 23.6% of firms engaging in non-patented technology), although the use of non-proprietary IP is also relevant for increasing the firm's ability to raise venture capital.

With respect to innovation benefits, patents allow firms to develop better technology (27.6%), to use the best inventions (29.6%), and to a lesser extent, to benefit from the involvement of users (16.7%). The same categories are also relevant in the other two IP marketplaces, although to a lesser extent. Instead, the most important benefit for firms that exchange non-patented technology is making or using compatible technology (18.1%), which is generally not possible when firms protect their technology though patents.

Patents, open source IP and non-patented technology allow firms to increase their ability to enter collaborative agreements (around 17% of respondents in each marketplace). However, when firms exchange non-patented technology, they are mostly seeking to build relationships with industry networks (30.5%; this option is also important to 17.1% of the firms that exchange patents) and to give something to the community (23.6%).

Increasing market share is a key benefit that firms seek when participating in the patent marketplace (seen as very important across all governance forms and for an average of 40% of the respondents that exchange patents). This is much less important in the non-proprietary IP marketplaces. In line with the results of other patent studies,[31] exclusive ownership or access to protected technology is regarded as very important for the firms' market positioning strategies. Nevertheless, contributing to innovation processes is the most important benefit firms seek from the patent marketplace; this is consistent with the view that the acquisition and exchange of knowledge embedded in patents allows firms to acquire good-quality technology and to build upon it in social interaction processes.[32]

Overall, two patterns stand out, even in the pharmaceutical sector, which has traditionally been considered one where the use of patents is widespread. First, participation in the patents marketplace is not the only way in which pharmaceutical firms foster their innovation processes: respondents also derive benefits for their own innovation activities from engaging in the open source and non-patented technology marketplaces. Second, innovation benefits are generally considered equally important

26 J. Kuan: Open Source Software as Consumer Integration into Production, in: Working Paper available at: www.papers.ssrn.com/ paper.taf?abstract_id=259648, 2001.
27 J. Bessen: What Good is Free Software?, in: R.W. Hahn (ed.): Government Policy toward Open Source Software, AEI Brooking Joint Center for Regulatory Studies, Washington DC 2002.
28 T. Wichmann: Basics of Open Source software markets and business models, Free/Libre and Open Source Software: Survey and Study, in: FLOSS Final Report, International Institute of Infonomics, Berlecom Research GmbH, 2002; T. Wichmann: Firms' Open Source activities: Motivations And Policy Implications, Free/Libre and Open Source Software: Survey and Study, in: FLOSS Final Report, International Institute of Infonomics, Berlecom Research GmbH, 2002.
29 A. Bonaccorsi, C. Rossi: Contributing to common pool resources. A Comparison Between Individuals and Firms', working paper, Sant'Anna School of Advanced Studies, 2003, available at: http:// opensource.mit.edu/papers/bnaccorsirossidevelopers.pdf.
30 J. Henkel: Open Source Software from Commercial Firms: Tools, Complements, and Collective Invention, in: GEABA Discussion Paper 02-27, 2002.
31 K. Rivette and D. Kline, op. cit.; W. Cohen et al., Protecting Their Intellectual Assets.., op. cit.; O. Granstrand, op. cit.
32 R. Merges and R. Nelson, on the complex economies..., op. cit.; H.R. Merges, R. Nelson: On limiting..., op. cit.; S. Winter, op. cit.; A. Plant, op. cit.

as certain other benefits, which differ by marketplace (for example, market positioning for the patent marketplace, building strategic relationships for the open source marketplace and financial gain for the non-patented technology marketplace).

Building upon Andersen and Konzelmann,[33] we hypothesised that within each marketplace there is a link between the governance forms in which firms engage and the benefits that they seek. That is, benefits are not only market-specific but also governance-specific.

In order to further deepen our understanding of the relationship between the use of different governance forms within each IP marketplace and the seeking of benefits, we have built an index which measures the extent to which organisations that take part in a certain governance form "specialise" in seeking a certain benefit when compared with the overall set of organisations in the marketplace. Because this index is modelled upon the widely used Revealed Technological Advantage index, we refer to it as the index of "Revealed Governance Advantage" (RGA).

Let x_{ij} be the number of times that benefit i is chosen in governance form j, and $\sum_i x_{ij}$ the number of times that all benefits are chosen in governance form j; let $\sum_j x_{ij}$ be the number of times that benefit i is chosen in all governance forms, and $\sum_i\sum_j x_{ij}$ the total number of benefits chosen in all governance forms (that is, the index is the ratio between the share of benefit i in governance form j and the share of benefit i in all governance forms). Then, for a certain governance form, the revealed governance advantage index is:

$$RGA = (x_{ij}/\sum_i x_{ij}) / (\sum_j x_{ij}/\sum_i\sum_j x_{ij})$$

This index assumes only positive values: a value that is smaller than 1 indicates that governance form j is relatively under-specialised in benefit i, while a value greater than 1 indicates that governance form j is relatively over-specialised in that particular benefit.

The same index can also be computed for IP marketplaces, rather than governance forms. The "Revealed Marketplace Advantage" (RMA) index is computed as

$$RMA = (y_{ij}/\sum_i y_{ij}) / (\sum_j y_{ij}/\sum_i\sum_j y_{ij})$$

where y_{ij} is the number of times that benefit i is chosen in marketplace j, $\sum_i y_{ij}$ is the number of times that all benefits are chosen in marketplace j, $\sum_j y_{ij}$ is the number of times that benefit i is chosen in all marketplaces, and $\sum_i\sum_j y_{ij}$ is the total number of benefits chosen in all marketplaces (that is, the index is the ratio between the share of benefit i in marketplace j and the share of benefit i in all marketplaces). This index allows us to compare the relative advantages of the various marketplaces, including open source, in allowing firms to achieve certain benefits.

Table 4 provides an overview of the results for the RMAs and RGAs. In the computation of the RGA indices, we do not consider open source, since all respondents indicated only one form of open source governance (open source pharmaceuticals).

Overall, the RMAs show that German pharmaceutical firms seek financial benefits primarily when they engage

Table 4
"Revealed Governance Advantage" and "Revealed Marketplace Advantage" for Various Benefits

IP Marketplace and IP governance forms	RMA or RGA index			
	Finance	Innovation	Strategic relation-ships	Market position-ing
Patents	*0.89*	*0.94*	*1.04*	*1.18*
selling patents	1.60	0.62	1.01	1.03
buying patents	0.89	1.03	0.84	1.14
out-licensing patents	1.42	0.62	1.68	0.69
in-licensing patents	0.59	1.20	1.12	0.95
cross-licensing patents	1.52	0.66	1.08	0.98
participating in patent pools	0.67	1.16	0.63	1.29
buying university-owned patents	0.59	1.38	0.56	1.14
licensing university-owned patents	0.53	1.55	0.51	1.03
Open source	*0.86*	*1.17*	*1.28*	*0.57*
Non-patented technology	*1.10*	*1.00*	*0.92*	*0.98*
releasing non-patented product or process innovations to the public	0.80	0.64	1.24	1.53
releasing non-patented product or process innovations to private firms	0.93	0.93	1.51	0.64
using non-patented product or process innovations	1.17	1.00	0.86	0.92
collaborating with universities without patent restrictions	1.11	1.47	0.48	0.76

Note: The RMAs within the table are italicised.

33 B. Andersen, S. Konzelmann, op. cit.

in the non-patented technology marketplace, innovation and strategic relationships benefits when they engage in the open source marketplace and market positioning benefits primarily when they engage in the patent marketplace. However, the RGA results indicate a more complex pattern underpinning these overall results.

In the patent marketplace, firms seek primarily financial benefits when they engage in the selling, out-licensing and cross-licensing of patents. Such benefits are least important when licensing university-owned patents. Firms seek primarily innovation benefits when they in-license patents, especially when they buy and in-license university-owned patents. This indicates that acquiring patents resulting from academic research is crucial for the innovation strategies of pharmaceutical firms.[34] Firms primarily seek to build strategic relationships when they out-license patents. Finally, market positioning benefits are particularly important to firms that buy patents, including academic ones originating from universities, and to those that participate in patent pools, indicating that acquiring access to exclusive technology is relevant to the firms' market positioning strategies.

In the non-patented technology marketplace, financial benefits are particularly important when firms use non-patented technology; this allows them to cut costs and to build strategic knowledge assets which in turn help them raise capital. Firms primarily derive innovation benefits from collaboration with universities, confirming the important role of academic knowledge in firms' innovation processes. Firms primarily seek to build strategic relationships when they release non-patented technology either to the public or to private firms, while market positioning benefits are particularly sought when releasing technology to the public.

In order to quantify the extent to which a benefit is specific to one or a few governance forms or whether it is equally sought in different governance forms, we compute the coefficient of variation of the RGA index across governance forms (σ_{RGA}/μ_{RGA} *100%); similarly, we quantify the extent to which a benefit is specific to a certain marketplace by computing the coefficient of variation of the RMA index across marketplaces (σ_{RMA}/μ_{RMA} *100%). The higher the coefficient of variation, the more a certain benefit is specific to one or few governance forms or to a marketplace, thus indicating a stronger revealed advantage.

34 Consistent with findings by E. Mansfield: Academic research and industrial innovation, in: Research Policy, Vol. 20, 1991, pp. 1-12; W. Cohen et al.: Links and Impacts..., op.cit., among others.

Table 5

Coefficients of Variation Across Governance Forms and Marketplaces

	Finance	Innovation	Strategic relationships	Market positioning
Index of governance specialisation (patent marketplace): σ_{RGA}/μ_{RGA} *100%	47.07	35.03	41.62	*17.12*
Index of governance specialisation (non-patented technology marketplace): σ_{RGA}/μ_{RGA} *100%	*16.84*	34.30	44.02	41.11
Index of marketplace specialisation: σ_{RMA}/μ_{RMA}*100%	*13.99*	*11.24*	*17.33*	34.31

The results in Table 5 show that benefits are quite specific to governance forms within each marketplace, with a few exceptions indicated in italics (market positioning benefits are similarly sought across most patent governance forms, and finance benefits are similarly sought across most non-patented technology governance forms). In all other cases, the standard deviation of the index is greater than its mean by more than 20%. Benefits are overall less specific to marketplaces than to governance forms, indicating that firms tend to seek all four categories of benefits in all marketplaces. Overall, with a couple of exceptions (which could be due to the somewhat low number of observations causing random disturbances), this confirms that the hypothesis put forward by Andersen and Konzelmann[35] that governance structures matter for value creation processes in IP marketplaces holds for firms in the pharmaceutical sector.

Institutional Failures in IP Marketplaces

In the strategic use of different marketplaces, firms may encounter obstacles that prevent them from obtaining the value they seek (for an overview of these obstacles, see the beginning of this article and the literature review underpinning RQ4 above). In response to RQ4, we investigate the various types of obstacles encountered by firms which prevent them from achieving the value they seek when exchanging IP. Furthermore, we examine whether the obstacles are somehow inherent to certain marketplaces or to specific governance forms within each mar-

35 B. Andersen, S. Konzelmann, op. cit.

ketplace. If this were the case, IP marketplaces would appear to suffer from certain kinds of "institutional failures", of which policymakers seeking to improve the smooth functioning of these institutions should be aware.

Table 6 summarises the main obstacles that pharmaceutical firms encounter when engaging in various IP marketplaces (the columns do not add to 100% because firms could choose more than one category of obstacles). The 13 variables underpinning the four broad obstacles in Table 6 are listed above under the heading "Data".[36]

Firms encounter somewhat different obstacles in the different marketplaces.

In the patent marketplace, the most relevant obstacles are contract negotiation and enforcement issues and a lack of transparency. Lack of transparency most often derives from difficulty in assessing the economic value of the patent (indicated by 49.5% of firms); the most difficult contract issues consistently concern the negotiation of a price for the patent (33.6%), but also the negotiation of the other terms of the contract (32.6%). Difficulty in assessing the economic value of the patent is particularly high when buying (57.1%) and licensing (77.7%) university patents. In an analysis of patent licensing consistent with these results, Cockburn[37] found that the most important reason that patent negotiations break down is an inability to agree on the financial and non-financial aspects of the contract; a very high share of respondents also indicated "disagreement on basic facts or assumptions underlying valuation" as a major problem.[38]

In the case of open source, the most relevant obstacles are search problems, particularly how to find the best open source technologies (indicated by 25% of firms), probably because of the wealth of technologies available as open source.

In the non-patented technology marketplace, transparency is the biggest problem. 29.4% of respondents that engage in this marketplace find it difficult to identify the best non-patented technology, while 15% find it difficult to assess the degree of novelty or the economic value of the technology and find that the technology's description is not clear.

Table 6
Obstacles to Participation in IP Marketplaces
(% of Firms Experiencing a Certain Obstacle Type)

Type of obstacle	Patents	Open source	Non-patented technology
Search	35.3	25.0	24.8
Transparency	52.0	16.7	30.2
Contract negotiation and enforcement	63.6	16.7	26.7
Regulation	23.3	16.7	16.6

Investigating whether these obstacles affect firms in all IP marketplaces or governance structures to a similar extent or whether they are instead specific to certain ones should help us clarify which obstacles are considered particularly relevant in each context. Thus, we compute an index similar to the "revealed governance advantage" and "revealed marketplace advantage" indices mentioned earlier, only this time with respect to obstacles (Table 7). Hence, we call them "revealed governance disadvantage (RGD)" and "revealed marketplace disadvantage (RMD)", respectively.

In the patent marketplace, contract negotiation and enforcement issues are particularly important, and they affect most forms of IP governance. Search issues are particularly problematic when cross-licensing and pooling patents. Transparency issues are problematic across the board, and regulation issues (having to do with the inability of regulations to accommodate different needs) are particularly relevant when in-licensing patents.

In the case of open source, search and regulation problems are particularly relevant. Search problems mostly relate to difficulties in finding the best open source available, while regulation issues mostly concern the different practices of firms, which can fail to abide by the norms of open source development.

Firms primarily encounter contract-related obstacles when they release non-patented technology to the public. The rigidity of regulations is an issue when firms release non-patented technology to private firms and when they collaborate with universities.

Exchanging (patented and non-patented) IP with universities is very important for pharmaceutical firms' innovation processes, but it gives rise to many different obstacles.

36 The firms' responses given with respect to each obstacle were aggregated into the four main categories ("search", "transparency", "contract negotiation and enforcement" and "regulation"), taking care to avoid double-counting. The shares of firms ticking at least one obstacle in each category were computed for each IP governance form, and they were then averaged across all governance forms within each marketplace.

37 I. Cockburn: Is the Market for Technology Working? Obstacles to Licensing Inventions, and Ways to Reduce Them, paper prepared for the Conference on Economics of Technology Policy, Monte Verità, June 2007.

38 Ibid., p. 9.

Table 7
"Revealed Governance Disadvantage" and "Revealed Marketplace Disadvantage" for the Various Obstacles

IP Marketplace and IP governance form	RMD or RGD index			
	Search	Transparency	Contract negotiation and enforcement	Regulation
Patents	*0.87*	*1.03*	*1.24*	*0.76*
selling patents	0.75	1.03	1.07	1.13
buying patents	1.13	1.03	0.86	1.13
out-licensing patents	0.65	1.11	1.11	0.98
in-licensing patents	1.15	0.98	0.82	1.29
cross-licensing patents	1.22	0.84	1.16	0.61
participating in patent pools	1.22	0.84	1.16	0.61
buying university-owned patents	0.75	1.03	1.07	1.13
licensing university-owned patents	1.11	1.06	0.89	1.00
Open source	*1.33*	*0.75*	*0.79*	*1.29*
Non-patented technology	*1.00*	*1.05*	*0.89*	*1.09*
releasing non-patented product or process innovations to the public	0.87	1.08	1.22	0.68
releasing non-patented product or process innovations to private firms	0.71	0.88	1.00	1.67
using non-patented-product or process innovations	1.12	1.08	1.05	0.58
collaborating with universities without patent restrictions	1.12	0.92	0.79	1.31

Note: The RMDs within the table are italicised.

This seems due to the excessive rigidity of IP regulations that render interaction difficult but also to the difficulty in finding the best patents and non-patented technologies (indicating that universities' technology transfer offices need to improve their methods in revealing their IP to the market).

Finally, the coefficients of variation of the RGD and RMD indices allow us to assess the extent to which obstacles are specific to certain governance structures and marketplaces (Table 8).

Transparency and contract design and enforcement issues tend to be similarly important across governance forms in the case of both patents and non-patented technology forms (the standard deviation of the index is less than 20% of its mean). Search problems and regulation problems, however, are more specific to certain patent governance forms and also to certain non-patented technology governance forms.

Table 8
Coefficient of Variation Across Governance Forms and Marketplaces

	Search	Transparency	Contract	Regulation
Index of governance specialisation (patent marketplace): σ_{RGD}/μ_{RGD} * 100%	23.76	*10.32*	*13.82*	25.37
Index of governance specialisation (non-patented technology marketplace): σ_{RGD}/μ_{RGD} *100%	20.94	*10.35*	*17.72*	48.87
Index of marketplace specialisation: σ_{RMD}/μ_{RMD} *100%	22.40	*17.85*	24.14	25.74

At the level of IP marketplaces, search obstacles are specific to open source, contract design and enforcement obstacles are specific to patents and excessively rigid regulations are specific to open source and non-proprietary IP in general.

We also investigated the extent to which the obstacles that firms encounter in each marketplace are correlated to the benefits they seek, but we did not find any strong patterns in this sense. This confirms that obstacles are more related to the features of IP markets and IP governance structures than to the firms' individual objectives.

Conclusions

The analysis of the intensity, strategic motivations and obstacles to participation in different IP marketplaces on the part of a sample of German pharmaceutical firms sheds new light on the relationship between the firms' objectives when trading IP and their choice of marketplaces and governance forms.

Our results show that pharmaceutical firms participate in a variety of proprietary and non-proprietary marketplaces, which constitute complementary rather than competing methods of regulating and trading one's intellectual property. While most analyses on the exchange of IP in the pharmaceutical industry focus on the use of patents, our results show that non-proprietary marketplaces are used at least as intensively as proprietary ones and suggest that greater attention should be paid to them, especially by policymakers. Industrial and research policies based on the assumption

that pharmaceutical companies mostly trade their IP in the form of patents are in fact likely to be off the mark, as they ignore a large share of these companies' IP activities. Thus, the implementation of an IP policy focused solely on supporting and enforcing the patent system may have the effect of holding the value created using other forms of IP below its potential.

Also, the finding that pharmaceutical firms derive different strategic benefits from participation in different IP marketplaces (e.g. patent, open-source IP and non-patented technology) provides a counterargument to the mainstream view that only proprietary or patent protection allows firms to develop significant value. For example, while still important, financial gains do not constitute the primary benefit that firms seek from patents. This also explains why firms exchange patents despite the difficulties that they encounter in terms of negotiating their price and assessing their economic value. The mainstream argument that patents are primarily important for value creation from ideas is put forward irrespective of IP governance structure. However, we find that each type of IP employs different governance structures (e.g. with respect to patents, simple licensing out or in, cross-licensing, patent-pooling etc.) for seeking various kinds of benefit.

Furthermore, while the generally accepted argument is that the public nature of knowledge can often lead to an underinvestment in knowledge production (which has been termed "the tragedy of the commons"), much less attention has been paid to the failure of institutions such as IPR to function efficiently and smoothly. The results of our analysis show that firms encounter obstacles in all IP marketplaces. It cannot therefore be assumed that these markets function perfectly. Instead, interventions aimed at removing or easing such obstacles may be beneficial.

In conclusion, the analysis confirms that each IP marketplace is very different and their specific features must be considered in depth before broad IP policies are issued. Our results, which provide some evidence that both the strategic benefits sought and the market obstacles encountered are specific to individual IP marketplaces and usually also to individual IP governance structures within those marketplaces, indicate that each IP marketplace provides specific advantages and suffers from specific institutional failures. Therefore, policymakers wishing to improve the functioning of IP marketplaces for pharmaceutical firms should be aware of their specificities. For example, the use of patents may not be the answer for all types of value creation processes within pharmaceutical firms. Extending IP policies designed for one IP marketplace (namely the patent marketplace) to other forms of IP might well produce undesired effects, since the different marketplaces are used for different purposes and are characterised by different obstacles.