IDEI report on

OBJECTIVES AND INCENTIVES AT THE EUROPEAN PATENT OFFICE

December 2006

INSTITUT D'ECONOMIE INDUSTRIELLE

Manufacture Des Tabacs
21 Allée de Brienne
Bât. F
31000 TOULOUSE
FRANCE
Tél. : +33 (0)5 61 12 85 89
Fax : +33 (0)5 61 12 86 37

OBJECTIVES AND INCENTIVES AT THE EUROPEAN PATENT OFFICE

December 2006[1]

Guido Friebel

Institut d'Economie Industrielle, University of Toulouse

Alexander K. Koch

Royal Holloway, University of London

Delphine Prady

Institut d'Economie Industrielle, University of Toulouse

Paul Seabright

Institut d'Economie Industrielle, University of Toulouse

[1]This report was commissioned by SUEPO, the Staff Union of the European Patent Office. The opinions expressed in this report are those of the authors alone and not those of the Institut d'Economie Industrielle, nor those of the SUEPO, of any members of the EPO or of its staff representatives.

Contents

Acknowledgements

We are grateful to Jing-Yuan Chiou for help in relation to Chapter 2. We also appreciate the fruitful discussions with members of SUEPO and our colleagues at IDEI.

Executive Summary

This report examines the effectiveness of the current system of incentives within the European Patent Office (EPO) and considers the possible consequences of placing greater emphasis on quantitative measures of productivity in rewarding EPO staff. It reviews the relevant scientific literature in two main categories:

- The literature on the economic objectives of the system of intellectual property and the role of patent examination within such a system.
- The literature on the role of incentives within organizations, and the extent to which different kinds of incentives may be appropriate according to the nature and goals of the EPO.

In addition, it reports recent experiences at the U.S. Patent and Trademark Office (USPTO). We conducted a questionnaire survey of EPO staff to allow identifying the relevant findings of the scientific literature and relevant experiences at the USPTO. The report summarizes its results casting light on the nature of work at the EPO and its specificities.

The EPO is an integral part of the global system of intellectual property rights protection. To fulfill its mandate of promoting innovation and thereby furthering competitiveness and economic growth for the benefit of the citizens of Europe and beyond, the EPO should apply an appropriate standard of patentability. Chapter 2 analyzes this issue and identifies risks

arising from applying in practice either a too strict or a too lenient standard.

The EPO has in place a Human Resource System that is meant to achieve this appropriate patentability standard in the patent examination process. Several developments have led to a perception that the Human Resource System should be adjusted to place greater emphasis on quantitative measures of productivity in rewarding EPO staff. Among these are most notably the growth in application numbers over the last few years, the accumulated backlog, and concerns regarding the future financial situation of the Office. Chapter 3 analyzes the potential consequences of such measures.

The main findings of the report are as follows:

1. Although there are costs from too stringent an interpretation of patentability requirements, notably the inventive step, too weak an interpretation of these requirements can have significant adverse effects on innovation.

2. Unfortunately, the literature does not give clear guidance as to exactly how stringent patentability requirements should be. The procedures of the EPO need therefore to be capable of responding to feedback from outside the Office (from the courts, the legislature, from scientific studies and so on) about the extent to which its procedures have the balance right or may be erring in one direction rather than another. In practice, this means that staff need to be given budgeted time to spend on reviewing case precedents (both in the prior decisions of the EPO and in judicial review by the courts), and also be provided with the incentive to keep up to date with the work of their peers.

3. An increase in incentives for quantity of work performed in a given time can impose significant costs on the quality of work – especially to for those aspects that are hard to measure. Our survey indicates significant divergence between EPO staff members' view of the appropriate balance between quantity and quality objectives, and the balance

they believe is achieved by the current system of incentives within the Office. While this divergence is not in itself an argument in favor of one or the other point of view, it is a matter of concern for the future functioning of the Office.

4. There is also a risk of adverse feedback effects to the Office's overall workload from a decline in the quality of work performed. Applicants may respond to any such perceived decline in stringency of the Office's examination procedure with a rise in the number of low-quality applications. So pressure to increase the Office's work-rate may actually increase, rather than reduce, its application numbers and backlog.

5. Our questionnaire survey shows that the work of different examiners is perceived by them to be highly interdependent: poor quality work by one examiner increases the load on his or her colleagues (the same is true of poor quality work by applicants and their legal representatives). Consequently, changes in incentives that encourage individual examiners to increase speed at the expense of quality could, paradoxically, are perceived to slow down the procedure by imposing additional delays on the work of other examiners.

6. We accept completely the importance of incentives for speedy, efficient processing of applications by the EPO. These are most likely to be achieved, however, by an appropriate balance between a system of "implicit" incentives – those that function via performance appraisal, the esteem of peers and the criteria for promotion – and "explicit" incentives – such as performance-related pay where remuneration responds automatically to some measurable criterion (e.g., the number of applications processed). The evidence we gathered suggests that the current mixed system of incentives the EPO works fairly well given the complex and multi-dimensional nature of the Office's objectives and criteria of excellence. Any proposal to strengthen the explicit component of such a system needs to take care not to undermine the implicit components. In particular, it will be important

to re-establish a greater degree of consensus about what the goals of the Office are, and about how the performance of individuals will be evaluated in relation to those goals.

Chapter 1

Introduction

1.1 The challenges facing the European Patent Office

This report, commissioned by the Staff Union of the European Patent Office (hereafter SUEPO), analyzes the objectives of the European Patent Office (hereafter EPO), the nature of its internal organization, and the way that the internal organization shapes the ability of the EPO to pursue those objectives, both now and in the future.

The background to the report is as follows. Concern has been expressed both within and outside the EPO over the last two to three years about the ability of the Office to respond to the demands placed upon it, given its existing resources. These demands take the form notably of an increase in patent applications, which rose from just over 79,000 in 1995 to nearly 179,000 in 2004 – an increase of 125% – and a very significant rise in the backlog outstanding. Applications have also become more voluminous, with a 50% increase in the average number of claims per application over the decade from 1995 to 2004[1]

The resources of the EPO are limited and it appears unlikely that significant increases in staffing can be the principal means of coping with the backlog. A report commissioned

[1]See President of the European Patent Office (2005).

from Deloitte & Touche in 2004 recommended that the management of the Office seek ways to improve the productivity of the applications process. Since then the management and staff of the Office have been engaged in continued discussion about the merits of various means to improve productivity, notably through changing the implicit and explicit incentives faced by staff. The Deloitte & Touche report recommended giving consideration to linking future salary increases to improvements in the performance of employees. The merits of this and other related measures have been central to the discussion within the Office.

To the extent that productivity is understood in terms of the numbers of patent applications processed, or granted, per member of the EPO staff, questions arise both about the effectiveness of different incentive mechanisms in improving the Office's quantitative performance, and about whether an increased emphasis on quantity might come at the expense of other important objectives, such as the quality of the screening given to each application. Even if there is such a trade-off between quantity and quality, it is of course possible that the current procedures at the Office may not accord the right balance between the two and therefore may need to be adjusted. This makes clear why it is important to understand what the terms of that trade-off are, and what might be the consequences of policies that increase the emphasis on one element of performance or the other.

There may also be other trade-offs besides those between quality and quantity of individual applications – increased staff time devoted to patent applications may come at the expense of time spent on research or on training, for instance. Such trade-offs may or may not be important. That is why a clear understanding of them is required.

The issue is complicated by the fact that even purely quantitative measures of productivity may give widely conflicting pictures about the evolution of the work performance of the EPO. To take one example, over the 9 years in which applications to the EPO rose by 125%, the total staff employed at the EPO rose by 61%. As a consequence, total applications per staff member

rose by 40%. Over the same period, searches completed by staff members increased by 25%, and patent grants by 41%. As this is less than the increase in staff, searches per employee fell by 22% and patents granted per employee fell by 12.5%. This reflects some combination of the growing backlog, an increase in the work required for the granting of a patent, and a rise in the number of applications withdrawn. [2]

Do these figures suggest that the EPO has applied tougher standards over time? Or has the average quality of applications decreased over time and the Office become less efficient at handling its workload, or even overwhelmed by it? Or are the figure reflecting an increase in the complexity of patent applications to be processed? Which of these purely quantitative measures gives a better picture, or do they all reflect some important aspects of the overall picture, and if so what are these aspects?

These questions are not only crucial to the internal functioning of the EPO but must also be situated in the context of the wider international debate about the effectiveness of the system of intellectual property rights protection in fostering innovation and growth in modern industrialized societies.

The Lisbon Agenda of the European Council has stressed the importance of intellectual property protection for promoting European competitiveness and growth. This emphasizes the importance of the ongoing debate about both quantitative and qualitative aspects of the European patent rights system for the future of Europe.

At the same time, in the United States there has been a lively and at times acrimonious debate about whether critical aspects of the current functioning of the US patent system are helping or hindering US innovation and growth. A prominent contribution to this debate has been a book by Adam Jaffe and Josh Lerner (2004) of the Harvard Business School. Its ti-

[2] Only some 2% of applications per year are formally refused, mainly because the predictable prospect of a refusal typically leads to withdrawal. These account for around a fifth of applications at each of the two phases of patent examination. See Chapter 3.5 for more details.

tle and especially subtitle (*Innovation and Its Discontents: How our broken patent system is endangering innovation and progress, and what to do about it*) clearly indicate major dissatisfaction with the current system. The authors believe that the U.S. Patent and Trademark Office (USPTO) and court system are unduly lenient in the award of and enforcement of patent rights. They argue that the result is the growth of a "patent thicket" in which the initiative of new inventors is stifled by potential infringement suits from holders of existing patent rights, whose existence may be unknown to the inventors. Ironically in view of the debate within the EPO, the authors point to current practice in Europe as being superior to US practice in many ways. In particular, they urge policy makers to ensure that the US reverse its excessive emphasis on quantity of patent applications granted and strengthen its emphasis on the quality of the screening process.

Debate about the quality of the patent application process has also taken place within Europe, in several contexts. On 16 January 2006 the European Commission opened a consultation process on the future of the European patent system. This was prompted in part by the deadlock over the Community Patent, which has been held up by disputes over translation. Many of the participants in the consultation expressed concern about issues of patent quality. Details concerning the legal patentability requirements are also being discussed. For example, the UK Patent and Trade-Mark Office has undertaken a consultation on "the inventive step", and in parallel has been holding discussions about the meaning of the "technical contribution" criterion proposed in the text of the EU Computer-Implemented Inventions Directive. The EU does not yet recognize the patentability of software or business methods as such (unlike the United States) and the merits of changing this are a highly contentious matter. The background for this is controversy over the allegedly "trivial" character of a number of patents issued in the United States in the fields of software and business methods. Indeed, concern about the alleged triviality of patent grants at the EPO was one reason cited in the debate in

the European Parliament that led to the vote to reject the EU Commission's Software Patent Directive.

It is in the context of this topical but controversial discussion that the Institut d'Economie Industrielle has been commissioned by the SUEPO to undertake a report on the objectives and organization of the EPO. The next section discusses the structure of this report.

1.2 The structure of this report

The report consists of two main substantive chapters. Chapter 2 discusses the objectives of the EPO in the light of the literature on the incentive properties of patents and within the context of an overall intellectual property rights system. The chapter considers different characteristics of patents – notably patent length, patent breadth, and the criteria for patentability[3] – and their contribution in terms of creating effective incentives for innovation.

The main conclusion of the chapter is that although this literature has given us many insights into the benefits and costs of different patent characteristics, it has not provided a characterization of the "optimal" characteristics of a patent system in a form that could be implemented by the European patent office. However, these insights do provide some guidance for the rather more limited task of evaluating what might be the consequences of getting the balance of these characteristics wrong.

The main practical implications of this chapter are that policy makers cannot hope to find an "ideal" criterion of patent quality that the EPO could then implement. But even if we cannot get the balance exactly right, we may reasonably hope to avoid getting it seriously wrong. Patentability criteria and their application by the EPO must weigh the risks of making

[3]In practice the criteria applied by the EPO are those of novelty, inventive step, and industrial applicability (see Section 3.5). However, the economic literature has made little attempt to distinguish the different incentive properties of these criteria. Usually the focus is simply on whether it is more or less difficult for a given invention to be granted patent protection.

excessively restrictive or excessively lenient quality judgments. In particular, this means for the EPO that it should adopt internal procedures that enable it to respond flexibly to evidence of error in its quality judgments, through an awareness of the characteristics of its current and past granting practices.

Two conclusions follow from this for the practice of the EPO. First of all, any attempt by one patent office – whether the EPO or a national office – to set a standard that diverges significantly from the standard in other offices may lead to forum-shopping by applicants. The consequence for the EPO would be a change in the quality and quantity of applications that it receives. This implies that comparison of granting practice across offices, as well as comparison across cases within the same office, would be highly desirable – a state of affairs that is far from what is happening at the moment.

Secondly, if a patent office seeks to implement a standard of breadth or of patentability, it needs procedures in place for ensuring that examiners are able and willing to make regular comparisons of current cases with those that have been accepted or rejected in the past to ensure consistency in patent granting. Where appropriate, these comparisons, court judgments or other sources of external feedback should lead to revision of practice. Of course, court judgments on their own are not an infallible source of guidance either; indeed the debate in the United States about the alleged increase in "trivial" patents focuses as much on the role of the courts in lowering patentability standards as on the direct role of the USPTO. So difficult questions arise about how exactly the patent system as a whole can respond to concerns about patentability if both the patent office and the courts share the same tendency to error; clearly a role for legislative guidance and scientific best practice needs to be envisaged as well. In this report we have not been able to consider exactly which of these external influences need to be incorporated into the practice of the EPO and how this might be done. The more general and important conclusion, though, is that "quality" should be understood not just as how well

patents that the EPO awards measure up to some external criterion of the quality but also – and just as importantly – as the extent to which the Office shows itself able to learn from experience and adapt its awarding criteria in the light of legislative and judicial decisions and changing scientific consensus. This interpretation should be borne in mind to understand the arguments and evidence considered in Chapter 3.

The current reform discussion focusses to a large extent on the backlog in patent application. EPO and its staff appear as a bottleneck: they "transform" patent applications into patents, or refusals. For this reason reform plans aim at reducing the time required by this transformation process. In particular, various incentive and control mechanisms are currently being discussed as means for increasing the throughput of patents at the EPO. However, as it stands, very little is known about how precisely this is to be achieved, how such mechanisms are to be designed and what the consequences of changes in the system governing the work at EPO would be.

It is important to reach an understanding of two crucial elements of the "production process" in which staff at the EPO is involved. First, some actors have information that others do not have. Examples of such asymmetric information are that applicants know more about the quality of their innovation than examiners (at least prior to examination); and examiners know more about the specificities of their field, as well as their own efforts and skills, than the EPO management. Second, as anywhere else, these information advantages are used in a strategic way by the actors within and outside the EPO. This significantly increases the complexity of interactions beyond the purely technological dimension.

With this in mind, we discuss in Chapter 3 how the internal organization of the EPO affects the quality and quantity of the patents that its staff issue. The chapter draws on two main sources. First, we provide an overview of the scientific literature on information asymmetries and incentives in organizations – especially as applied to organizations with a

complex mandate like that of the EPO. Although we believe that incentives play an important part in creating a productive working context, we are well aware that the EPO is not General Electric. Therefore, we have sought to identify those lessons from the organizational incentives literature that are relevant for the particular situation of the EPO.

Second, we report the results of a questionnaire survey of all EPO employees conducted in April 2006, for which we were fortunate to receive a response rate of over 60%. This is extremely high for a survey of this kind[4] and reflects the exceptional cooperation that we have received from the staff at the EPO. The purpose of the survey was not to assess the degree of satisfaction with the organization or otherwise of the staff with their work. Rather it aimed at understanding how details regarding the nature of the work carried out and the nature of interactions between employees affect the way in which implicit and explicit incentives currently operate or changes in them would be likely to function.

The survey produced both plausible and reassuring findings, but also held surprises – all discussed in detail in Section 3.6. In particular, we realized the importance of interactions between EPO staff and that the workload of any one staff member is highly dependent on the quality of work performed by their colleagues. We have therefore drawn attention not just to the potential trade-off between the quantity of work performed by individual staff and its quality but also and more subtly, to the potential impact of changes in the quantity of work performed by an individual employee on the quantity of work that the organization as a whole can perform. The main insight of the chapter is that an inappropriately designed system of incentives aimed at increasing the measured quantity of work performed might not only diminish quality of patent decisions, but even perversely affect in the longer run the ability of the Office to keep up with the quantitative demands in the patent system. The chapter concludes with a series of tests that can be applied to any proposed change in the incentive

[4]In particular, many of our questions focused on aspects most relevant to the work of examiners. It appears that this did not make the survey less appealing to other categories of staff.

system to see whether its adoption is likely to deliver what its authors hope it to achieve.

Chapter 4 gives an overview and conclusions for the EPO as a whole.

We conclude this introduction with a word about what the report does not examine. For the bulk of the report we consider that the management of the EPO shares a concern for implementing a system of patent rights and practice that is optimally designed to promote innovation and growth in the European economy. We have explicitly avoided considering whether the current governance structure of the EPO is able to assure this commitment. However, we are aware that this governance structure embodies some features that have the potential to create conflicts of interest and interfere with the commitment of the EPO to an optimal set of objectives from the perspective of the European society as a whole. Most notably, there is a division of responsibilities between the EPO management and staff on the one hand and the representatives of contracting states, who often are members of national patent offices, on the other hand. Conflicts of interest may also arise from the uncertainty that staff and management face about the future course of the EPO – and these may obstruct the effectiveness of incentive systems. Although these issues are not considered further here, this does not mean that we regard them to be of negligible importance. However, we have not considered them in sufficient detail to be able to discuss them in an informed way. Therefore, no opinion should be attributed to us about the appropriate resolution of such questions.

Also, our concern in this report has been almost entirely with the work undertaken by staff members of the EPO and not with the division of tasks between staff and contractors outside the organization. The latter question raises complex issues of evaluating the quality of tasks contracted out. While these issues share some features with the problems considered here it should be emphasized that they are not exactly the same.

Chapter 2

The objectives of the European patent system

2.1 Introduction

Patents confer the exclusive right to exploit an invention for a fixed period. But they are only one way in which inventors can protect their intellectual property: copyright, trade-marks, and – most importantly – trade secrecy can all fulfil some of the functions of patents. To these alternative options inventors can have recourse if the patent award system does not function in a way that is to their liking.

In this chapter we ask what the objectives of the patent award procedures of the EPO should be. The general answer looks obvious: to award valid patent claims and decline invalid ones – all this in a timely manner and at low cost. But the details of the answer are much less obvious. What should the criteria of validity be? What is more important, to ensure that valid patents are granted or that invalid ones are not? How important is speed compared to accuracy in the granting process? Can the objectives of the patent award procedures be stated explicitly so that their fulfilment by the EPO can be precisely judged, or can they only be

subjected to an implicit judgment in terms of whether the EPO has got the balance between the different criteria roughly right?

Even if we can determine what the role of patents in general should be, we also need to keep in mind that the EPO does not function in an institutional vacuum. It is part of a worldwide network of national patent offices, some of which in countries that are themselves EPO members, others (including importantly the USPTO) are from outside the EPO member states. The EPO is also subject in various ways to the political and legal constraints coming from the court system, the work of national legislatures, and the pressures arising from its own governance structure which makes the EPO accountable to the representatives of member states. This institutional context creates both constraints and opportunities that must be borne in mind in any discussion of the objectives of the EPO.

We first survey the scientific literature on optimal patent design and consider the role of patents in the overall system of intellectual property rights in a modern industrial economy. This provides the backdrop for discussing the specific question of what determines the "quality" of a patent application and what the various ways are in which such applications can be screened. We then look at empirical evidence about the comparative performance of different systems in terms of the criteria of quality, and discuss what constrains the ability of any patent-granting organization to achieve optimal performance. Finally, we draw conclusions for what the objectives of the EPO should be, and what should guide any evaluation of its day-to-day activities. The question of how the internal organization of the EPO facilitates or impedes the pursuit of these objectives will be taken up in Chapter 3.

2.2 Optimal patent design

For economists, the patent system is an incentive system based on the creation of property rights - that is, rights to the monopoly ownership of ideas embodied in physical applications. Society confers monopoly rights on inventors in order to encourage innovation and its dissemination. Since monopoly rights inflict costs on society, economists have considered how to balance these costs against the likely benefits in different environments – subject to overall considerations of simplicity and transparency. The latter militate against adopting systems that are excessively fine-tuned. We begin by inquiring what characteristics patents should have.

2.2.1 Patent instruments

The three main characteristics of patents that public policy can influence are patent length (i.e., the time period for which the inventor is granted monopoly ownership of the invention), patent breadth and patentability - the criteria that inventions must fulfil in order to qualify for a patent in the first place.

In practice patentability requirements can have several dimensions - notably the degree of novelty, inventive step, and industrial application – which the economic literature does not clearly distinguish. The main idea underlying analyses of the patentability criterion is simply that it can be made more or less stringent, so that inventors may have to make greater or lesser efforts (and spend more or fewer resources) in order to satisfy it. In some sense, setting the patent criterion can therefore be thought of as adjusting the height of the "hurdle" that the innovation of an inventor has to clear to be granted a patent.

- **Patent length** was the first characteristic to be explicitly analyzed from the point of view of economic incentives (by Nordhaus 1969). Although patents have a fixed statutory

length (20 years from the application date), there has also been some analysis in recent work of the renewal system, where the de facto length is endogenously chosen by the patent-holder via a maintenance fee (Cornelli and Schankerman 1999, Scotchmer 1999).

- **Patent breadth** was the second instrument considered by economists (Gilbert and Shapiro 1990, Klemperer 1990). Unlike length, patent breadth is a rather abstract concept. Authors use different definitions in diverse models, and there is no easy mapping from these definitions to legal practice. If one thinks of the range of technologies and possible products in spatial terms, patent breadth refers to the "territory" in this space over which the patent-holder has exclusive control. The usual justification of how the patent system controls the breadth is through patent claims approved by the patent office and upheld in court, and the "doctrine of equivalents" as well as the "reverse doctrine of equivalents" adopted by the court.

- The **patentability requirement** has received rather little attention in the economic literature until recently, when economists began to analyze cumulative innovations (e.g., O'Donoghue 1998, Scotchmer and Green 1990). Previous works simply assumed that the invention is patentable, and the inventor should be given some reward. Even in the cumulative innovation literature, the question is usually only whether a second-generation innovation should be patentable, while a first-generation (or basic) innovation is still assumed to be patentable.

In the cumulative innovation environment, where we can think of successive inventions as being ranked by levels of quality, there is a further distinction between lagging and leading breadth, or backward and forward protection. The lagging breadth of a patent covers the lower-quality inventions that would infringe the patent, while the leading breadth covers the higher-quality inventions that would infringe it. The broader the patent, the greater the

improvement in quality a subsequent invention must provide to count as non-infringing[1]. Although patentability is related to breadth it is not quite the same; since a subsequent invention could be of high enough quality to be non-infringing without being patentable in turn, or could be patentable while nevertheless be infringing (this would be the situation of mutual blocking). We discuss these points in more detail in Appendix 2.6.

2.2.2 Discrete innovation: length and breadth

The economic literature about optimal patent length and breath typically considers an innovation in isolation, and does not take into account its potential effect on spurring (or inhibiting) future research. The main question is how to structure the reward to innovators, but not what kind of innovation should be rewarded (so patentability plays no role in this literature). The optimal policy design minimizes the social cost of patent rewards with proper combination of patent length and breadth.

The social costs of patent rewards are usually measured by the so-called "deadweight loss", which is the value of the inventions that are under-used because the patent-holder charges a monopoly price above their cost of production, so that only those buyers willing to pay the full monopoly price ever make use of them (for example, the deadweight loss for an AIDS drug would be represented by all the patients who go untreated because they cannot afford to pay the full price of the drug). The basic idea is to find policies that produce as little dead-weight loss as possible for any degree of incentive given to the innovator in terms of profits from selling the invention. Think of this as trying to minimize the ratio d/π, where d is the deadweight loss and π the profit accruing to the patent-holder. Longer patent lives, like broader patent definitions, will increase *both* d and π – the trick is to raise d as little as possible for any level

[1]Strictly, a second patent that has all the features of a first patent plus some improvement will always infringe the first patent (and may be deemed to do so by the doctrine of equivalents even in the absence of all the features if the differences are deemed unimportant). Leading breadth is the (abstract) notion that the improvements may by themselves count as infringing if insufficiently differentiated from the features of the original patent.

of π judged necessary to give the necessary incentive to inventors.

If the economy is reasonably similar over time (for instance, if there is no reason to think that competitive conditions will constrain patent-holders' ability to raise prices differently in the future relatively to the present), both dead-weight loss and profit are likely to be proportional to the length of the patent (subject to some discounting of the future). However, they may well not be proportional to patent breadth. Gilbert and Shapiro (1990) show that for homogeneous products and under conditions of price competition (where patent breadth determines the patent-holder's ability to raise the price), dead-weight loss increases more than proportionately in patent breadth. So d/π increases in patent breadth, and the optimal patent design will therefore define patents as narrowly as possible, but make them very long because of the need to reward innovators.

Klemperer (1990) and Gallini (1992) discuss different circumstances under which this conclusion may not be justified after all. Klemperer (1990) considers horizontal product differentiation when consumers have different tastes. If a narrow patent would induce consumers to switch to substitute products rather than to stop consuming the product altogether, the optimal policy may be to issue a broad patent which "captures" enough of the potential substitutes to yield a profit to the inventor with a minimal dead-weight loss. Gallini (1992), on the other hand, introduces the social loss associated with competitors' costly imitation (or inventing around the patented product). Patent breadth influences how difficult and costly it is to invent around the patent and enter the market with a rival product, and broad patents reduce the incidence of costly imitation. This might seem strange – imitation lowers market prices which is good for consumers, so it might appear as though we should have as much imitation as possible. But lowering prices by imitation is always less efficient than lowering prices by having less monopoly power in the first place. If prices need to be high to provide profits to encourage innovation, then it is clearly desirable that the high prices should encourage as

little costly imitation as possible for as long as they last.

Finally, Denicolò (1996) provides a general condition in this spirit, in an effort to reconcile the diverse results described above: narrowing patent breadth and intensifying post-innovation market competition is to be avoided if it generates additional social costs (such as those due to imitation) that outweigh its benefits in terms of dead-weight loss as conventionally measured. In short, minimizing the ratio d/π is still the right criterion, provided d is defined to include the appropriate social costs.

Most of these studies take as given the reward to the inventor and do not ask how to determine how large that reward should be. Maurer and Scotchmer (2002) provide a way to make the reward size commensurate with the amount necessary to provide suitable innovation incentives. They suggest that, contrary to current practice, independent invention should be allowed as an effective defence against an infringement suit. As in Gallini (1992), the possibility of independent invention limits the patent-holder's profitability. But unlike Gallini, Maurer and Scotchmer (2002) argue that this will not act as a disincentive to innovation, because a patent-holder can use licensing to bargain with a potential entrant over the fee that will prevent the cost of duplication. The patent-holder can therefore extract a benefit that is of the same order of magnitude as the potential entrant's cost of duplicating the invention.[2] In addition, when there are many potential independent inventors, licensing preserves some competitive benefits: the patent-holder would prefer to take more of her profits through licence fees and less through high prices, in order to deter independent invention. As long as the cost of independent invention is not very significantly lower than the invention cost incurred by the patentee, the patent-holder will be able to recoup her R&D expenditure through licence fees. The independent invention defence then serves as a mechanism that limits the patent-holder's reward to an amount commensurate with her R&D cost.

[2]Indeed, Gallini (1992) does not consider licensing.

2.2.3 Cumulative innovation: length, breadth, and patentability

Several modern technology fields, such as semiconductors and software, exhibit the feature of cumulative innovation. Unlike stand-alone inventions, a technology breakthrough provides routes for future innovations (improvements, applications, *etc.*). For two reasons, it is necessary to provide a basic invention with some protection against future innovations (this is known as forward protection). Without this protection, the early inventor will not fully take into account the value of her contribution to future R&D. In some cases, such as when innovation takes the form of quality improvement in the same market, she needs to compete with future inventors. In the extreme case, a future improvement will supersede her invention and make it obsolete.

Forward protection can be provided in two ways: future innovation can be ruled as an infringement on the basic innovation (leading breadth), and it can also be denied patent protection (via a strong patentability requirement). All contributions to this literature consider leading breadth as a policy instrument; only some of them also take into account the patentability requirement. The choice between these two methods of granting forward protection raises some important issues of incentive design.

Division of surplus in the two-stage model

Different contributions to this literature make different assumptions about the feasible licensing opportunities for inventors, and sometimes the results turn crucially on the assumptions that are made. Consider the case of two-stage innovation, where different parties undertake R&D projects at different stages. If, as assumed by Green and Scotchmer (1995), it is easy to reach *ex ante* licensing agreements, the two inventors can bargain before the second generation inventor incurs the R&D cost (though after the first generation inventor has been granted a patent). Then, in the absence of uncertainty, the decision to develop the second technology is

always made efficiently. The two parties will agree to incur the cost and develop the second generation technology if and only if it creates benefits that outweigh the costs. The policy issue then is how to give the first generation inventor enough licensing income to induce her to undertake the invention, especially if the invention has little market value on its own. Different policies affect the relative bargaining strength of the two inventors in different ways. Green and Scotchmer (1995) argue that it is optimal to give the early inventor the widest possible leading breadth so that any second generation invention infringes on the early invention.[3] By the same token, Scotchmer (1996) argues that given the second invention infringes on the first invention, granting patent protection to the second invention only strengthens the second inventor's bargaining power, which is harmful to the first inventor's incentives while having no boost on the second inventor's incentives.

On the other hand, if only *ex post* licensing is possible (because inventors can bargain only after the second generation inventor has incurred the cost and completed the R&D project), then there may be underinvestment at the second invention stage. The second inventor knows she will be bargaining from a position of weakness, since she will have already incurred the sunk cost of the project and cannot credibly threaten to abandon it (this is a version of what is known as the "hold-up" problem). Optimal patent policy then needs to balance the innovation incentives of different generations of inventors. Stronger forward protection shifts the surplus to the first inventor, but at the price of possibly stifling second stage R&D.

This is a version of what has been called the "patent thicket" problem: desirable inventions may be discouraged owing to the fact that potential inventors cannot costlessly and efficiently bargain with upstream patent holders before they commit themselves to the necessary irrecoverable innovation investments. In some cases they may be unable to do so simply because they

[3]They do not consider whether the second generation invention should also be granted patent protection. Also note that their result may not hold in the presence of some uncertainty at the bargaining stage. The reason is that, should they fail to reach an agreement, the broadest forward protection may dissuade the second inventor from innovating.

have no idea that upstream patent holders exist or who they are.

Among other authors analyzing two-stage models, Chang (1995) considers only leading breadth and argues in favor of strong forward protection for first generation inventions which have relatively low stand-alone value. Denicolò (2000) and Denicolò and Zanchettin (2002) analyze different combinations of the patentability requirement and leading breadth. Denicolò and Zanchettin (2002) illustrate different effects of these two types of forward protection. With only *ex post* licensing, the patentability requirement has a blocking effect in that the second inventor will never develop technologies that are not patentable.[4] But leading breadth may have a profit-sharing effect, in addition to the blocking effect. When the second invention is patentable, leading breadth creates mutual blocking, which can be solved via *ex post* bargaining. As long as the value of the second invention is large enough, hold-up problems do not stifle innovation and the two parties can share the surplus. For this reason, the authors favor leading breadth over strong patentability requirements as a means of encouraging second-generation innovation.

Denicolò (2000) provides other reasons for thinking that denying patent protection to the second invention via over-strong patentability requirements can generate efficiency losses. Consider a two-stage patent race, where at each stage the inventor who first discovers an innovation is granted the patent. Again suppose that the second invention is not patentable and infringes on the first invention. If the first inventor can also race at the second stage, then under a policy denying patent protection to the second invention only the inventor who succeeds at the first race has incentives to develop the second invention. Therefore, the first inventor will fully internalize the benefit of future innovation (the intertemporal externality); but at the same time there is always underinvestment at the second stage because R&D competition is eliminated. This trade-off makes over-strong patentability requirements an

[4]This assumes that there are no other means to protect innovation, such as trade secrecy or a first-mover advantage in bargaining.

unsatisfactory policy.

Models of this kind therefore provide some reason for caution in designing patentability requirements and specifically for not making these requirements too strong. If the patentability hurdle is too great, desirable second-generation innovation may not take place. However, there are two important caveats before this conclusion can be given more general force. First of all, the argument applies only to patentability requirements in respect of prior art that consists of patents still in force. Where the prior art consists of technologies in the public domain there is no such disadvantage of strong patentability requirements (though there may be others). Secondly, where inventions may take place in more than two stages, weak patentability requirements strengthen the second-generation inventors' incentives relative to the first generation inventors, but also relative to third and future generations, which may not be desirable (for instance because of patent thicket problems). In order to examine these issues more carefully we therefore need to look at models with multiple generations of inventions.

Quality ladder models and market turnover

O'Donoghue (1998) and O'Donoghue *et al.* (1998) consider a quality ladder model, where an infinite sequence of innovations takes place and firms repeatedly supersede each other's inventions. In this case, every inventor both learns from previous innovations (like the second generation inventor in the two-stage model), and contributes to later innovations (like the first generation inventor). Therefore, along a stable equilibrium path, the division of surplus between different generations is not an issue. The problem is to create enough surplus for each inventor.

Again, forward protection is essential here. When an inventor brings quality improvements, the social benefit lasts forever; but without forward protection, the inventor's profit stream stops when an improvement emerges and supersedes her technology. To overcome this problem,

leading breadth and strong patentability requirements provide different solutions. Note that the statutory length of the patent may not be an effective instrument in this environment. A patent's effective life can be much shorter than its statutory life and stops at the moment some other uninfringing improvement emerges. This means that the degree of forward protection may have much more influence on a patent's effective length than does its statutory length.

O'Donoghue *et al.* (1998) consider leading breadth, while assuming that all improvements are patentable. Leading breadth again causes mutual blocking. Through licensing an inventor shares the surplus from subsequent innovations, which in turn boosts incentives. But these higher incentives come at the cost of more concentrated market power, because licensing also consolidates different inventions under a single firm's control.

In a different paper, O'Donoghue (1998) argues that a strong patentability requirement can raise innovation incentives by helping market leaders to entrench themselves and thereby earn higher profits. Suppose an improvement is patentable only if its size is large enough (larger than the second inventor would choose without the requirement), and suppose no there is no leading breadth. Because no one would aim for a non-patentable innovation,[5] the patentability requirement forces inventors to pursue more ambitious projects. But more ambitious projects also take longer to realize. This prolongs an existing market leader's incumbency; a longer incumbency in turn generates higher profits for whoever becomes a market leader and thus boosts innovation incentives. In other words, the patentability requirement provides forward protection by slowing down the market turnover. Note that in the absence of leading breadth, the patentability requirement does not have the effect of consolidating inventions. Therefore both its incentive effect and the associated dead-weight loss are lower than under leading breadth. The author also argues that combining the two policy instruments would be welfare enhancing.

[5]Unlike in O'Donoghue *et al* (1998), in this paper the innovation size is chosen by inventors.

Information-related issues

A number of other papers discuss the impact of different instruments on information dissemination, or on the informational asymmetry between the inventor and patent authority. These papers assume away licensing opportunities to distinguish themselves from the "profit-sharing" models just surveyed and to focus on information spillovers. The first-generation inventor competes with others for subsequent stages of research. Early patenting and disclosure of the invention has the advantage for society that it furthers research by all inventors and thereby accelerates the pace of innovation. But this means also that an individual inventor profits only from the early commercialization of a patent that discloses the invention, and loses the competitive edge she would otherwise enjoy at the later round of R&D competition if the information were withheld. Two papers consider how to use patentability requirements (Scotchmer and Green 1990) or length and breadth (Matutes *et al.* 1996) to fine-tune the incentives for early disclosure.

In a two-stage innovation race, Scotchmer and Green (1990) consider the different effects of a weak patentability requirement (where the intermediate invention is also patentable) and a strong requirement (where only the final invention is patentable). The weak requirement creates an option value for the inventor at the first stage, who can patent and market the intermediate invention. But this option may not be executed because it means losing the head start at the second stage by disclosing the intermediate result. The authors also show that a strong patentability requirement may generate higher *ex ante* profit and so induce more entry into the race. This is because under a weak patentability requirement more intensive market competition ensues when two inventions are patented and marketed by different owners. Strong requirements concentrate the market and generate higher profits for the winner at the second stage.

Matutes *et al.* (1996), on the other hand, consider the impact of different combinations of patent length and breadth on incentives for early disclosure. Suppose a basic technology can spur numerous valuable applications, which can be developed by the inventor of the basic technology or by other competitors. Delaying disclosure allows the inventor to inhibit competition with others in the development of applications, although at the cost of delaying the commercialization of those applications that she herself has developed. Patent length controls the time during which the patent-holder can exclusively develop applications, and patent breadth restricts the applications other competitors can develop. Matutes *et al.* (1996) show that in general a narrow but long patent is superior to a broad but short patent. A narrow patent preserves some applications to the inventor, but does not prohibit others from developing and marketing uninfringing applications. By contrast, under an (infinitely) broad patent, only the patent-holder can market new applications, while others need to wait until the patent expires. Because the patent-holder has limited capacity to develop applications, a broad patent then lengthens the total time before the bulk of the applications are brought to market.

Lastly, Hopenhayn and Mitchell (2001) adopt a more general approach, drawing on the literature on "mechanism design", which instead of asking what are the incentive effects of a particular policy, tries to identify the best policy for achieving certain goals. They show that when inventors have better information than the patent authority about the likely value of inventions, the patent authority can offer a menu of patent types with different lengths and breadths. This induces patent applicants to sort themselves efficiently according to which inventions can best benefit from broader versus longer patents (the point being that the relative attractiveness of length and breadth protection is likely to differ between high- and low-value innovations). As a special case of their proposal, these authors also show that when the innovation takes the form of a quality ladder, higher-value innovations should get more breadth

for a shorter life.

2.2.4 Summary - optimal patentability requirements

The studies just reviewed do not provide very easy guidance for a patent office. First of all, not all of the relevant dimensions are under the patent office's control – most obviously, patent length is set by the legislative branch.[6]

Even forward protection is not entirely controlled by the patent office. The economic concept of leading breadth is usually implemented by courts through the doctrine of equivalents. As to the patentability requirement, although the patent office clearly determines this directly through the approval, denial, or modification of patent claims, its activities are subject to review by the courts, where the patent applicant can appeal the patent office's decision.

Nevertheless, it is worth trying to summarize what we have learned about patentability requirements. A relatively strong requirement tends to

- weaken the bargaining position of subsequent inventors *vis à vis* early inventors in bargaining over licensing, which is beneficial if there are no transactions costs of bargaining and subsequent innovation decisions are always efficient (Scotchmer 1996);
- weaken the incentives for downstream innovations if there are important transactions costs of bargaining over licensing (Denicolò 2000, Denicolò and Zanchettin 2002);
- encourage firms to undertake more ambitious R&D projects and slow down the market turnover (O'Donoghue 1998), which is good for innovation incentives;
- hamper information disclosure, but may induce more entry into R&D by softening post-innovation competition (Scotchmer and Green 1990).

[6]But the patent office can fine-tune patent length by adjusting the maintenance fee in a renewal system (Cornelli and Schankerman 1999, Scotchmer 1999); or by altering forward protection, as in a quality ladder model (O'Donoghue, Scotchmer, and Thisse 1998).

Unfortunately, however, although these arguments help to understand what are the consequences of setting the patentability requirement relatively high or relatively low, they do not answer the question of what the "right" compromise should be. We return to these issues below.

2.3 Patent quality and the work of the patent office

A small but growing literature studies the role of patent offices in ensuring the quality of issued patents. The sense of patent quality at issue here is not the "absolute"merit or commercial value of the patented technology[7], but rather the extent to which issued patents meet the standard of patentability set by policy makers, which is often defined or made more precise by the courts.[8] Obviously, any such discrepancy involves implementation issues at the patent office. This section reviews recent work on patent quality as well as the functioning of the patent office. All studies we review here are motivated by the perceived decline in U.S. patent quality in recent years, and therefore mainly focus on the U.S. performance (see also Section 3.4). This is particular true for empirical studies, as we shall see. The details specific to the EPO will be discussed in Section 3.5

2.3.1 A theoretical look at the patent office

Langinier and Marcoul (2003) and Caillaud and Duchêne (2005) are two theoretical papers analyzing the determinants of patent quality. In both papers, private firms decide whether to apply for patent protection for their technology after gaining some private information about whether their technology is "good" (meets the statutory patentability requirement) or

[7]There is a huge literature measuring patent value through indices such as forward citation, family size, *etc.*. For a recent critical survey, see Reitzig (2004).

[8]It should be noted that court decisions may not always define the standard in the way that policy makers or society would desire. An example for this is the controversial debate about the effect that creating in 1982 the US Court of Appeal for the Federal Circuit (CAFC) in the US had (e.g., Jaffe and Lerner 2004).

"bad" (does not qualify for patent protection unless the patent office makes a mistake). Firms' application decisions depend both on this private information and the patent examination policies adopted by the patent office. After receiving applications, the patent office undertakes a costly search and examination, which is dependent on the volume of applications (Caillaud and Duchêne 2005) or the office's prior belief about the likely quality of the application (Langinier and Marcoul 2003). Assuming that the patent office errs only on the side of leniency, the two papers focus on different policy tools[9].

The papers look at the optimal amount of search and examination efforts that the patent office devotes to an application. In common with the literature on optimal auditing procedures the papers show that, in the absence of any credible mechanism for committing to an auditing procedure, there is no plausible equilibrium in which only the owners of good inventions apply for patents. If only good applications were submitted, the patent office would respond optimally by cutting back on its search and examination procedures to avoid wasting resources. However, then all applicants with bad applications would find it advantageous to submit their applications because the chance of getting a grant are relatively high. Therefore, to catch bad applications if they are submitted or prevent them from being submitted in the first place the patent office needs to perform search and examination at a level that is too high for the good applications. The optimal level of search and examination effort balances their direct costs with the costs arising from granting bad patents. In equilibrium therefore, a steady flow of bad applications among the good is what requires the office to perform search and examination with a credible level of rigor.

Langinier and Marcoul (2003) are concerned with the patent applicant's search of prior art and the incentives to reveal this information to the patent office. They assume that the

[9]Both papers neglect the issue of how the patent office can implement these policies internally. Our Chapter 3 focuses on such incentive problems within the patent office.

applicant submits a search report and the examiner then performs a complementary search.[10] They show that when the patent office cannot commit to the level of search, the applicant discloses all details of her search if this reflects favorably on her application and withholds some information otherwise. It might appear that if commitment to a search level were possible the examiner should optimally give more scrutiny to those applications that look relatively incomplete. However, the paper shows that when the patent office can commit to its search levels, the optimal policy is "equal treatment" for all applications, regardless of the information disclosed by applicants. The reason for this is that only such a policy can induce truthful information revelation on the part of the applicants.

Caillaud and Duchêne (2005) do not consider the applicant's information transmission incentives. Instead, they are more concerned with the "overload" problem facing the patent office, where the probability of successfully weeding out bad applications falls as the volume of applications rises. This gives rise to multiple equilibria, and a vicious circle: if more firms "attack" the patent office with more bad applications, the patent examination effort that can be devoted to each application drops, and so it becomes easier to get patents, which in turn attracts even more applications and further worsens the examination quality.[11] This is an important result that is very much relevant for the EPO, as we discuss at length in Section 3.7.2 below. When R&D decisions as well as application decisions respond to the quality of examination, the overload not only lowers patent quality, but also has a negative impact on R&D incentives: it induces firms to imitate others, getting a valuable patent without incurring the innovation cost. To tackle this problem, the authors show that a uniform application fee is not an effective policy tool[12] whereas it may be desirable to delay the examination process.

[10] For more details on the search carried out by an examiner see Section 3.5.

[11] Jaffe and Lerner (2004) discuss in some detail the implications of the possibility of such a vicious circle for the USPTO – see also Chapter 3.7.2.

[12] The authors suggest the possibility of setting different fees according whether the patent is issued - and, in particular, setting high fees for those applications detected as being particularly low quality.

A longer but more detailed examination reduces the patent office's error probability, which in turn discourages bad applications and helps prevent the vicious circle from operating.

Finally, Lemley (2001) puts forward the "rational ignorance principle", according to which it is reasonably efficient to implement a low standard of patent examination. Because the vast majority of patents turn out to be of only small economic importance there is little cost of granting them even if they are invalid. He argues that if an invalid patent is granted in an economically important area, market participants will bring the case before court to settle the validity issue. Lemley claims that it is more efficient to rely on the court system to settle validity issues for a fraction of all patents rather than devoting a lot of resources to examining closely all applications at the patent office – without knowing which ones will be the ones that are going to be important. Among others, Jaffe and Lerner (2004) criticize this argument. The problem they point out is that it is typically cheaper for the litigating parties to settle out of court, preventing the patent validity from being legally checked. Even if the benefit for society from settling the issue of validity outweighs the cost of bringing the court case to an end, this benefit is a public good for which the litigating parties receive no compensation if they forfeit the gains they can make from settling out of court rather than pursuing the legal case. As a consequence of this, a low standard of patent examination leads to poor quality patent decisions. These are then not always corrected when this matters very much to society, and the resulting uncertainty about the validity of patents may stifle innovation.

2.3.2 Empirical quality comparisons

Although there is a widely perceived problem of the low quality of issued patents in the United States, it is very difficult empirically to define patent quality[13], let alone to examine it with

[13]The following suggestion during a congressional hearing in July 2003 for aspects to be covered by patent quality illustrates the complexity: "a quality patent is one that can be enforced in court and (1) consistently survive validity challenges, (2) be dependably employed as a technology transfer tool, (3) fortify private rights by making proprietary uses, and therefore value, more predictable, (4) clarify the extent to which others may

precision. Two possible ways of doing so are the following[14]:

- international comparisons of patent examination data in different jurisdictions; and
- the results of court rulings or post-grant reexaminations (in the U.S.) or opposition (in Europe) of validity when the issued patent is challenged.

Both approaches need to be used with care: the first will be unable to spot aspects of quality that are common to all jurisdictions, and the second will not be informative if there is doubt about the criteria being used by the courts. Indeed, much of the criticism of US patenting practice has been directed against the practice of the Court of Appeal for the Federal Circuit (CAFC) created in 1982 (e.g., Jaffe and Lerner 2004).

Another problem with using legal decisions to measure quality is that only a very small percentage of issued patents become the subject of litigation (e.g., NAPA 2005, p.173) and even opposition rates at the EPO are extremely low (5.3% in 2004). Also, as mentioned above, the parties involved have strong incentives to settle the case, either before starting formal procedures or at least before litigation resolves the patent quality issues. While this explains the overall low rate of legal cases relative to the total number of patent decisions, litigation and opposition rates vary significantly across fields, under the influence of factors that affect parties' willingness to settle cases beforehand.

Nevertheless, there may still be useful information contained in such comparisons. Using the first approach, Quillen and Webster (2001) show that in the mid-1990s the USPTO's grant rate (the number of applications granted divided by the number filed) was 95%, much higher than those of the European (68%) and Japanese (65%) patent offices.[15] This serves as weak

approach the protected invention without infringing." (NAPA 2005, p.62)

[14]Note that the USTP also regularly conducts internal quality evaluation to review examiners work. See Section 3.4 and Cockburn *et al.* (2002).

[15]The computation takes into account continuation applications and continuation-in-part applications. The data cover applications allowed in the fiscal years 1995–1998 for original applications filed in the fiscal years 1993–1996.

prima facie evidence of the "over-generosity" of USPTO and its low degree of quality control.

However, Graham and Harhoff (2006) argue that examination outcomes cannot be taken as a simple indicator of patent quality. Using both international comparisons and litigation data[16], these authors identify the "European twins" of litigated U.S. patents as well as a control group of non-litigated U.S. patents. The authors find that the EPO grant rate is considerably higher for the litigated twins than for the non-litigated twins. The authors suggest the difference may be due to different application strategies on the part of firms. However, it is important also to bear in mind that litigation may be due to many other factors than the quality of the litigated patents – including, notably, the willingness of the main firms in the relevant sector to collude.

To examine this hypothesis, Sanyal (2005) explicitly model the behavior of applicants behavior and patent grant performance at the country level. The main hypothesis is that if a lower standard of U.S. patent examination (or other changes in law that attract more patenting) is mainly responsible for the patent explosion, then it should not affect the behavior and performance of non-U.S. patent applicants when seeking non-U.S. patent protection. Indeed, estimation results show that (i) more grants attract more applications[17] but (ii) inventors from countries from which patent applications originate that are more likely to succeed in the U.S. are also more likely to succeed in other countries. Echoing Kortum and Lerner (1999), the result suggests an increase in the invention rate, rather than an increase in patent office leniency, is playing a significant role in the surge in the U.S. patenting.

[16]This is developed in their earlier joint work with others. See Graham *et al.* (2003).

[17]A "loosening" of the grant standard by one percent increases applications by 8 percent. This confirms the vicious circle story of Caillaud and Duchêne (2005).

2.3.3 Empirical examinations of patent office practice

Besides evaluations of patent office performance as reflected in patent and litigation data, two recent studies take a look at the way U.S. patent examination works in real life. These also explore issues that we will return to in Chapter 3.

Cockburn *et al.* (2002) report interviews with members of the U.S. patent community, including patent examiners, USPTO management, and patent attorneys, and construct a dataset to examine "examiner fixed effects" on patent validity (that is, evidence of statistically significant differences between individual examiners). The dataset starts from patents for which the Court of Appeal for the Federal Circuit (CAFC) ruled on validity during 1997-2000, identifies the primary examiners involved and traces the entire career history of these examiners. The authors find that there exist significant heterogeneity in examiners and examination processes. For the examination process, different technology fields exhibit differences in organizational structure, and this affects the division of labor in examination. For instance, in many of the mechanical fields, an individual examiner may examine nearly all of the applications within specific patent class or subclasses. In contrast, some other fields have a more team-oriented structure. Several examiners share multiple subclasses, and are also more like to discuss and share knowledge. Note that the degree of specialization affects not only the effectiveness of monitoring, but also the prior art search. A more specialized examiner inevitably tends to cite more often those patents she has examined before.

Concerning examiner heterogeneity, in the words of one of their interviewees, "there may be as many patent offices as patent examiners." The differences include: examiners' tenure, the number of patents they have previously examined, and the degree to which the patents they examined receive forward citations. The last variable is used to index how "generous" an examiner is when making grant decisions. A more generous examiner allows broader patents,

which are cited more often later. However, these differences have a different effect on patent validity in later litigation: there is no evidence that examiner experience or workload affects the probability that CAFC rules invalidity; but a more generous examiner has a higher invalidity probability.

Sampat (2004), on the other hand, focuses on the source of prior art – that is, the proportion of the references in an issued patent that are cited by its applicant and its examiners respectively. Based on patents issued in nanotechnology, the author finds that relative to the patent applicant, a U.S. examiner cites less non-patent than patent prior art, and less prior art in a new technology field. In addition, the examiner's share is lower for a more important patent (in terms of forward citations received). This might reflect the effect that an applicant has more incentive to search and reveal the information for more important patents (as in Langinier and Marcoul 2003). As in Cockburn *et al.* (2002), no consistent evidence can be established concerning the examiner's experience on the citation share. On the other hand, teams of junior-senior examiners do display larger shares of prior art[18]. This might be simply due to "a second set of eyes" on the application, or through more complicated mechanisms.

Lastly, Lerner (2005) conducts a empirical study covering 60 countries in 150 years. The main question is to see how asymmetric information affects the discretion the patent system gives to patent-holders (in terms of the renewal system, delay in examination, *etc.*) and to the patent office (in terms of the extension of patent length, the division of patent validity decision between the patent office and courts, *etc.*). Theoretical work on information economics and regulation suggests that in the presence of asymmetric information it may be beneficial to induce the revelation of private information by offering a menu of choices and giving applicants some discretion. But to cope with the risks of bureaucratic capture, it may be necessary also

[18]The USPTO pairs a junior examiner with a senior examiner during the training program, which is similar to an apprentice-mentor relationship.

to restrict the flexibility of the patent office. There is some evidence that the actual structure of procedures across countries reflects these considerations. In particular, larger and wealthier countries, where information problems may be more severe due to a more complex economic structure, are more likely to restrict the discretion of the patent office by oversight from the courts.

2.4 Overview of the European patent system

A number of useful studies have been conducted of the European patent system that may help us to evaluate the extent to which the system influences the kinds of patent that are awarded.

Starting from the European Patent Convention (EPC) and the creation of the EPO in the late 1970s, Europe has undergone a series of efforts to harmonize national patent systems and to create a centralized mechanism for patent applications. Since the 1990s, most formerly communist countries have signed the EPC[19] and among non-member states, five have reached an "Extension Agreement" with the EPO, to extend the protection conferred by European patents in these countries[20]. Through these efforts European patent systems have tended to converge in several respects, and inventors enjoy a much simpler route to get effective patents in desired European countries through patent applications to the EPO. However, as we shall see, important divergence remains both in the national law and the relevant procedures.

2.4.1 Strength of national protection in different countries

Ginarte and Park (1997) and Lerner (2002) conduct long-term international comparisons of national patent systems. Although these are now somewhat out-of-date, here we summarize their results concerning European countries.

[19] As of 2006, EPC is in force in 31 countries.

[20] These countries are Albania, Bosnia and Herzegovina, Croatia, Macedonia, and Serbia and Montenegro.

Ginarte and Park (1997) consider the strength of patent protection in five categories, and construct a measure to evaluate the overall strength of national patent systems for 110 countries between 1960-90. The five categories are

(i) coverage: a country gets 1/7 points if it provides patents in each of the following fields: pharmaceutical, chemicals, food, plant and animal varieties, surgical products, microorganisms, and utility models;

(ii) international treaties: a country gets 1/3 by acceding to each of the following treaties: Paris convention and revisions, Patent Cooperation Treaty (PCT), and Protection of new varieties;

(iii) loss of protection: a country gets 1/3 point by *not* having each of the following restrictions on patent rights: working requirements[21], compulsory licensing, and patent revocation;

(iv) enforcement: a country gets 1/3 point by offering each of the three legal tools at the enforcement stage: preliminary injunctions, contributory infringement, and burden-of-proof reversal[22];

(v) duration: a country gets 1 point by providing a patent term of 20 years (or higher) after application, (or 17 years or higher after grant, depending on the national law), and a part point proportional to its length if shorter than 20 years.

The results concerning European countries are listed in TABLE 2.1, where '*' indicates EPC countries in the year of 1990. The United States, Japan, Korea, and Argentina are also included for comparison.

[21] This requires the patent-holder to put the invention into practice, e.g., to manufacture a good based on the patent.

[22] This shifts the burden to the alleged infringer to show he has not infringed on the patent. This is designed to facilitate for the patent-holder enforcing a process patent.

Country	1960	1965	1970	1975	1980	1985	1990
Austria*	3.38	3.38	3.48	3.48	3.81	3.81	4.24
Belgium*	3.05	3.38	3.38	3.38	3.38	4.05	3.90
Cyprus	1.90	1.90	2.24	2.24	2.24	2.24	2.24
Denmark*	2.33	2.66	2.80	2.80	3.62	3.76	3.90
Finland	1.99	1.99	2.14	2.14	2.95	2.95	2.95
France*	2.76	3.10	3.24	3.24	3.90	3.90	3.90
Germany*	2.33	2.66	3.09	3.09	3.86	3.71	3.71
Greece*	2.46	2.46	2.46	2.46	2.46	2.46	2.32
Iceland	2.12	2.12	2.12	2.12	2.12	2.12	2.12
Ireland	2.23	2.56	2.99	2.99	2.99	2.99	2.99
Italy*	2.99	3.32	3.32	3.46	3.71	4.05	4.05
Luxembourg*	2.29	2.29	2.71	2.71	3.05	3.05	3.05
Netherlands*	2.95	3.29	3.61	3.47	4.24	4.24	4.24
Norway	2.66	2.66	2.80	2.80	3.29	3.29	3.29
Spain*	2.95	3.29	3.29	3.29	3.29	3.29	3.62
Sweden*	2.33	2.66	2.80	2.80	3.47	3.47	3.90
Switzerland*	2.38	2.71	3.14	3.14	3.80	3.80	3.80
U.S.A	3.86	3.86	3.86	3.86	4.19	4.52	4.52
Japan	2.85	3.18	3.32	3.61	3.94	3.94	3.94
Korea	2.80	2.80	2.94	2.94	3.28	3.61	3.94
Argentina	1.93	1.93	2.26	2.26	2.26	2.26	2.26

Table 2.1: Index of patent protection

From Table 2.1, all listed countries demonstrate a trend towards strengthening their patent protection over time. And in 1990, EPC member states in general provided much stronger patent protections than non-member states. The former group had an average of 3.72, and the latter an average of 2.72. However, patent protection was still stronger in the U.S. than all the European countries in the table. Also, even among EPC member states there remained some differences. Countries with stronger policies (Austria, Italy, and Netherlands) provided protection exceeding 4 points, but the lowest in the dataset, Greece, had only 2.32 points.

Another long-term (150 years), international (60 countries) analysis of patent protection is conducted by Lerner (2002). He considers some aspects in common with Ginarte and Park's (1997) study, such as the coverage of certain fields, patent length, and limitation on protection (working period and compulsory licensing). On top of these, he also includes the cost of patent protection and discrimination against foreign patent-holders. His result show as of 1999, among the European countries in his dataset[23]

[23]Including Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Switzerland, Ukraine, and the UK.

(i) patent subjects: most provide protection for chemicals, food and medicine. The majority provide full or conditional protection for plants – the exceptions being the Czech Republic, Denmark, Finland, Ireland, Norway, Portugal, Romania, Sweden, and Ukraine. No countries provide software patents.

(ii) patent length: all provide twenty years' protection from the application;

(iii) cost of patent protection: this is measure by the total fee charged for the full patent length (in 1998 U.S. dollars). See Table 2.2 (U.S.A., Japan, Korea, and Argentina are included for comparison);

(iv) limitation on protection: all countries, except Ireland, Portugal, and Ukraine, grant prior user rights as defense against infringement charges. Most countries have a three-year working period requirement, except in Czech and Hungary where no such requirement exists, while in Germany the patentee needs to begin working the patent immediately after issuance. And most countries have a compulsory licensing clause, except Austria, Czech Republic, and Ukraine; and

(v) discrimination against foreign patent-holders: no countries have a discriminatory policy against foreign patentees.

Country	Cost (1998 U.S.$)	Country	Cost (1998 U.S. $)
Austria	5867	Netherlands	6062
Belgium	1398	Norway	4300
Czech	2278	Poland	2569
Denmark	4951	Portugal	1517
Finland	4544	Romania	3976
France	3597	Spain	2840
Germany	6803	Sweden	2720
Greece	2728	Switzerland	5111
Hungary	2835	Ukraine	2992
Ireland	3541	U.K.	3787
Japan	15150	U.S.A.	5840
Korea	4757	Argentina	2657

Table 2.2: Cost of Patent Protection

These results show that patent harmonization efforts have succeeded only in some respect, notably patent length and domestic treatment for foreign patent-holders.

2.4.2 Procedural features

European cooperation in the patent system is not confined to patent law, but occurs also in the procedures of patent application. Indeed, a centralized European patent application might be one of the most successful achievements for the European patent community. But that does not mean that each national patent office (NPO) adopts the same approach as the EPO when examining national patent applications. On the contrary, the NPO route has very different features from those of the EPO, as we shall see. We mainly touch upon these differences here and provide more details of the EPO patent examination procedure in Section 3.5.

Patent enforcement, on the other hand, is currently entirely conducted in and therefore controlled by national judicial systems; so are the amendment and revocation of issued patent rights, except patent opposition in the EPO within nine months of issue. Potential jurisdictional differences thus add uncertainty or even inconsistency to the European patent system.[24] We discuss in the following some current features of a European patent application and enforcement, both at the European Patent Organization and national levels.

Application routes and examination:

As stated above, inventors can file patent applications with the EPO, together with a "menu" of countries where they wish patents to be in force after issue. This "à la carte" approach provides significant advantages for inventors seeking patent protections in several countries, notably cost savings over filing several country-level applications.[25] However, national applications remain as an important option. For instance, independent inventors or small entities may only need patent protection in their home countries and so prefer applying to the NPOs. A third route is to file a PCT application (Patent Cooperation Treaty) and chooses the EPO as one designation.

Besides filing costs and examination fees, perhaps one of the most important differences is the examination effort exercised by the EPO and each NPO. There is significant divergence among the

[24] To overcome this problem, EPC countries set up a working party in 1999 to study and propose a "European Patent Litigation Agreement" on the creation of a European Patent Court.

[25] Akers (1999): "As a general rule, once it has been decided to seek patent protection in more than three countries that are contracting states to the EPC, it is more economical to file and prosecute a European patent application with designations covering the countries of interest."

EPO and the various NPOs.

At the EPO, before issuance a European patent application has to survive both the preliminary examination on the formalities, such as the application identity, fee payment, and claims and specification requirement, *etc.*, and the substantive examination, i.e. the subject matter, industrial application, novelty, and inventive step. Currently the EPO also searches for prior art itself.

While, for instance, Austrian, German, and UK patent offices have similar examination procedures to those of the EPO, not all NPOs perform all prior art search and/or substantive examination prior to issuing national patents, though. For substantive examination, Swiss and Slovenian patent offices do not examine the novelty and inventive step criteria, and there is a patent registration system in the Netherlands. The French patent office (l'Institut Nationale de la Propriété Industrielle, INPI) outsources the search task to the EPO, and has limited substantive examination as well.

The difference in examination procedures and requirements may reasonably lead to differences in the scope of patents granted by pursuing different routes. However, it is worth noting that even when holding both a European and a national patent on the same invention, under some national laws the patent-holder may not be able to choose which patent right to assert. For instance, according to UK patent law such discretion is controlled by the patent office.

Second, an interesting feature of Slovenian patent law is that, although there is no substantive examination, in order to enforce her patent rights, before filing infringement lawsuits the patent-holder is required to submit written proof (in the form of a Document of Evidence, DoE) that the patent does fulfil the novelty, inventive step, and industrial applicability requirements.[26]

Challenge and enforcement

As far as post-grant procedures are concerned, currently the EPO plays a role at this stage only by presiding over patent opposition and deciding the case. Opposition is possible only within nine months after the issue of the patent. After nine months, validity issues can only be resolved in national courts.

First, the German law allows for only three months, and in Austria four months, to oppose a

[26]The DoE is also required at the end of ninth year of the patent term; otherwise, the patent is no longer valid after the tenth year (see Strel 1997).

patent after issue. Perhaps in reflection of the legal traditions, no discovery is available at the EPO and German patent office and court. At the Austrian patent office the opposition decision is decided in writing without a hearing being held, while discovery is relied upon heavily by the UK courts. This may generate different information for the same case in different legal arenas, and potentially lead to different or inconsistent decisions.

Secondly, in practice an infringement suit in court usually triggers an invalidation suit from the defendant. Here national treatments again present considerable differences. When the defendant challenges the validity of a patent at the EPO, infringement proceedings might continue in the German and UK courts. On the contrary, in Austria, France, and Belgium the national legal proceedings are suspended pending the outcome of the European opposition.

Another distinguishing feature of German patent law is the split between infringement and validity issues. Contrary to, say, the French or UK system, patent validity may not be questioned in an infringement suit. The defendant may only file an invalidity challenge in the patent office during the three-month opposition period, or, after that period, bring a revocation request to the centralized German Federal Patent Court. The district court (and court of appeal for the second stance) can decide only on the infringement issue, but has the discretion to stay the procedure pending the revocation outcome.

2.5 Bringing theory and practice together: what have we learned?

The review of the theoretical literature on the incentive properties of the patent system has made one thing very clear. We can say something about the costs of setting inappropriate criteria of length, breadth or patentability; but it is very difficult to say what the right level of each of these criteria should be. Furthermore, whereas the law can choose an enforceable criterion of patent length such as 20 years (whether or not such a criterion can be defended on theoretical grounds), it is not possible even to specify a rule for patent breadth or patentability against which the performance of any given patent-awarding body can be evaluated.

To see this, note that any decision-making body wishing to implement a standard of acceptance or rejection (whether this be patent applications, employment candidatures, applications to school or university, requests for grant of a technical standard, submissions for publication, or any similar standard) can do so by one of two mechanisms, which we can call a decision-rule mechanism and a case-comparison mechanism respectively.

A decision-rule mechanism uses an external standard of comparison, and asks of each new case how it compares with the standard – typically using some threshold of acceptability. For instance, students might be accepted to university if they achieve more than a certain score on a test. This threshold may of course change over time under the influence of policy decisions, competition for scarce places, judicial review and so on.

A case-comparison mechanism uses an internal standard of comparison, and asks of each new case how it compares with previous cases that were accepted or rejected. If the new case is "better" according to the standard than previously accepted cases, it should be accepted, while if it is "worse" than previously rejected cases, it should be rejected. If it is worse than previously accepted cases but better than previously rejected ones, it is in an intermediate category that could be either accepted or rejected. The implicit threshold may of course change over time if, for whatever reason, it is judged that certain cases that were previously accepted would not now be acceptable, or that certain cases that were previously rejected would now be acceptable.

For standards of breadth or of patentability to be implementable by a decision-rule mechanism, these standards would each need to be embodied in a description the application of which to any given patent application could be agreed upon by any two reasonable and competent observers. It is easy to see that this is an unrealistic expectation. It is not even clear along what dimension breadth and patentability can be measured, let alone how to establish where to locate a particular application on these dimensions or how to compare them to a putative threshold. An experiment undertaken by the UK Patent Office[27] illustrates the near-impossibility of using successfully any decision-rule mechanism for a criterion such as the "technical contribution" – which has been proposed as a way of ensuring that the inventive step criterion for patentability is not too easily met in certain technical fields[28].

[27] Reported at `http://www.patent.gov.uk/about/ippd/issues/eurocomp/results.htm`

[28] The EU Council proposed definition of a technical contribution reads as follows: "A contribution to the

Trial workshops were held at which competent participants were asked to judge whether 18 fictitious applications met each of 12 candidate definitions of a technical contribution. All definitions produced major disagreements among participants when applied to at least some cases; no candidate definition produced both reasonable consensus and reasonable conformity to the Patent Office's own interpretation of current law in more than ten cases out of eighteen.

It seems therefore that the only realistic way for any patent office to implement standards of breadth or patentability is by the case comparison method: asking for instance, "Is this application more or less patentable than applications we have approved in the past?" This also makes it clear how standards of breadth or patentability can evolve over time under legislative or judicial pressure. The courts can overturn the validity of a previously issued patent, or can assert that a patent application that was turned down should have been approved. If it is believed that the patent office has got the balance wrong in some respect, the legislature or policymakers can require patent offices to approve patent applications significantly more easily or significantly less easily than in the recent past. While knowing how precisely this can be achieved is a more delicate, it is clear what cannot be done: to give the patent office an external standard of breadth or patentability defined in terms of a decision-rule, and then simply observe the patent office's performance to see whether it is following the rule.

Case-comparison methods are quite common practice for many kinds of organizations. Firms and educational institutions are required by law in many countries to observe non-discrimination in their recruitment practices. Non-discrimination requires consistency of standards across a variety of cases and not recruitment according to some absolute standard of competence or achievement. There is no reason, therefore, to think that the use of case-comparison methods would be significantly more difficult for the EPO than for other large organizations applying them. This would, however, require that the EPO's internal procedures were such as to make case-comparison both feasible and effective: individual examiners would have to have incentives that were compatible with their taking case-comparison seriously.

Two conclusions follow from this for the practice of the patent office. First of all, if a patent office

state of the art in a field of technology which is new and not obvious to a person skilled in the art. The technical contributions shall be assessed by consideration of the difference between the state of the art and the scope of the patent claim considered as a whole, which must comprise technical features, irrespective of whether or not these are accompanied by non-technical features"

seeks to implement a standard of breadth or of patentability, it needs procedures in place for ensuring that examiners are able and willing to make regular comparisons of current cases with those that have been accepted or rejected in the past, and – where appropriate – to revise these comparisons under pressure from court judgments and legislative decisions and under the influence of scientific evaluations and informed external opinion. Secondly, any attempt by one patent office (whether the EPO or a national office) to set a standard that diverges significantly from the standard in other offices may lead to forum-shopping by applicants, and consequently to a change in the quality and quantity of applications that it receives in the future. This implies that comparison of granting practice across offices, as well as comparison across cases within the same office, would be highly desirable - a state of affairs that is far from what is happening at the moment.

It would be wrong to think that the difficulty of implementing a decision-rule mechanism for patent quality means that patent quality is an unimportant objective for the patent system. On the contrary, we have discussed above some of the potential costs of getting the quality judgments wrong. If quality criteria are too stringent then many potentially valuable innovations will gain no patent protection, which in turn reduces incentives for innovation in the first place. If they are too weak then patent thicket problems will result and potential innovators will be deterred by fear of infringements (including of patents of whose existence they are currently unaware). Both types of mistake, therefore, will tend to discourage innovation. In addition, if quality criteria are too weak then firms will respond by increasing low-quality applications, which is likely to worsen the workload problems of the patent office – potentially leading to a vicious circle.

This completes our discussion and review of the literature on the objectives of the European patent system. Chapter 3 turns now to the internal workings of the European Patent Office itself.

2.6 Appendix

To understand the concept of leading and lagging breadth, and the patentability requirement, consider Figure 2.1 overleaf.

In Figure 2.1, the line represents the technology space, the new invention seeking patent protection

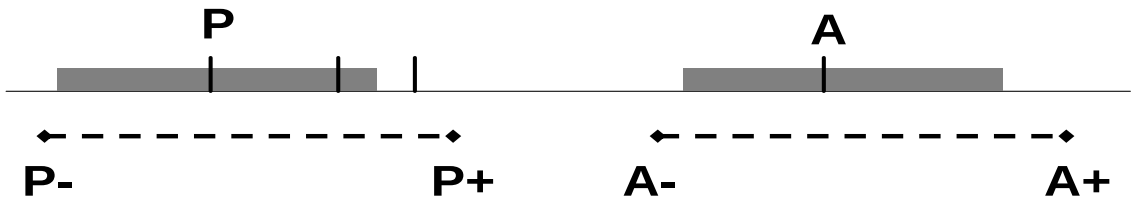

Figure 2.1: Patent breadth and patentability

locates at point A, and point P is the existing technology level available to the public, i.e. the prior art. The prior art may consist of existing patents or of non-patent information.

The patentability requirement is represented by the gray area surrounding P and A, when A becomes part of the prior art. Given the prior art P, no other inventions fall in the gray area surrounding P can be granted patent protection. For example, A and A' are patentable, but not A''. And if A is patented, it flows into the public domain and blocks other inventions in the gray area around A from patenting. A wider area then implies a higher patentability standard.

Breadth, on the other hand, is represented by the dash-line area. When A is patented with patent breadth $[A^-, A^+]$, its owner enjoys the exclusive control over the range $[A^-, A^+]$, and permission from the owner is required for anyone who wants to use technologies in this range. If we think of different inventions on the technology space exhibiting a "vertical relationship" such as quality, and so A has a higher quality than A', we can introduce the concepts of leading and lagging breadth. For the patent A, its leading (lagging) breadth covers those inventions within its control and with higher (lower) qualities, namely those inventions in $[A, A^+]$ ($[A^-, A]$, respectively). Lagging breadth protects the patent-holder

from imitation, and leading breadth protects against future innovation.

Note that it is not required that the breadth protection coincides with patentability criteria. For example, when P is patented with breadth $[P^-, P^+]$, A'' is both not patentable and infringing, while A' is both patentable and infringing. The second case is usually referred to as "mutual blocking:" the owners of patents A' and P cannot use technology A' without each other's permissions.[29]

[29] There is a third case of non patentable but not infringing.

Chapter 3

The EPO Human Resource System and the organization of work

3.1 Introduction

3.1.1 The link between the outside and the inside of the EPO

The preceding chapter discussed the role of the EPO in the international intellectual property right system. In order for the EPO to play its intended role in the intellectual property system, there must be a match between the internal and the external governance structures.

The link between the external and the internal perspective on the EPO is the following. The role of the EPO's external governance structure is to furnish the goal in terms of optimal mix between quality and quantity of patents awarded as well as the weight that should be attached to the two potential errors in patent decisions (that of erroneously rejecting a valid patent and that of granting an invalid one). The role of the internal governance structure is to implement this goal to the extent possible. Put differently, through a complex production process, EPO staff transforms patent applications into awards or refusals. Like any other agency or firm, the EPO must not be treated as a monolith, as it consists of a large number of internal stakeholders on different levels: the member states that are represented in the Council, top management, middle management, examiners, formality staff, *etc.*. All of these

have different interests, both taken as subgroups and at the individual level. Therefore, the behavior of the EPO staff cannot be arbitrarily altered by simply issuing appropriate orders. Rather, the internal governance structure needs carefully to direct individual members' behaviors towards furthering the goals of the organization.

We have so far treated the EPO as a black box: we now attempt to open up the box to understand its internal workings. We call the "Human Resource System" (HRS) the set of governance instruments used within the EPO to coordinate work of its staff and provide them with incentives. The HRS encompasses career paths, evaluation and reporting practices, time budgeting, allocation of different tasks, but also potentially performance pay or other types of bonuses.

The very same forces that add to the complexity of the relationship between patent applicants and the EPO as a whole, also make it a complex task to design the HRS within the EPO. Different actors on different levels in the hierarchy have "private information" - that is, they know things that others inside or outside of the organization do not know. Also they have scope for using this information strategically in their own interest. This strategic behavior arising from the asymmetric information of the stake holders in the organization will be crucial for understanding how effective different internal governance mechanisms are likely to be. We will see that problems from asymmetric information can arise because the actions taken by individuals and groups are only imperfectly observable by management and because members of staff have access to privileged information relevant to the examination process or otherwise of importance for the work of the EPO. Unless this is taken into account by the designers of the HRS, any reform of it must fail.

The EPO currently employs a system of motivation, evaluation and compensation practices that provide staff with what economists call "implicit incentives". These are, for instance, the incentives provided by the expectation of promotions as reward for good work or arising through peer pressure. They tend to develop over time, and organizations adapt them only slowly to outside changes. It is important to distinguish the concept of implicit incentives from that of explicit incentives, such as performance pay. The former build a link between performance and the utility (monetary and non-monetary) of an individual or group, whereas the latter impose a direct link between some measurable performance indicators and pay.

Explicit incentives are often introduced as a reaction to perceived dysfunctionalities. For instance, pay may be linked to performance by a precise formula which yields a certain amount of additional money for every additional point on a performance measurement scale. There is ample evidence that such explicit incentives can be a powerful tool to overcome information asymmetries and that they can help motivate people in an organization to take actions that are more aligned with the interests of management and other stakeholders. However, there are no "best practices," that can be simply implemented in the EPO: incentive systems involve substantial risks if they are not well designed for the environment in which they will operate.

After our careful review of the HRS at EPO, it appears to us that the current system of implicit incentives at EPO is reasonably functional. It provides a set of balanced incentives to trade off quantity and quality and induce some cooperative behavior among staff. However, the backlog of unprocessed patent applications and concerns about the financial outlook have induced management and some of the member states to believe that the EPO should increase the speed with which patent applications are processed. An apparently easy fix for this problem would be to introduce explicit monetary incentives tied to the quantity of patent applications processed. Furthermore, the perceived need to increase throughput of patent applications could lead to putting more weight on the quantity of patent examination actions taken when examiners are evaluated.

One may or may not agree with this view, but in any case, there remains the question whether the introduction of such explicit incentives can be successful in achieving the desired outcomes without creating excessive risks for meeting the goals of the organization. In order to evaluate the risks that introducing explicit incentives entails, one must have solid theoretical principles and detailed knowledge about the production process at the EPO. We therefore first review the scientific literature on incentives (Section 3.2), and offer a comparative view of incentives in organizations (Section 3.3). To gain insight into the specific issues related to incentives in a patent office we examine recent experiences with explicit incentives adopted by the U.S. Patent and Trademark Office (USPTO) (Section 3.4). We then present an analytical description of the work processes in the EPO and its Human Resource System as well as a brief review of the reform suggestions currently being debated (Section 3.5). This is followed by a description of the most striking results of a detailed survey with more than 4,000 responses within

the EPO (Section 3.6). Finally, Section 3.7 brings together all these elements and evaluates the impact that proposed reforms may have on the ability of the EPO to meet its goals. The following outlines the approach adopted in our study and summarizes the most important results of our investigation.

3.1.2 The approach adopted and the main results

Our approach is as follows. The scientific literature identifies the conditions under which explicit incentives – such as pay for performance – work well, and what are risk factors. The comparative perspective of incentives in organizations allows for a first plausibility check of these theoretical conditions and corroborates them. The experiences at the USPTO in conjunction with the documentation of how human resources work at the EPO, as well as the extensive survey that we have conducted, allow us to compare these theoretical conditions with the ones at the EPO.

The survey plays the crucial role of providing the link between the general lessons from incentive theory and the comparative perspective on organizations on one side, and the evaluation of risks associated with the suggested changes in incentives of the other. To be more concrete: the main role of the survey is *not* to document to what extent staff are satisfied with their job, with their compensation and so on. These are interesting questions, but they have been addressed elsewhere. Rather, the guiding idea behind the survey is to get a precise idea of the specificities of the work at the EPO. This understanding of the specificities then allows us to identify the relevant results from the theoretical literature and discard irrelevant arguments.

To make this point clear: it is not surprising that staff may care more about the quality of their own work than management does. This difference in preferences is a widespread phenomenon. It is however important to see that staff at the EPO does not just care for quality of work because of some intrinsic difference in preferences compared to those of management. Rather, the reason why people care for quality seems to have a number of quite subtle sources:

1. *Quality of one staff member's work affects the quantity of another staff member's work*: In the survey, 64% of the staff (and 85% of examiners) say that a high quality of patent applications saves them a lot of their time; 33% say the same about work of colleagues within their department. Hence, quality concerns may be due to the simple fact that a higher quality of work of one

person helps another person to master higher quantity. This effect is extremely strong for the link between applicant and examiner, but it is also quite substantial for the link within the departments of the EPO: as the work is highly interactive and success is interdependent, it would be a mistake to see the incentive problem in an isolated way for a given individual. Rather, when one member of staff reacts to incentives by working faster, but also by providing lower quality inputs to the work of others, the overall quantity produced may fall rather than rise. That is, there is a risk that the very goal of such an incentive introduction is undermined: even if each individual reacts in the desired way, the complex production process may result in a distortion, because people provide lower quality inputs into each other's work.

2. *Increasing the quantity of patent applications processed may create new backlogs.* Making examiners work faster on the patent applications they face may indeed *increase the quantity or throughput* of patent applications in the short term. However, in *the medium term, the backlog could increase, not decrease.* In the short run a decrease of the average time for applications indeed reduces the backlog. In the medium run, however, one needs to take into account the impact of the strategic reaction of applicants. Anticipating that the standards for patent awards deteriorate, applicants with less valuable patents enter the fray. Further, the incentives of applicants to exert effort for describing and preparing their patent application may decrease. This makes the work of examiners harder. Thus, the backlog may increase and the quality of inputs to the examination process deteriorate. This is a situation which may engender a vicious circle as described in Section 2.3.1.

In more general terms, a number of aspects of the work at the EPO will make it difficult to introduce incentives that induce patent examiners to go faster.

1. The link between an examiner's effort and the number of patents processed is rather complex. The BEST system (see Section 3.5) involves the highly interdependent tasks of search and substantive examination. Search is a *complex task* because identifying the state of the art requires specific knowledge of the examiner and the willingness to go through a potentially large amount of documents. Examination is complex, because the "inventive step" is a concept entailing a

number of dimensions and necessitates individual judgment of the examiner. Neither search nor examination are tasks whose fulfillment can be easily codified, monitored or measured. Most importantly, the link is complex because there are many more people involved than a given examiner at the EPO: colleagues in the department, in other departments, and most importantly, the applicant.

2. The available performance measures do not capture all aspects of EPO agents' actions that are relevant to the goals of the organization.

3. Not all of the performance measures are aligned closely enough with the subgoals of the EPO. In particular, some of these measures could be increased through actions that are detrimental to the EPO's goals.

4. There is much variation in the extent to which individual performance measures respond to the effort of the examiner.

5. Given the specific type of workforce at the EPO, the introduction of explicit incentives may lead to undesired changes in the decision of individuals to join or to leave the organization.

All of this makes us believe that the work of the EPO requires *delicate balancing of diverse criteria*. In particular, there exists a stark tradeoff between quality and quantity of search work. To identify the state of the art does not only require the right search strategy, but its success depends crucially on the experience, skill, effort and patience with which an officer carries it out. When the emphasis on quantity of measurable output grows, a reallocation of effort towards producing more measurable results, and not towards better work, may result. Thus, the multi-dimensionality of the examiner's work imposes a limit on the use of explicit incentives unless one would be willing to accept a complete reallocation from thoroughness and quality to speed and quantity. This and the possibility of a vicious circle, where lowering quality standards feeds back through changed incentives for applicants into increasing numbers of applications of lower average quality, creating new pressure to increase throughput, would ultimately mean that patent quality might deteriorate dramatically, thereby exposing patent holders to substantial legal uncertainty and severely diminishing the benefits for society arising from the patent system.

A further risk is associated with the *uncertainty* that affects the inputs and results of the work of the EPO. Applications differ in their complexity and the work which they require. It is often not clear in advance how much effort will be needed to carry out the search and examination tasks for a particular application – it is especially unclear to what extent communication with the applicant over reformulating claims will be necessary. Appeals and opposition cases are to some extent random events, because they are related to strategic behavior of patent applicants or their competitors, and hence not necessarily directly linked to the quality of the initial work. This causes considerable uncertainty for the examiners involved and also makes it more difficult to use completed actions over a given period as a reliable productivity measure. Additional uncertainty stems from the institutional structure of the European Patent Organization which is marked by diverging concepts about the role of the patent system and the desired quantity and quality of patents awarded.

Further, the activities of different individuals are *highly interconnected*. The organization of work in EPO relies on cooperation within a given unit, both between colleagues and between directors and their subordinates. It also relies on cooperation across units, for the exchange of information, training, coordination. When incentives are given for the fulfillment of individual tasks, however, there is a risk that the incentives to cooperate decrease.

All of the above show that the *introduction of explicit incentives* is a complicated task. Unless there is a balanced set of such incentives that takes care of the various potential pitfalls identified, this system may become dysfunctional. Even worse, it also bears two additional risks: first, the *risk of destroying the functioning existing system of implicit incentives* such as promotions, self-esteem, identification with the work and the desire to be appreciated by one's peers. If anything the survey that we have carried out indicates that the stress on quantity in the existing system may already be too strong. Second, there is a risk that explicit incentive systems have *sorting effects*. To date, staff at the EPO consists of highly-skilled people with what appears to be high degrees of intrinsic motivation. Experience at the USPTO suggests that after introduction of explicit incentives, it may become significantly more difficult to attract the same kind of staff. It is to be expected that many more senior, experienced staff will not be willing to expose themselves to high income risks and at the same time to be in a workplace that leaves them little flexibility in the way they work.

3.2 Scientific background – The theory of incentives

Our analysis of the proposals for reforms outlined in the previous section builds on four pillars: the modern theory of incentives, an empirically founded comparative perspective on incentives in organizations, the experiences at the USPTO, and a survey of EPO staff. The first of these pillars is introduced in this section and provides the theoretical underpinning for analyzing the interactions of stakeholders in organizations.

An organization such as the EPO provides a structure for the interaction of individual stakeholders in the patent system. A core interest of the social sciences is to understand the mechanisms that govern such interactions as well as the processes involved in the creation and evolution of such organizations and other institutions. The primary purpose of institutions is to facilitate the coordination among individuals concerning economic, political, and social decisions. Such institutions can be formal (e.g., firms, bureaucracies and clubs) – or informal (e.g., family, social networks, and markets). Traditionally, economists have focused on the role of markets and left the study of other institutions such as organizations to sociologists and industrial psychologists. However, the classical work of Coase (1937) and Barnard (1938), followed by Simon (1947), Cyert and March (1963), and Doeringer and Piore (1971) has triggered much interest among economists in studying interactions in organizations. Today, organizational economics is a core discipline of modern micro-economics.

The economic approach to studying organizations distinguishes itself from that of other social sciences in three ways. First, economists use a set of formal methodologies about which there is general agreement in the discipline. Unlike other social sciences, this avoids the pitfalls of research being associated with a segmented set of "schools" that base their arguments on mutually exclusive assumptions.

Second, the formal methodology of economics is based on a small set of assumptions about individual behavior. The use of formal reasoning, most notably of game theory, has been very influential in setting up economic theories of organizations. Game theory was pioneered among others by Nobel Laureate John Nash (1950). It posits that people behave strategically and that these strategic interactions can be analyzed using mathematical tools. Drawing on this, a large body of literature called *incentive*

theory[1] has evolved that analyzes the strategic use of information between a principal (for instance, the managers of a firm) and the agents (for instance, the workers). This literature investigates how the design of contracts and organizational rules can help solve the problems that the principal faces when dealing with agents who know better than her about certain aspects relevant to their work or their own motivation.

Third, there is agreement that economic theories must be testable. Econometrics is the branch of economics dedicated to the development of appropriate statistical tools for this purpose.

3.2.1 Principal-agent relations

Economists have developed a convenient analytical framework for studying incentives in organizations: the *principal-agent model*. Many situations in organizations can be described in terms of one party – the principal – who seeks to affect the actions of another party – the agent – by providing appropriately designed incentives. Crucially, the agent has some informational advantages over the principal. For example, the filer of a patent application has detailed knowledge about the nature of the invention, aspects of which affect the patentability of the innovation and may (purposefully or unintentionally) not be reflected in the application. The principal-agent approach allows us to address the fundamental question of what organizational practices on the level of the EPO could help to overcome the informational advantage of the applicant.

But this is not the only type of question that can be analyzed with the principal-agent approach. Typically, there exist many such overlapping principal-agent relationships in an organization. For example, within a public organization upper tiers of management are principals vis à vis lower tier agents. However, these managers themselves respond as agents to a minister or some other higher levels of the government. At the same time, the public organization as an entity may act as a principal with regard to firms which it supervises or regulates.

Looking at the EPO, there are principal-agent relations between the contracting states to the European Patent Convention (EPC) and the EPO, between examiners and applicants, between management and staff, *etc.*. Understanding the forces governing each of these relations separately is necessary to

[1] Other names used are *agency theory* or *contract theory*.

grasp the combined effects of organizational policies on the ability of the EPO to fulfill its mission. This section introduces the relevant theoretical concepts, drawing on examples from the relationship between management and staff.

3.2.2 Hidden actions (moral hazard)

For the purposes of this study, the most important category of interaction between principal and agent is that labeled *hidden actions* or *moral hazard*. It describes situations in which three conditions hold. First, the actions that an agent can take directly or indirectly affect the outcomes that the principal cares about. Second, the principal and the agent have different preferences regarding the desired actions or outcomes. Third, the principal cannot observe what actions the agent takes.

Because of the first two points, the principal (say the management of the EPO) would ideally want to link compensation of the agent (say an examiner) directly to the actions taken. Then good actions (say a high number and high quality of processed applications) could be rewarded with high pay, while bad actions (shirking on either quantity or quality of work) could be penalized with reduced pay. In other words, in such ideal circumstances in which actions are observable, an examiner would receive better pay if he or she worked hard, produced good quality results *etc.*. than if not. In the framework of simple physical work this may be straightforward to implement because actions are either easily monitored or directly linked to outcome variables that are of interest to the principal. This is reflected in the "scientific management" techniques pioneered by Taylor (1911) in the early 20th century, where time- and motion-studies formed the basis for organizing work processes.

Most modern organizations, however, handle tasks that are far more complex than production using conveyor-belt assembly lines. For example, a patent examiner must grasp the technical details of an application, and develop a good search strategy to identify and correctly interpret relevant documents of prior art, even before attempting to examine the application in more detail. An inherent feature of such complex tasks is that principals usually cannot directly observe the precise nature of actions taken by of their agents – at least not without incurring significant costs. Moreover, the outcome measures that are observed (e.g., the number of A, X, and Y references in a search report) are not straightforwardly linked to the efforts of the agents but depend on many other factors (e.g., the availability of prior art,

the quality of classification work carried out earlier for related patents, the experience of the patent examiner at performing searches in this technical field, the effort put in by the examiner to develop a good search strategy, correct identification and interpretation of the relevant documents, *etc.*.).

Using such outcome measures as the basis of *incentive pay* can only be successful in inducing the agents to behave in the way the principal desires if the principal has a *good understanding of the link between actions and outcomes*. For a number of reasons, this link is often not so clear.

First, the principal may find it hard to fully understand the technological link between work inputs of agents and different outputs. The link may be quite complex, both because there are a number of tasks that an agent works on, and because these tasks may involve a number of agents. Our survey for instance (discussed in Section 3.6) shows that interactions between staff within and across units in the EPO are important for work outcomes. It also shows that some directors know a good deal about the specificities of their subordinates' work, while others seem to understand these less well.

Second, even if the technological link is fully understood there may be other factors under the influence of the agent that affect outcomes. For example, the link between the quality of an application and the subsequent examination outcome observed in practice might change once incentives are tied to these outcome measures. The reason why a previously identified technological link may now longer appear to hold is that such incentives can introduce a temptation to use the room for discretion, say if granting a patent leads to more rewards or easier rewards for the examiner than rejecting an application. As we will discuss below, improperly designed incentives introduce such possibilities for *gaming* and can lead to very undesirable outcomes despite what initially appeared to be incentives based on a clear technological link between actions and outcomes.

Third, even if such gaming possibilities are absent, many other factors which are beyond the control of the agent may affect outcomes. For instance, one examiner may be lucky to receive applications that are easy to deal with - for instance because the applicants have done a good job in clearly documenting their innovations and carefully formulating their claims, because prior art does not cast doubt on the novelty of the claim, and therefore a grant is straightforward. Her colleague may be unlucky and receive harder cases - for instance, because the applications are complex and have many claims, require multiple rounds of communication with the applicant to modify claims, and may end in rejections which

necessitate additional documentation and carrying out oral hearings.

These factors beyond the control of the agent and unobservable to the principal make it costly to link compensation strongly to output measures because such a policy would expose the agent to substantial income risk. Most people do not like risk. Because of such risk aversion the principal must offer a risk premium relative to a situation where income is not so strongly affected by the riskiness of output measures. This is the same principle that governs differences in average returns across financial investments. An individual who puts his money in government bonds can be almost certain to get his money back with a small return. In contrast, if he puts it into stocks of a risky high-tech company he faces a high chance of losing money. To compensate for this risk relative to government bonds the investor requires a very high return if the company's business succeeds - and even a higher average return over good and bad outcomes combined than under a more predictable set of conditions. As we will discuss below such risk considerations may be particularly relevant for EPO staff.

An example from outside the EPO may make the link between risk and incentives more clear. The punctuality of a bus service depends both on the driver's effort and on uncontrollable factors such as traffic and weather conditions, people with special needs taking longer to board/alight,and so on. One the one hand, if pay is closely linked to punctuality, the driver will do his best to stick to schedule. However, the reason that bus services usually are run by a bus company or municipality rather than by individual entrepreneur bus drivers is that the former are in a better position to absorb the financial impact of uncontrollable factors than the individual bus driver. On the other hand, if the driver feels no consequences from not sticking to schedule you can expect to see a lot of chatting between drivers at bus stops.

Thus, there exists a fundamental trade-off between aligning compensation closely with output measures – to give incentives at the cost of offering a risk premium – or to make compensation less responsive to output – to provide insurance against these uncontrollable factors that affect output (Prendergast 2000, 2002a). In other words, an organization that pays a fixed wage contract insures its employees against the bad luck that they may have in the job; but the employees may then be tempted to put less effort into their jobs than they would if they were paid for each unit of output they produce. The optimal compensation contract will try to strike a balance between those two forces: typically pay

includes some fixed component to provide a minimum safe income and some variable component that gives employees an incentive to work hard.

The preceding discussion was framed in terms of immediate monetary rewards, so-called *explicit incentives*, such as bonuses and wage increases. However, it is important to note that rewards and penalties can also arise in terms of so-called *implicit incentives*. In the EPO, for instance, everybody knows that in order to be promoted, one has to reach and maintain a certain level of performance. Thus, good performance does not immediately translate into more pay, but has an impact on the employee's reputation in the organization and his or her future career. Section 3.3.7 refers to theoretical and empirical work showing that a system of implicit incentives, which often evolves over a long period of time, can provide strong motivation for the workforce.

In sum, situations of moral hazard require some link between outcomes and compensation or other types of rewards and penalties to induce agents to provide effort or take appropriate actions. Two factors may reduce the effectiveness of incentive pay: opportunities for gaming of performance measures, and the level of risk beyond the control of the agent inherent in the performance measures.

We will see in the discussion of the contemplated EPO reforms that other factors weaken the link between effort and outcome even further, which lead us to believe that explicit incentives may carry high risks for the EPO's ability to meet its goals. Of particular interest is the fact that when agents carry out many tasks, or when many agents collaborate, there are limits to the usefulness of incentive pay.

3.2.3 Hidden information (adverse selection)

Principals often have *less information* than the agent about important characteristics of the agent at the time that they enter into a contractual agreement. Two examples may help understand the relevance of such *hidden information* (also referred to as adverse selection) for the EPO.

First, candidates for jobs are the "sellers" of their human capital. Clearly, an individual has more information about her abilities and past experiences than the prospective employer. The problem for the latter is to distinguish between job applicants many of whom may look similarly suited for the position to be filled. One imperfect and costly solution is to find out about applicants' skills directly

(e.g., using an assessment center). Another solution is to rely on signals that job applicants provide about their ability. Spence (1973) demonstrated that the level of education may be such a signal. The argument is simple: more productive individuals can distinguish themselves from less productive individuals by choosing a relatively high level of education because low-ability individuals would not find it worthwhile to go through the pain and cost of obtaining the same education credentials that a high-ability person can acquire more easily. Nothing in that argument actually requires the education even to be useful for the job at hand. In other cases, the principal can get agents to reveal their private information by offering different contract options and allowing agents to choose from them – a technique called *screening* (Mirrlees 1971, Myerson 1982). For example, an insurance company can separate to some extent low-risk drivers from high-risk drivers by offering two types of insurance policies, one with a low premium and a high excess and one with a high premium and a low excess (Rothschild and Stiglitz 1976). It is however hard to imagine that the EPO could make use of such techniques, for instance by allowing people to choose the extent to which they are on incentive pay.

Second, the agent may obtain important information about aspects of their work that the principal does not have access to. This type of hidden information is problematic for the principal because it affects the actions that an agent will take in response to an incentive mechanism. For example, if a job placement officer receives some reward for placing unemployed individuals this may induce placement officers to focus only on the "easy" cases, while the neglected "hard" cases are the ones which the principal (society) is particularly interested in. This has been noted by a number of papers on job training agencies (Asch 1990, Courty and Marschke 1997, 2005). Similarly, if an EPO examiner were to receive a piece-rate reward per processed or accepted patent application, he may concentrate on the simple cases and put aside the more complicated cases.

One way to elicit such private information is to offer different contracting options. For example, a regulatory body which oversees the pricing policy of utility firms needs information about the operators' costs to judge what appropriate prices are from society's perspective. Relying on operators' reports is problematic because these have a clear incentive to overstate their costs. However, the regulator can indirectly obtain information about the "true" costs by offering appropriately designed alternative output-price combinations (Baron and Myerson 1982). A low-cost firm will then find it optimal to

produce according to the contract offer that allows for a large output at a small unit price rather than pretend to be a high-cost firm by choosing the alternative low output and high unit price contract. Another response to such hidden information is to audit the agent and impose sanctions for misreporting information. However, it is usually not optimal to audit every single case because such "state verification" is costly. The work of tax authorities is a good example for this problem of finding a balance between ensuring that individuals or firms declare all their income and the cost of carrying out audits. The probability of auditing should depend on the "plausibility" of the tax report: if the agent claims to have low taxable income the probability of audit should be higher than if the agent reports a high income (Townsend 1979, Baron and Besanko 1984, Mookherjee and Png 1989).

In sum, the principal can often only learn directly about information that is private to the agent – be it about himself or relevant to parts of his job – at a significant cost. These costs need to be balanced against the need for maintaining a threat that during the occasional audit the agent will be caught when misreporting information. An alternative is to extract private information indirectly by relying on signals provided by the agents or by offering contract options so that agents with unfavorable information do not find it worthwhile to hide this by imitating the choices of agents who have favorable information. Typically, this also comes at a cost to the principal relative to the situation where the agent has no informational advantage.

3.2.4 Summary

Currently, there is a debate whether staff pay and promotion opportunities should be linked more directly to the number of patent files completed. These suggestions are based on the perception that there are inefficiencies in the work processes that could be overcome by a better design of the reporting and compensation system.

It is natural that any such inefficiencies are the consequence of private information of the examiners and other staff. Otherwise, the superiors could simply order people to carry out the actions believed to be appropriate by the management. Agency theory examines precisely this problem: how should a "principal" design the reporting, motivation and compensation system when his "agents" are better informed.

This section has introduced the most important theoretical concepts that guide our analysis of the incentive system at the EPO.

- *Moral hazard* – the agent knows his or her actions while the principal can only observe outcomes that are somehow linked to the actions.
- *Hidden information* – the agent knows more about his skills than the principal or has better information about the difficulty of a task, the quality of a patent *etc.*.

The next section looks at how incentive systems work in practice in solving such incentive problems and what additional considerations are needed when designing a compensation system.

3.3 A comparative perspective on incentives in organizations

Incentive contracts that provide an explicit link between pay and performance are not as widespread as one might expect. In the public sector, most people receive a fixed wage (e.g., Burgess and Ratto 2003, Dixit 2002) and even in private sector organizations compensation is typically not very strongly tied to performance (e.g., Gibbons and Waldman 1999, Prendergast 1999).

At first glance this is puzzling. Agency theory in its simplest form predicts that this should lead to low levels of effort (see Section 3.2.2). One reason for this phenomenon could be that performance pay – when implemented in practice – does not affect production in an organization as strongly as theory suggests. Empirical studies addressing this question mostly analyze the consequences of adopting a piece rate rather than a fixed wage in private sector firms. As the next section describes, the evidence suggests that when "good" measures of performance exist, the production structure is simple, and the interaction between different agents is of little importance for the organizational goals, such piece-rate incentives can be implemented with success.

3.3.1 When piece-rate incentives work

Many studies find positive and significant productivity effects of piece rates, using data from private sector firms (e.g., Shearer 2004, Bandiera *et al.* 2005), longitudinal household survey data (e.g., Parent 1999, Booth and Frank 1999), or matched employee-employer data (Pekkarinen and Riddell 2006).

The probably most famous example is the one of the auto glass repairer Safelite studied by Lazear (2000). The firm switched from hourly wages to a policy combining a base wage with an amount paid per window installed. The switch to piece rates caused average output to rise by 44%. Importantly, the study reveals that only half of this owes to workers exerting more effort because of variable pay, i.e., an "incentive effect." The other half of this gain stems from a "sorting effect". Performance pay made it possible to attract higher performing workers than with fixed wages. As explained in Section 3.2.3, individuals will compare contracts on offer based on private information that they have about their own ability. Thus, job seekers who believe that they have a relatively high productivity will favor firms offering a piece rate over those with fixed wages, and vice versa for individuals who believe that they have a relatively low productivity. Such a sorting effect might also work along dimensions not related to ability, such as risk aversion (Ackerberg and Botticini 2002).

A further important influence on the effect of incentive pay is the complexity of work. Using a data set that covers employer and employee information from all blue collar workers in the Finish metal manufacturing sector between 1990 and 2000, Pekkarinen and Riddell (2006) find that the effects of incentives on productivity and worker earnings are highest for simple production processes (+11%) and lowest for complex production processes (+4%).

Two conclusions emerge from the empirical literature.

- Pay for performance can lead to a significant increase in productivity if a "good" performance measure is available; i.e., when the link between an agent's effort and the principal's desired outcomes of the production process is not too complex.
- The introduction of explicit incentives can lead to self-selection. For simple production processes incentive pay may attract people who are more productive (Arya and Mittendorf 2005, Lazear 1986). For more complex production processes, this sorting effect may have a less favorable impact: as incentive pay exposes workers to more risks, the firm cannot attract or retain risk-averse people anymore.

This latter point is of particular relevance for the EPO. The Office is able to attract and retain highly qualified personnel despite offering lower earnings potential than some other career options in

the private sector, partly because it has more job security and a predictable career path and flow of income. The difference in earnings potential can be interpreted as the price that relatively risk-averse individuals are willing to pay for this job attribute – economists call this compensating wage differentials (Rosen 1974, 1986).

The preceding discussion may already yield a first understanding of why there are limits to the use of incentive pay in practice. As we will see now other factors can make it even more difficult to successfully implement explicit incentives.

3.3.2 Multiple tasks and choice of performance measures

The nature of most modern workplaces is such that people work on multiple tasks. For example, in the EPO an examiner does classification work, compiles and evaluates search records, carries out substantive examination *etc.*. Bengt Holmström and Paul Milgrom (1991) developed agency theory further to account for this type of work-related complexity.[2] They show that in a multi-task situation in which task fulfillment for some of the tasks is harder to measure than in others, it may be destructive to provide agents with explicit incentives and better to just pay fixed wages.

The reason is simple and can be illustrated by considering teachers for instance. Say a teacher is responsible for teaching mathematics and educating the pupils to become responsible citizens. Checking whether someone is a good math teacher is relatively simple, because you can look at the math results of the teacher's pupils in a standardized exam or in nation-wide high-school tests. But how can you measure whether the teacher has been instrumental in conveying certain values society believes in? In this situation, if the government decides to pay teachers in terms of the math results of the pupils, it must be feared that teachers will reduce their effort to teach civic values, and instead use all the time in class to teach maths. Hence, if the government wishes teachers to perform both tasks, it may be better not to incentivize teachers: while the total effort of the teacher may be smaller in the absence of incentive pay, the allocation between the tasks may be closer to what society desires. While "multi-tasking" is in the nature of many jobs, in some cases the principal can provide agents with clearly defined and focused tasks to avoid such problems (Holmström and Milgrom 1991, Dewatripont, Jewitt,

[2]Dewatripont *et al.* (2000) provides a survey of the recent theory building on this seminal paper.

and Tirole 1999, Seabright 2000, MacDonald and Marx 2001).

There are a large number of studies on the effect of incentives in multi-task situations. Some, but not all of them find the predicted effect of a shift from quality to quantity provision. A study on tree-planters by Paarsch and Shearer (2000) finds large productivity effects in terms of quantity, but a decrease in quality; exactly the problem that the theory predicts will arise when too high-powered incentives are given in multi-tasking situations. A study by Asch (1990) found that rewarding US Navy recruiters based on recruitment numbers lead to a reduction in recruiters' efforts to maintain recruitment quality. However, in a number of studies on incentive programmes in Israel, Lavy (2002, 2003) does not find much evidence of the quality/quantity tradeoff. Another aspect of quality is of course that people may respond to incentives by "cutting corners" to meet performance targets or increase measured performance – this is the focus of the next section.

3.3.3 "Gaming"

As a general rule, when designing incentives for agents the principal should link compensation to any available measure that helps provide additional information about the effort put in by the agent (Holmström 1979, Shavell 1979). However, in practice there is often the big problem that the available output measures can be prone to gaming by the agent (Baker 1992, 2002).

A famous example is the attempt by Lincoln Electric to reward secretaries based on the number of key-strokes – exploiting what appears to be a straightforward technological link between actions and desired outcomes. The effect of this measure was that secretaries started spending their lunch breaks repeatedly hitting one of the keys to improve the performance measure (Fast and Berg 1975). Paying mechanics at Sears commissions based on profits from car repairs induced many of these to mislead customers into authorizing unnecessary repairs which ultimately hurt their company.[3]. This common problem in incentive provision is aptly summarized by Steven Kerr (1975) as the "folly of rewarding A while hoping for B."

The risk of gaming is closely related to the multi-tasking problem discussed in the previous section. The fact that the agent can take various actions that affect the outcome measure leads to a shift towards

[3]See Baker *et al.* (1994), who also give other examples. Also, see Chevalier and Ellison (1997) for the impact of performance incentives on risk taking by fund managers

activities that improve the performance measure rewarded but do not necessarily further the objectives of the principal. The link can easily be seen by returning to the teacher example. When teachers are rewarded based on test results or face strong pressure to improve such results through other channels, a consequence may be "teaching to the test" – teachers and their students narrowly focus on the test and ignore other, untested aspects of knowledge (e.g., Lazear 2006). Another response may even be outright cheating by teachers (e.g., giving away answers to tests before hand) – a phenomenon analyzed by Brian Jacob and Steven Levitt (2003) and summarized in Dubner and Levitt's (2005) recent book.

In particular, when an agent engages in a task where the outcome measure accumulates over some time, the principal needs be extremely careful in choosing how to measure and compensate performance. In such cases it can be optimal to reward each increment in performance equally to avoid strategic timing of effort or misreporting of outcomes (Holmström and Milgrom 1987).

There is considerable evidence that gaming takes place when an agent is rewarded for exceeding a performance target in a given period. If a task is subject to productivity shocks, agents can react to good conditions by not reporting output or delaying output realizations that exceed the target to carry this over to the next period, allowing the agent to work less hard then. This is often referred to by personnel managers as "income smoothing." There also are interesting examples from public organizations. For example, Courty and Marschke (2004) present evidence on strategic reporting in the Job Training Partnership Act program, which provides training for the unemployed in the US. It turns out that some administrators reported successes of the program with a time lag.

3.3.4 Lacking commitment of the principal and the ratchet effect

In most situations, principal and agents do interact over a longer horizon. There are good sides to such longer-term relations: the principal can provide risk-averse agents with insurance through stable wages. Because compensation need not be closely linked to output within a given period, incentives can be provided through the prospect of higher earnings in the future following good performance. In fact, much of the puzzling lack of explicit pay for performance can be explained by arrangements in organizations that link pay to positions and reward good outcomes with a higher probability of promotion to better paid positions (e.g., Gibbons and Waldman 1999)– this will be looked at below in

Section 3.3.7.

However, the benefits of long-term relations hinge crucially on the commitment power of a principal. If the principal is not able to commit to the incentive scheme that will be in place in the future, problems arise if agents have hidden information about relevant aspects of their job, for example the difficulty of a task. Without commitment, after observing unexpectedly good performance the principal may well decide that the performance standard required was set too low and impose a tougher standard in the next period. Anticipating this "ratcheting" of performance standards, agents will be cautious not to work too hard (Lazear 1986, Kanemoto and MacLeod 1992, Laffont and Tirole 1993, Carmichael and MacLeod 2000). This makes it more expensive for the principal to elicit effort. Berliner (1957) coined the term *ratchet effect* for the tendency of planners in the Soviet Union to penalize plant managers for increased output with harder quotas.

The perception of lacking commitment of a principal and the resulting ratchet effect can severely obstruct the creation of value in organizations. This is particularly the case if trust in an organization is low, if management changes often, and if there are outside stakeholders that change the rules of the game frequently. These sources of uncertainty greatly reduce the efficacy of explicit incentives.

3.3.5 Cooperation between agents

Modern production often relies heavily on cooperation among agents. There is a substantial literature showing the difficulties in providing individual incentives, if cooperation or "help" efforts are important for output.[4] The most important lesson is that the introduction of strong individually-oriented incentive schemes can be dangerous when help effort cannot be monitored or measured. Then there is an unwanted reallocation from some tasks (that may be good for the organizations but are not rewarded) toward those that are directly rewarded. This is exacerbated when trust between agents and principal is low. While help effort is hard to measure, there is some empirical evidence that corroborates these theoretical propositions. In a survey of 23 Australian workplaces and 2,066 workers, Drago and Garvey (1998) find that explicit incentives, such as piece rates and profit sharing schemes, were negatively related to helping effort in the organization.

[4]For example, Holmström (1982), Lazear (1989), Itoh (1991), Jeon (1996), Auriol *et al.* (2002), Che and Yoo (2001), Chen (2003), Marx and Squintani (2003), and Koch and Morgenstern (2005).

3.3.6 A solution? Subjective evaluation

One solution that avoids relying on performance measures that then induce dysfunctional behavior is to base compensation on subjective performance measures (Baker *et al.* 1994). However, subjective performance assessment can also give rise to biases in an hierarchical organization where supervisors evaluate the performance of lower ranks and report as agents to upper ranks. There might be a "leniency bias" resulting from the reluctance of supervisors to give bad ratings and additionally a "centrality bias" because supervisors want to avoid conflict arising from big differences in ratings across individuals (Prendergast, 1999, 2002b). Moreover, agents may engage in activities that distract them from their regular work: attempting to curry favor with the supervisor, other "rent-seeking" activities or behavior aimed at influencing the supervisor's evaluation (Prendergast 1993, 1996, 1999). Incidentally, there is some evidence that incentives provided to managers that are more strongly linked to performance can reduce problems of favoritism – at least in supervising simple production tasks (Bandiera *et al.*. 2006).

3.3.7 The power of implicit incentives

Given the points discussed above, it should have become clear that the introduction of explicit incentives can have strong effects on productivity. However, success of such measures depends crucially on the fit of explicit incentives with the workplace and the specificities of the production problem at hand. These problems are only part of the explanation for why explicit incentive schemes are not as widespread as basic incentive theory wold predict. The other part of the answer is that most organizations have in place Human Resource Systems that create incentives that are implicit in nature rather than of the explicit type.

Long-term relationships with some or all of the workforce allow many organizations to avoid the problems of paying employees directly based on performance measures observed in a given period. Instead, they design career paths to motivate their staff and provide their employees with training and benefits. All of these instruments are *implicit incentives*.

The empirical literature has shown that career paths seem to do a good job in providing incentives and in selecting workers for the most important job. These systems of implicit incentives, also called "internal labor markets" (Doeringer and Piore 1971), are often quite stable over time (e.g., Baker *et*

al. 1994a, 1994b). In some cases individuals' career paths are entirely within an organization so that employees are shielded from the perils of the general labor market. However, in many cases the general labor market provides individuals with strong incentives to produce results that further their chances to obtain a better position in- or outside their current employer. Such *career concerns* can substitute for explicit incentives (Fama 1980, Holmström 1982/99). However, there are two caveats. First, the motivating force of impressing potential future employers becomes a weaker motivator the older and the more experienced a worker is - a theoretical prediction also confirmed in empirical studies (Gibbons and Murphy 1992). Second, an individual's desire to produce results that look "good" on his or her CV can lead to behavior that is not in the interest of the current employer. For example, a manager may be more interested in pushing short up term profits to secure a better job elsewhere in the industry on the back of this "success" than in furthering the long-term objectives of the current employer. An example of this is evidence on mutual fund managers distorting their portfolio allocation in response to career concerns (Chevalier and Ellison 1999). Also, career concerns may adversely affect the willingness of staff to cooperate: individuals become more interested in what furthers their own career prospects than in what is beneficial for the organization (Auriol *et al.* 2002, Koch and Morgenstern 2005).

It is thus important that the implicit (and explicit) incentives designed by an organization take into account the career concerns incentives – both positive and negative – that arise from the wider labor market.

3.3.8 Other non-tangible sources of incentives

The preceding discussion has presented the incentive effects that arise from the desire of individuals to gain from their actions in terms of a better job or better compensation, either now or in the future. However, it is crucial to bear in mind that there are other factors that influence behavior in organizations which are not covered by this. We will not survey here the growing body of literature in *behavioral economics* that integrates the influence of social norms and psychological mechanism into the study of organizations[5], but only highlight a few themes.

Individuals may be strongly motivated by the desire to "do a good job", conform to professional

[5]For a survey, see for example Fehr and Falk (2002).

norms and so on (e.g., Besley and Ghatak 2003). Such *intrinsic motivation* may be very sensitive to how the work of an individual is judged by others, as shown in the literature on *crowding out* of intrinsic motivation by monetary incentives.[6] Related to this is the concept of *peer pressure*. Kandel and Lazear (1992) argue that factors such as guilt and shame, or norms to work as hard as the colleagues do can have strong incentive effects. There is some empirical evidence that mutual monitoring among individuals working together closely has positive productivity effects (Knez and Simester 2001, Falk and Ichino 2006). Another motivating factor for individuals is the desire for *status* and recognition. Promotions typically confer such status rewards because the positions higher up in the hierarchy of an organization typically have higher status.[7]

Such non-tangible incentives have been suggested as one possible explanation for the otherwise puzzling finding of several studies that profit-sharing at the company level appears to have a sizeable effect on work effort. For most employees this effect cannot be explained by the direct impact that an increase in the individual's effort has on the profit of the organization (and therefore her profit share) because the link is rather weak: unless you are at a very senior position your work effort will usually barely make a dent in the overall organization's profit. If corroborated, the non-tangible incentives argument could indicate that explicit incentives introduced at the company or workgroup level might have fewer risks of provoking negative consequences than those introduced at the individual level – a lesson that might be of relevance to the EPO. Prendergast (1999, pp. 39-44) discusses such findings, including the possibility that profit-sharing may work by inducing a sense of "belonging", before concluding that it is hard to be sure that the findings have properly controlled for other possible explanations for changes in productivity.[8] One might further add that if profit-sharing does indeed work by triggering intangible incentives, it will do so only in an overall context in which employees feel valued – they need to be part of an overall package which makes that message credible to the employees. Even then a careful investigation of the potential effects is necessary because group incentives always carry the risk of individuals offloading work on their colleagues. Occurrence of such *free riding* (Holmström 1982)

[6] See for example, Benabou and Tirole (2003), Seabright (2002), and the survey by Deci, Koestner, and Ryan (1999).

[7] See for example, Auriol and Renault (2000, 2001), Oxoby (2002), and Moldovanu, Sela, and Shi (2005).

[8] Oyer (2004) argues that profit sharing measures (such as employee stock ownership plans) are often not meant to increase effort but rather help avoid costly renegotiation over contracts by keeping employees' earnings in line with outside earnings opportunities.

can then itself undermine cooperation and other aspects of organizational culture that are important for non-tangible incentives to work. Therefore, we do not offer any conclusions on these issues in this report but consider them to be worth further investigation.

3.3.9 Summary

The overall picture that emerges from the comparative perspective on incentives in organizations is that no Human Resource System can solve perfectly all problems of asymmetric information in organizations. The incentive system must strike an optimal balance between the costs of providing incentives for appropriate behavior and the potential gains from improved outcomes. Moreover, it is imperative that the information asymmetries and the discretion that members in an organization have are fully understood when designing the incentive system.

Pay for performance can be a powerful ingredient of such an incentive system. However, the use of incentives that are directly or exclusively tied to quantitative performance measures can lead to outcomes that hurt the goals of the organization. This is more likely when work is complex, when it requires balancing diverse criteria, when the results of the work are subject to much uncertainty, when the activities of different individuals are highly interconnected, or when there is lacking credibility of long-term commitment to the incentive system.

Explicit incentives are not the only motivators in human resource systems. A system of implicit incentives consisting of external labor market career opportunities, an internal promotion-based hierarchy of positions and social interactions at the workplace (peer pressure) may give staff strong motivation to work. These implicit incentives do not suffer from the same problems as explicit incentives, and can therefore be a substitute for them or a complement to them.

3.4 Experiences at the USPTO

Reflecting a global trend also witnessed at the EPO, the *U.S. Patent and Trademark Office* (USPTO) has seen a large rise in the volume of patent applications.

The increased number and complexity of applications[9] has lead to an increase in the time needed

[9]OIG (2004) (p.17) provides statistics on complexity measures such as average number of claims in applica-

to process patent applications: average pendency rose from 20 to 28 months over the decade until 2004 and the time until the applicant receives a first assessment of the patent application (first action) rose from on average 8 to over 20 months (GAO – United States Government Accountability Office 2005, p.8). The most recent figures compare with overall pendency of 41 months and first-action pendency of 22 months at the EPO (Trilateral Co-operation 2004).

3.4.1 The patent examination process at USPTO

The patent business line of the USPTO has 6,494 staff, of which 4,177 are examiners (USPTO 2005, p.148), and is thus roughly equal in size to the EPO (see Section 3.5 below) and it also has a high unionization rate.[10] Two key differences[11] from the EPO are that decisions in the USPTO can be taken by a single primary patent examiner rather than an examining division and that there is no non-judicial post-grant review system comparable to the opposition mechanism at the EPO.[12]

3.4.2 Careers at USPTO

Career paths at the USPTO are similar to those at the EPO (see Section 3.5 below): examiners usually enter at around level GS-7 and have noncompetitive promotion possibilities within the organization at a potential rate of one GS level per year up to the primary examiner (GS-13) level. This corresponds roughly to the A4 grade at the EPO. More senior level positions are usually filled also from within the ranks of examiners. However, in contrast to the EPO where examiners almost all remain with the agency, a position as patent examiner at the USPTO is often just used for funding law school or as a stepping stone to lucrative private sector jobs as lawyer or patent attorney where experience inside the USPTO system is invaluable (e.g., NAPA 2005, p.82). As a result, attrition rates are relatively high, in particular for younger staff (see below).

tions (18.4 in 1998 and 23.5 in 2002) and in patents issued (15.3/17.4), the number of restrictions per examiner (8.2/12.5), hours for first action (18.3/18.5), and actions per application (2.3/2.4).

[10] The *Patent Office Professional Association* (POPA) is integral to the patent examination process and represents around half of the patent office staff (NAPA 2005, p.111). There are other unions though. For more on labor relations, see NAPA (2005), chapters 5 and 6.

[11] Another difference is that patentability requirements in the US are novelty, non obviousness, and utility, which are closely related to the criteria applied by the EPO.

[12] Introducing such a system is currently planned under the Patent Reform Act of 2005 (H.R. 2795) submitted to Congress (e.g., Hall and Harhoff (2004), Jaffe and Lerner (2004, chapter 7), NAPA (2005, chapter 3), USPTO (2005, p.48)).

3.4.3 Evaluation

The compensation package at the USPTO includes a variable pay component linked to the number of patent applications processed. Consistently failing to meet quotas may result in dismissal[13], whereas cash rewards are granted for exceeding targets (GAO 2005, p.29). Productivity is measured in terms of "counts": an examiner receives two counts per application, one for the first action and one for the final disposal. The number of counts to be reached ("expectancy goal") is computed based on the assumption that 80 percent of the 2,080 hours in a 52 work-week year are devoted to examination. Goals are adjusted for experience and the type of patent. On average, each examiner is expected to complete 87 files per year. Grade adjustments mean that in an average field a GS-7 examiner has 39.3 hours to process an application, whereas a primary examiner at GS-14 level only has 20.4 hours (NAPA 2005, p.99).

Performance appraisals determine eligibility for three types incentive awards: (1) gain sharing (average production over fiscal year exceeds 110, 120, or 130 percent of production goal – worth 1-6 percent of base salary), (2) special achievement (production in four consecutive quarters exceeds 110 percent of production goal – worth 3 percent of base salary), and (3) pendency reduction award (examiner workflow management over two consecutive quarters – worth 0.5 percent of base salary[14]). Gain sharing and special achievement awards are received by around 60-70 percent of examiners and pendency awards by 30-40 percent (OIG, 2004, p.24) and more than half of the examiners received an outstanding rating in 2001 and 2002 (p.21).

3.4.4 The challenges faced by the USPTO

The USPTO faces similar challenges to the EPO in terms of increasing volume and complexity of patent applications. In particular, the backlog of applications is projected to be over one million by 2010 (USPTO 2006). In addition the USPTO has been subject to criticism about the quality of patents granted (e.g., Hall and Harhoff 2004, Jaffe and Lerner 2004). This is compounded with difficulties in recruiting and retaining qualified staff. Overall examiner attrition rates fluctuate between 8 and 15

[13] A measure of this are the 329 oral warnings and 48 written warnings issued in 2004 (Nappa 2005, p.110).
[14] Workflow management is assessed on satisfactory performance in 17 tasks (see OIG, 2004, p.35)

percent of staff (GAO 2005, p.23). Of particular concern is the high level of attrition among examiners with less than 5 years experience. Full proficiency in conducting patent application reviews is reached only after 4 to 6 years and training an examiner requires money and significant time investments by experienced examiners.[15] Of those who left the agency during 1990 to 2000, 30 percent had less than one year of service, 17 percent less than two years and 9 percent less than three years, accounting for more than half of patent examiner attrition (NAPA 2005, Appendix F). As a result, the staff have a very different profile of service length than the EPO – as is discussed in Section 3.6.

3.4.5 Reform initiatives: The 21st Century Strategic Plan

Congress reacted to these developments with the Patent and Trademark Office Authorization Act of 2002, which required the USPTO to develop a 5-year strategic plan for lowering staff turnover, improving patent quality, and reducing pendency. Reforms and initiatives under the so-called *21st Century Strategic Plan* were to be funded by an increase in user fees[16] and fall into three cross-cutting strategic themes: agility, capability, and productivity (USPTO 2003). The agility theme comprises initiatives to implement electronic end-to-end processing of patents and to outsource non-core activities. The capability theme aims at enhancing patent quality through workforce and process improvements. The productivity theme includes efforts to reduce pendency of patent applications.

To address the challenges from increasing workload and reduce the backlog the USPTO has drastically increased hiring, taking in roughly 1,000 new examiners in both 2005 and 2006 (USPTO 2005). The agility and productivity initiatives aim at freeing examiner capacity by outsourcing tasks such as patent classification and search functions. In particular, relying on search results from other Patent Offices is supposed to reduce duplication of effort (USPTO 2003, p.7). In 2005 search activities associated with Patent Cooperation Treaty applications were competitively sourced as part of a pilot study (USPTO 2005, p.7). The goal is to reduce search responsibilities and thereby increase examiner pro-

[15] NAPA (2005, p.81) reports expenditures in 2000 of almost $22 million to train junior examiners, broken down into time costs of $8.7 million for supervisory patent examiners, $3,5 for primary examiners, and $9.6 for junior examiner training classes.

[16] It should be noted that the USPTO does not retain user fees but relies on the usual appropriations process when the federal budget is set. For example, from 1992 to 2004 the agency had $741 million less funding than the fees it collected, representing around 7 percent of the total USPTO budget during this period (NAPA 2005, p.40).

ductivity. To make the processing of applications more efficient, the USPTO moves towards end-to-end electronic treatment of applications. Variable fees are used to induce applicants to file applications in electronic form. With effect from 2005, fees were separated into components for the different stages of processing the patent applications: filing the application, searching the literature, and examining the claims. This is meant to induce applicants to withdraw applications not deemed to have a high probability of being granted and brings the fee structure closer to that at the EPO. More use of fee differentiation to provide incentives for applicants to limit the number of claims or supply themselves search reports are discussed (GAO 2005, p.13 and USPTO 2003, p.19).

Capability initiatives address the issue of hiring and retaining qualified examiners. While patent examiners benefit from a special pay rate that is about 10 percent above that of comparable federal employees, entry level salaries still are significantly lower than private sector pay for individuals with a high degree of scientific, technical, and legal knowledge. However, the USPTO offers high job security and relatively stable career paths within the organization. Positions up to the senior executive level are usually filled from within the USPTO, offering the opportunity for examiners to reach within 5 to 7 years primary examiner positions with earnings of around $ 100,000. In interviews, U.S. patent examiners cite as most important aspects for their decision to remain at the USPTO competitive salary and flexible working hours (GAO 2005, p.20). The cyclical pattern in the ability of the USPTO to recruit and retain staff reflects this. When the economy picks up there are more quits and fewer qualified candidates available than when conditions are not so good. A dramatic example was the exit of roughly 46 percent of examiners with background in electrical engineering, computer engineering, and computer science during the 1999/2000 dot.com boom, exacerbated by the increased demand for patents in this sector (NAPA 2005, p.81). In response, the USPTO has formed a permanent recruiting team composed of senior and line managers and offers recruitment bonuses ranging from $600 to $10,000.

To address the high attrition rates among junior staff in particular and improve the skills of its workforce, the USPTO has developed several initiatives under the capability theme. Recently, retention incentives were agreed that require the recipient of the one-off bonus to commit to a certain length of service or repay the amount (POPA 2006). Recruitment criteria for new patent examiners now also include tests of English language proficiency (GAO 2005, p.40).

To address concerns about the quality of granted patents examiners now need to pass a test for promotion to primary examiner with the authority to issue patents (GS-13 level). Primary examiners are subject to a recertification examination every three years. The initial recertification phase will be completed in 2006 (GAO 2005, p.41). In addition, at least four work products are reviewed as part of an examiner's annual quality review. More details of examiners' decisions must now be provided for the reviewable record. Evaluations of search quality were planned to be implemented as pilot projects in 2006 (GAO 2005, p.43). Moreover, more samples of works in process are reviewed by the *Office of Patent Quality Assurance*. In 2005 the patent allowance error rate computed from quality reviews was 4.6 percent (USPTO 2005, p.21).[17] For areas with high error rates a more intensive "second pair of eyes" review is put in place, which checks for proper claim interpretation and ensures that the closest prior art has been discovered and correctly applied.[18] A pilot program for pre-appeal brief conferences was started in 2005 – a procedure similar to oral hearings at the EPO (USPTO 2005, p.5).

3.4.6 Experiences with reform initiatives

Comprehensive reviews progress with implementing proposals under the USPTO's strategic plan where carried out by in 2005 by the *United States Government Accountability Office* (GAO) and a panel of the *National Academy of Public Administration* (NAPA). The GAO (2005) report concludes that the USPTO "continues to face three long-standing human capital challenges that could also undermine its recent efforts if not addressed" (p.5). These are:

- First, a lack of effective mechanisms for managers to communicate and collaborate with examiners.
- Second, a system of production quotas that is not accepted by examiners.
- Third, lacking resources for ongoing technical training of examiners.

The GAO found that management decisions in the USPTO rely heavily on communication between managers and input involvement of examiners in decision making is not sought. In addition, the lack of

[17] In the fiscal year 2004 Review and training quality assurance specialists performed 11,300 reviews (NAPA 2005, p.68), which contrasts with 378,984 applications filed (USPTO 2005, p.118).

[18] However, there is evidence that patent applicants try to game the system by filing around such areas of heightened scrutiny (Jaffe and Lerner 2004, p.213).

communication between examiners and management has led to "an atmosphere of distrust of USPTO management" and negatively affected staff morale (GAO 2005, p.5). This has been compounded by frictions of the agency with the examiners' trade union, *Patent Office Professional Association* (POPA).[19] The Academy Panel also recommends that the USPTO develop strategies towards achieving a more positive and collaborative organizational culture (NAPA 2005, p.144).

The compensation of examiners depends largely on the number of patent applications processed. Production quotas have not been altered since 1976. According to interviews conducted by the GAO, staff perceive the time allocation and quantitative targets under the current production quotas as insufficient for delivering the increased level of quality that the agency expects. Similar views were documented for a quarter of respondents to employee surveys from 1998 to 2001 (GAO 2005, p.30). However, according to staff interviews there were no negative consequences for examiners who produced low quality work. Data from 1999 until 2004 show an increase in formal performance-based actions initiated against examiners. The most common cause for such actions is failure to meet production criteria (NAPA 2005, p.111).[20]

An earlier report by the *Office of Inspector General* at the *U.S. Department of Commerce Office* (OIG) (2004) examined the performance appraisal and award system of the USPTO. Its conclusion is that production quotas do not accurately reflect actual time requirements because 7 out of 8 patent technology centers processed applications in less time than allocated according to fiscal year 1999-2003 production statistics (p.12). However, no records of actual working hours are kept and the examiners' trade union POPA as well as the interviews conducted by GAO (2005) suggest that many examiners voluntarily work overtime to meet targets. Moreover, exit surveys suggest that work-load pressures are one factor contributing to staff attrition (see below).

Gain sharing appears to offer little incentive for exceeding the target by more than 10 percent: Average productivity is around 110 percent of the expectancy goal (OIG 2004, p.12). In 2003 roughly 40 percent performed with 100-109 percent of their target, 51 percent became eligible for gain sharing by reaching 110-119 percent, 8 percent reached 120-129 percent, and no one exceeded 130 percent of the

[19] While POPA is the most important union regarding the patent process, other unions also represent staff at the USPTO. For more on labor relations at the USPTO (see NAPA 2005, chapters 5 and 6).

[20] See also Note 13.

target (OIG 2004, p.26). Furthermore, the report notes that examiner production varies greatly from one quarter to the next, in particular in the fourth quarter because of attempts to meet award criteria for gain sharing. Such year-end work loading reflects the problems with rewards based on performance measures that accrue over time discussed in Section 3.3.3. The OIG recommends a closer alignment with the performance targets for the agency as a whole. In particular, the pendency reward is based on many criteria not directly related to the pendency measure for USPTO (p.24ff). Such problems of tying incentives for a unit or individual performance to the goals of the organization are common in federal agencies (NAPA 2005, p.100).

Building on the OIG report, the NAPA panel identified as a weakness of the current performance appraisal and award system of the USPTO that it does not reward quality as strongly as production. It reports an example given by USPTO directors to illustrate that "as a result of a formula that is productivity-driven, certain unwanted behaviors may actually be encouraged" (p.104). Improving quality from a fully successful rating to a commendable rating in all elements can increase the bonus from 1 percent of annual salary to 2 percent if at least 110 percent of the production goal is reached. In contrast, an examiner who 100 percent satisfies the expectancy goal and has outstanding quality would not be eligible for any lump sum bonus.

In addition, quotas do not reflect other responsibilities such as documenting explanations for decisions reached and responding to calls from applicants and the public (GAO 2005, p.29). Moreover, there is no provision for group incentives in the USPTO reward system to promote efforts that do not directly affect the own productivity measure, for example that high achievers support others in improving their work. The NAPA panel (2005, p.106) cites examples of other organizations that have complemented gain sharing with group rewards to successfully "foster collaboration, mentoring, group cohesiveness, knowledge sharing, and commitment to common goals, particularly to counteract a work environment that encourages solitary enterprise and is populated by 'production loners.'" It recommends implementing policies for rewarding units that reduce group pendency or meet some other pre-defined broader organizational goals.

According to the NAPA panel, the USPTO's culture of strong focus on measurable production contrasts with that in most other federal agencies with a highly educated workforce (NAPA 2005,

p.142). A study by the private consulting firm Booz-Allen & Hamilton (1995), cited in the GAO and NAPA reports, concludes that the USPTO is "production driven" and that the narrow focus on production targets puts examiners under considerable stress. Dissatisfaction with the nature of the job and production system as well as the workload at the USPTO were given as reasons for leaving the agency by about half of the respondents to exit surveys in 2002 and 2004, which had a response rate of less than 25 percent (GAO 2005, p.30).

The NAFTA panel (p.106) concludes that it "is essential that a rewards program reinforces goals the agency wants to attain–such as shared information among examiners, retention of high-quality workers, innovation in the patent prosecution process, and reduced pendency." For addressing the recruitment and retention problems it advises raising the pay of patent examiners to the level of staff at the US bank regulation agencies, to allow the USPTO compete with other public and private organizations that require the same skills on a more equal footing. However, the panel cautions that such a pay increase alone will not solve the management and personnel issues facing the agency (p.136). The panel's recommendations for updating the production and quality standards and awards are partially reflected in the USPTO management's proposals from March 2006 for a new contract to be negotiated with POPA.[21] For example, these introduce a finer gradation of productivity targets for gain sharing and introduce a quality reward of up to 5 percent of salary for examiners at or above the GS-12 level (Article 18).

Another critical issue identified in the different reports is the lack of mandatory ongoing technical training for examiners. There only is a requirement to follow legal training (GAO 2005, p.30). The prevailing view among agency officials is that examiners learn on the job and stay abreast of new technological developments contained in patent applications. In interviews patent examiners and supervisory patent examiners explain that the literature they review in applications does not reflect the most recent developments in a technical field, particularly in rapidly evolving disciplines. The agency offers some voluntary in-house training and funds for scientific conferences on voluntary basis. However, there appears to be reluctance to use these because these activities are not counted towards production targets (p.31).

[21] Available at `http://www.popa.org/pdf/misc/mgmt-01mar2006-proposals.pdf`.

Overall, there is still much need for adequately designed reforms at the USPTO, which is captured by the statement of the OIG (2006) in their March 2006 semiannual report to Congress (p.7): "we believe the problems USPTO suffers are serious and require sustained commitment of senior managers to resolve."

3.4.7 Summary

The USPTO faces three challenges: increasing volume and complexity of patent applications; concerns about the quality of patents granted; high level of attrition, particularly among examiners with less than 5 years experience. It is interesting to confront these challenges with what is at hand at EPO where the current discussion focuses on how to tackle the backlog, while there seem to be fewer concerns about the quality granted and low attrition rates, but fears that this may change when certain reforms where implemented.

Since the USPTO is often a stepping stone for a career in the private sector, promotion possibilities are not the sole motivator and implicit incentives are complemented by explicit incentives tied to production quotas. Problems with adequately measuring and rewarding all important aspects of examiners' work appear to tilt overall incentives towards granting patents quickly rather than maintaining high quality. As a consequence, the agency relies on a monitoring system where around four percent of files are quality reviewed. Evaluations of recent reforms highlight the difficulties inherent in explicit incentive schemes in the complex work environment of the patent office. In particular, there is a need for providing appropriate mechanisms for improving patent quality. The problems of staff attrition appear to persist.

3.5 The Human Resource System in the EPO and the challenges that it faces

The *European Patent Office* (EPO) is a multi-national public institution that serves as the executive branch of the *European Patent Organization*, granting European patents for the contracting states to the *European Patent Convention* (EPC). The office is a unique organization in several ways. First, it

is supervised by a multilateral body, the Administrative Council of the European Patent Organization, composed of delegates from the member states of the EPC. Second, its personnel (6,118 in 2005)[22] is located in four different offices situated in three different countries: Munich (3,301), The Hague (2,423), Berlin (277), and Vienna (117). Third, the EPO employs a large number of highly skilled people, a large part of whom are expatriates from over 35 countries. Most importantly, it is its mission that makes the EPO so special: to support innovation, competitiveness and economic growth for the benefit of the citizens of Europe. Through the work of EPO staff an invention becomes a patent, receiving protection from the legal system and allowing the inventor to reap the fruits of his or her idea.

There are three staff categories in the EPO. Employees in category A represent the bulk of staff: 4,216 in 2005, corresponding to 69% of the total workforce (European Patent Office 2006, p.57). They are mainly examiners (3,658). The B category (1,751, 29%) comprises administrative and "formality" staff. Further, there are technical support staff in category C (151, 2%). Roughly half of the EPO's staff are members of the *Staff Union of the European Patent Office* (SUEPO).[23]

We will mainly focus on examiners because their work, career paths, and appraisal system are most specific to the goals and constraints of the EPO and the European patent system in broader terms (see the discussion in Chapter 1). To some extent the issues that we highlight apply to other staff as well. Further, we focus on the work in joint clusters – the units carrying out search and examination – rather than on functional units.

3.5.1 The patent examination process

Patents are granted for innovations which meet the relevant requirements of the *European Patent Convention* (EPC) and satisfy the three criteria for patentability:

1. *novelty*, i.e., the innovation is not already part of the state of the art;
2. *inventive step*, i.e., the innovation is not obvious to a skilled person with knowledge of the state of the art;
3. *industrial applicability*.

[22] European Patent Office (2006, p.55).
[23] `http://www.suepo.org`, accessed September 2006.

In addition the application has to describe the invention in sufficient detail to satisfy the disclosure requirement.

The patent examination procedure begins with the filing of an application by the patent seeker. Formality staff processes and checks the submitted documents for completeness. The file is then classified and allocated to an examiner who carries out two main steps: the search procedure and the examination procedure, each giving rise to separate fees for the applicant. These steps used to be carried out by different specialized units, but in the new so-called BEST system, they are in the hands of the same examiner. We will argue below that this has an important impact on the efficacy of explicit incentive schemes.

The search procedure involves first studying the claims in the application, which define the object of the invention and the breadth of the patent sought. Then the application is classified according to the related technical fields and a search report is generated and published. The report lists references to prior patents and to documents in the non-patent literature, such as scientific or technical articles, that describe the state of the art regarded as relevant to the application. The documents are classified according to their relevance for the claims in the application and thus provide the applicant with a signal about the potential outcome of the further examination procedure. Simple descriptions of the state of the art do not threaten the patentability (novelty and inventive step) of the invention (so-called "A-references"). However, some documents can be potentially harmful to the claims even when taken alone ("X-references") or in combination with other references ("Y-references").

After the search report has been issued, the applicant has 6 months to decide whether to pursue the application and incur the examination fee. In 2005 the EPO carried out 163,100 searches and 18,500 applications were withdrawn after the search phase, corresponding to 19% of the cases completed that year (European Patent Office 2006, p.18 and 22).

The substantive examination procedure is carried out within an examining division appointed by the director responsible for the technical field. It consists of the first examiner, who carried out the initial search, as well as a second examiner and a chairman. Based on the search report, the first examiner checks whether the claims in the application meet the patentability requirements and writes a report on the patentability of the innovation, which is sent to the other two members of the division

for approval. In case of objections the first examiner communicates with the applicant, who can then furnish further explanations or amend claims before a decision on the application is made. At any stage the applicant may withdraw the application or simply abandon it by not responding in time. Otherwise, the procedure ends either with the grant of the patent (possibly with amended claims), or with a refusal accompanied by a written reasoning open to appeal.

Applicants always have a right to comment in writing on the progress of their application, but in case of refusal the applicant has the right to be heard in person, and can ask for oral proceedings before the examining division (Art 116, EPC). In 2005, the EPO granted 53,300 patents, corresponding to 53% of cases completed that year; 28.2% were withdrawn at the examination stage or ended with a refusal (European Patent Office 2006, p.22).

On average it takes 45 months to obtain a European patent, which is then valid for 20 years from the date on which the application was filed (European Patent Office 2006, p.22).

The EPO's opposition procedure gives any third party that believes that a patent does not meet the requirements of the EPC the right to file opposition against it within nine months of the date of grant (Art 99 EPC). It allows the introduction of evidence that has not been considered by the examining division (e.g., proprietary manuals that challenge novelty). The Opposition Division is composed of three members of whom at least two were not part of the Examining Division. It arbitrates between the patent proprietor and the opponent and takes a final decision. 2,331 decisions in opposition cases were reached in 2005. Of these cases, 30% ended with a rejection of the challenge, 32% with the patent being upheld in amended form, and 38% with the patent being revoked (European Patent Office 2006, p.19).

Decision of the receiving section of the EPO (e.g., regarding fees), an examining division, or an opposition division can be appealed against in front of the a Board of Appeal by any party adversely affected. In 2005, the EPO's boards settled 1,499 appeals (European Patent Office 2006, p.27).

3.5.2 Careers in the EPO

The EPO hires on the international labor market, requiring a university degree for A-staff (which in many fields must be an engineering degree) and command of the three official languages English,

French, and German. As a consequence, qualification of EPO officers is very high. Our survey indicates that 34% of staff have research experience in industry and 35% in scientific research (for more details see Section 3.6). Hiring can occur at different levels of the hierarchy. Following a one-year probation period, the typical employee will remain within the EPO throughout his or her entire career.

The A-category hierarchy consists of four subsets. First, there are the professionals, mainly examiners, in grades A1 to A4. Second, middle management in grade A5 consists of Directors, who each head a team of typically 20 to 30 people. Middle management positions are mainly staffed from within the EPO, so Directors typically have extensive experience as examiners. Third, there are senior management positions as Principal Directors, who each manage a joint cluster. Less than 5 percent of examiners reach middle or senior management positions. The creation of a "fast-track" promotion system has had an increasing role in internal recruitment in recent years. Finally, there are upper and top management positions of Vice Presidents and President, filled both internally and through external recruitment. Similar grade structures are in place for the B and C categories.

Transitions in the hierarchy follow a system of managed career progression. Promotions can occur at certain time windows which depend on performance evaluations that are carried out bi-annually as part of a full reporting exercise for all staff (for the procedure, see Section 3.5.3). The better these evaluations are, the shorter is the time period an individual must have spent in one rank before being considered for a higher ranked position. Promotion decisions are taken by Promotion Boards, which are composed of two staff representatives and two middle managers, as well as a chairman nominated by the central management.

Focusing on professional careers as an examiner, the most important promotion is that to the A4 grade. With average performance evaluations of "good" (= grade 3), examiners can expect to reach this rank within 19-25 years at the EPO. Faster career progression is possible: "very good" evaluations (= grade 2) lead to promotion within 15-18 years and "excellent" evaluations (= grade 1) shorten the time needed to 11-14 years.

To move into management positions (grade A5 and higher), application to an open position is required. Evaluation procedures are similar to those for promotions within the professional career.

Roughly 80% of examiners do not reach such management positions. That is, careers are mostly

professional ones and promotions essentially occur within the same broad job category. Entrants are informed that careers at the EPO are "flat" and the willingness of applicants to accept this is part of the recruitment evaluation. Given these recruitment criteria that help select textquotedblleft patient" employees, it can be assumed that promotions even within the same broad job category do provide some motivation, as do the concerns for appreciation by colleagues and superiors.

Furthermore, it is important to note that the move into management positions is not the only one that changes the job category of an employee. An important promotion channel within the EPO is to become a member of the Boards of Appeal. This move goes along with a higher status and with substantial job enrichment – arguably quite an important element for examiners. The survey (see Section 3.6) shows that a large proportion of examiners report being involved in continuous learning and training activity – they seek actively to learn and to enrich their job. Being a member of a Board of Appeal also involves in increase in the importance of an examiner's job. The Boards are presently *de facto* setting the standards for patentability requirements. Hence there is a strong link between promotion criteria and future patentability standards. This further reinforces the necessity of a balanced set of criteria (for instance, quality vs quantity) when evaluating the work of examiners, as one cannot take for granted that higher quantity is necessary linked to setting better standards for patentability.

3.5.3 Reporting system and performance evaluations

During the reporting exercise (usually bi-annually), Directors evaluate performance of staff along four dimensions: productivity, quality, attitude, and aptitude. Each dimension is assigned a grade (1-excellent, 2-very good, 3-good, etc) which is supplemented by comments of the reporting officer.

A quantitative performance measure is the basis for the productivity dimension. Examiners accumulate points for search and examination actions taken. Another factor are the time budgets allocated for search, opposition, classification and other duties (see Section 3.5.4).

3.5.4 Time budgeting and productivity measures

In general the total time available for the so-called "core activities" search, examination, opposition and first-time classification of documents (if applicable) is calculated by taking the total available time of the examiner (working days in the year minus leave – holiday, sick leave, etc) and deducting any time spent on so-called "non-core activities" which are all allocated time budgets under Boxes II (e.g., training), III (e.g., working as trainer) or IV (e.g., staff representation work).

For the core activities performed by an examiner (with exception of classification work) points are allocated. These points enter the performance score. Most patent applications are now handled within the so-called BEST system, an integrated search and examination procedure implemented by the 2000 Diplomatic Conference on the revision of the EPC.[24] As a consequence, a file is treated by the same first examiner during the search and substantive examination phases. Such a *completed action* adds one point to the performance score of the examiner. For a given file, 2/3 of the point are given for the *first action* (search and initial communication with the applicant). The remaining 1/3 of the point accrue for the final action, without distinguishing between grant or refusal.

While the bulk of the time is used for second or further communications with the applicant, no points are given for intermediate actions such as various rounds of communication with the applicant. For classification work the number of files classified is simply totalled.

The other members of the examining division are not allocated a time budget under Box II, III or IV; nor do they receive any points. The fact that there are no points for the chairman and the second examiner in examination work does not encourage the members of the division to spend much time for interaction, cooperation, and coordination among each other. In particular, refusals and oral proceedings involve heavy work from all members of the division, and the absence of any rewards for the chair and second member adds a further bias towards granting a patent. This effect is possibly even stronger than the effect of giving the first member of the division the same number of points for a grant or a refusal.

No time budgets under Box II, III or IV are allocated for opposition work. In oppositions points

[24] By 2004 around 90% of examiners had completed the necessary training for carrying out this integrated examination procedure (European Patent Office 2005, p.11).

are awarded to the 1st member for a first action (communication with the parties) in opposition. When an opposition is terminated via decision of the opposition division, all members (fist member, second member and chairman) receive (different numbers of) points.

3.5.5 The challenges ahead

The HRS of the EPO builds on implicit incentives that seem to be reasonably functional. It provides a set of balanced incentives to trade off quantity and quality and induce some cooperative behavior among staff. However, the backlog of unprocessed patent applications and concerns about the financial outlook have induced management and some of the member states to believe that the EPO should increase the speed with which patent applications are processed. Some believe that higher speed would be able to reduce the backlog and improve the financial situation of the EPO.

A number of reform proposals have been discussed. We are currently not in a position to identify the likely outcome of these discussions. Also we have limited information about the precise way these reforms may be implemented. Given the experience of other public institutions in similar backlog situations, the temptation is strong to introduce explicit monetary incentives tied to the quantity of patent applications processed. Furthermore, the perceived need to increase throughput of patent applications could lead to putting more weight on the quantity of patent examination actions taken when examiners are evaluated.

However, it seems clear that the proposals entail tying explicit monetary incentives to the quantity of patent applications processed by each examiner. Furthermore, it has been argued that the evaluation of examiners – an important determinant of promotions – should put more weight on the quantity of patent examination actions taken.

In the language of incentive theory, there is likely therefore to be both an increased weight on quantity and speed in the system of implicit incentives, and a potential move towards making incentives more explicit, by linking the salaries of EPO staff to the quantity of patents processed in a given period of time.

3.5.6 Summary

Our description of the workplace and in particular the results of the survey make quite clear that work at EPO follows a complex process in which specific knowledge and initiative of the examiners, collaboration between examiners and other staff inside EPO, and quality of applications prepared by applicants are of crucial importance. The existing implicit incentives, in particular the way evaluation schemes are designed, seem to take into account the need for careful balancing of many dimensions of the work. This is further accompanied by time budgeting. While the reform proposals have not been decided upon, they seem to envisage two things: changing the implicit incentives to increase speed and quantity, and introduce explicit pay with the same goals.

3.6 Results of the survey

The preceding sections had two goals: to describe the most relevant concepts from incentive theory and to give a brief review of comparative experiences from other organizations. In this section we summarize the results of an electronic survey that we have carried out using the Opinio software. The survey questions related to the following topics: personal characteristics, compensation and evaluation, staff's perception of the workplace, interactions between staff, and time allocation across different work tasks (see Appendix A.1).

The survey has a crucial role for this study. It provides the link between the general lessons from incentive theory and the comparative perspective on organizations on one side, and the evaluation of potential benefits and risks associated with the suggested changes in incentives of the other. The purpose of the survey is to provide information about the specificities of the work at EPO. It is the documentation of these specificities that then allows us to identify the relevant results from the theoretical literature and to discard irrelevant arguments.

The questionnaire was distributed electronically in April 2006 to all staff in the EPO with a choice of three versions, German, English and French. The English questionnaire can be found in Appendix A.1. The response rate of 60 percent is remarkably high, with 4,269 responses out of 7073 invitees. We take this as an indicator of the perceived importance of the issue of redesigning the human resource

system at the EPO, and the high commitment of the EPO staff to contributing to the debate around this issue.

3.6.1 Caveats

It is important to bear in mind that there are potential pitfalls in a survey of this type. First, people may fear that their answers could be used against them. In order to avoid this, the survey assures the anonymity that is necessary for honest answers. Questions were designed so that no individual staff member can be matched with the information given by a respondent; for example people were not asked to identify which precise unit they work for, but only which Directorate General (DG) or joint cluster they belong to.

Second, people may have different perceptions and tastes regarding fundamental concepts such as "quality of work" and "cooperation". Moreover, there may also be potential response biases – owing for instance to union membership. For example, even if many of the staff agree that more weight should be placed on quality of work, this does not necessarily mean that from the point of view of society the EPO should favor quality over quantity. In fact, it is not very surprising that when asked directly, staff have the perception of caring more about quality than management, as many things may be hidden behind the stated preference for quality. Therefore, it is crucial to place responses regarding issues such as the consideration for quality into the context of other responses about work processes to gain a better understanding of the nature of work at the EPO as well as the agency relationships within the organization. Indeed, we found out that the quality of work of an individual member of the staff is of importance also because it may be an important input into the work of many others within the EPO. We will make this interpretation clearer below.

The Appendix provides summary statistics of the responses (Appendix A.2). Rather than discussing these one by one, we attempt to provide a general picture of the work processes and functioning of the Human Resource System (HRS) in the EPO. This general picture provides the backdrop for our qualitative evaluation in the last section of this chapter of the risks involved in changing the HRS in the EPO.

service length	EPO[a]	USPTO[b]
0-5 years	38.6%	55.4%
6-10 years	29%	23.1%
11-15 years	7.4%	11.3%
16-20 years	17.4%	5.2%
more than 20 years	7.6%	5.0%

Sources: [a] Survey from April 2006, [b] NAPA (2005, p.80).

Table 3.1: Service length distributions for examiners at the USPTO and EPO

3.6.2 Personal characteristics

The staff at EPO who responded to our survey are 71% male. 42% of respondents are in the age group between 30 and 39 years old, 32% between 40 and 49; we did not ask for the precise age or nationality to assure anonymity. Staff are highly educated – 25% have education on BA level, 46% hold a Master's degree, and 27% a Ph.D.. Qualification levels are even higher for examiners, the respective figures are 28% for BA level, 59% for Master's level, and 39% for a Ph.D.. Staff also bring to the organization substantial work experience: 63% have more than four years of work experience outside the EPO. Many of the staff have a research background, 35% overall and 49% when looking at examiners only; 34% of staff worked in R&D departments in industry. Finally, more than 60% moved across country borders to start their job at the EPO.

It is useful to compare this with facts from the USPTO. Here, the staff are in general younger, and people tend to stay with the organization only for a few years; staff are less educated, and naturally, less international. In fact, while the USPTO is in many cases a stepping stone for careers in the private sector (e.g., as a patent attorney), the majority of EPO examiner staff stay in the office for a long period of time as can be seen from Table 3.1. In particular, more than half of the USPTO examiners have been at the agency for less than five years, while the same is true for only 39% of EPO examiners. Around a quarter of the EPO examiners are very experienced personnel with more than 15 years of service, around two and a half times higher than the corresponding share at the USPTO.

3.6.3 Compensation and evaluation and perception of the workplace

One of the reasons why there may be so little turnover at the EPO is compensation, which is perceived as more than competitive given the workplace characteristics:

- 30% say that the compensation package is competitive,
- 34% say it is somewhat better than elsewhere,
- and 30% say that the package is much better than elsewhere.

While there is thus high satisfaction with the material side of the job, there seems to be disagreement between staff and management about the criteria according to which people should be promoted. In the perception of EPO staff:

- quantity of work is currently the most important aspect when they are evaluated,
- a good relationship with supervisors comes second,
- and quality of work third.

In the opinion of staff, however,

- quality should be the most important aspect,
- technical expertise should come second,
- and quantity of work third.

Further, 82% say that in general there is too much emphasis on quantity of work. Surprisingly, two thirds of the respondents believe that they agree with their direct supervisor on the goals of their work. Interestingly, staff would want more meritocracy: while for actual reporting and promotion decisions the time spent in the current position is perceived as the

fourth most important aspect (almost equal to quality), staff believe this should come after quality, technical expertise, quantity, legal expertise, help and input to colleagues, coaching and training, good relationships with colleagues, and be given the same importance as chairing oppositions.

Thus there appears to be a wedge between the beliefs of directors and examiners about the right balance between quality and quantity of work in the EPO and the balance put in place by the reporting and evaluation system. There is more to this wedge:

- 38% of staff believe that senior management cannot understand at all the quality of work they undertake,
- however, only 3% believe the same about their direct supervisor,
- and only 1% about their direct colleagues;
- 31% believe that "the public" cannot understand at all the quality of work,
- but only 8% believe the same about patent applicants and their representatives.

The top layer of the hierarchy indeed seems to be perceived as largely disconnected from examiners, directors and other staff.

As mentioned in the beginning of the section, these responses on their own should not be interpreted as a reason for society to put more emphasis on quality than on quantity of work by the EPO. There are many reasons why staff may want more emphasis on quality, one of which could simply be that this may give them more freedom to do things the way they see fit. Also, there are also some reasons why directors may tend to agree with staff – they usually had been examiners themselves and may therefore sympathize with their subordinates. However, what is crucial is that the quality of one person's work affects the quantitative workload of that

individual's colleagues. This will become clear below and is a fact with crucial repercussions on the usefulness of incentives.

3.6.4 Interactions between staff

Staff appear to spend around a quarter of their work time on tasks where they interact with others, directly or indirectly via a computer network. To get a better idea of the nature of interactions between staff and their immediate supervisors we asked how often staff members discuss their work with the immediate supervisor. We here distinguished between a) formal and procedural issues, b) details of the work - that is, technical and legal issues.

We were surprised to see that the frequency of interaction is in general rather low. Concerning interaction with supervisors on *substantive legal and technical issues* we found:

- 32% interact every 6 months or less on procedural issues,
- 41% up to once per month,
- 27% up to several times a day.

Concerning interaction with the supervisor on *technical or legal issues* the figures are:

- 37% interact every 6 months or less,
- 36% up to once per month,
- 24% up to several times a day.

Beyond the fact that average interaction is infrequent and is more frequent on technical and legal and less on substantive issues, we find it striking that there is a lot of variance. Some staff members have frequent interaction with their supervisor while others have very little contact.

Simple linear regression show that the frequency of consultation on substantive issues between supervisor and subordinate depends on the agreement on the goals of work and on perceptions about competence of a supervisor:

- the more subordinates and supervisor agree on the goals of work, the more they interact,
- the more a subordinate perceives a supervisor to be competent, the more they interact.

We will refine these results, but already at this stage, they make clear one thing: there is an important agency problem at the workplace. A supervisor who is not perceived competent or represents goals that are not shared by staff will find it much harder or impossible to monitor the work of staff. However, monitoring is needed to administer incentives when output measures are multi-dimensional or very hard to measure. Otherwise, output measures may not only be useless, but destructive, as they are subject to gaming.

Another striking finding concerns the impact of *quality on the quantity* of work that can be mastered. We have already talked about the importance of the quality of work in the perception of EPO staff. Many believe that quality is undervalued. One might say that this is natural as in many situations staff care more about quality than management. However, in the case of EPO there is an effect that goes beyond this almost classical conflict between principals and agents. We find that quality of one person's work is a crucial input to the quantity of work another person can deliver.

We asked people how much of their own working time can be saved by high quality of other people's work. An overview of results is reported in Table 3.1 (for details see Table 20).

The results show that examiners believe that the work of EPO has high degrees of interconnectedness. First, what one staff member does, affects the time and hence the costs associated with the work of other people in the department and to a lesser extent elsewhere

High quality of work by individuals	saves a lot of my time	saves some of my time
within my department	33%	34%
outside of my department but within EPO	24%	32%
outside of EPO: applicants and their agents	64%	12%
outside of EPO: national patent offices	20%	24%

Source: Survey from April 2006

Table 3.2: Impact of other people's work quality on own work

at EPO. Interestingly, the quality of applicants' and their agents' work is most important[25], while the work of national patent offices is less important. This result shows that the concerns for quality of staff are not simply a matter of preferences that may differ from those of management. Rather, there are concerns for quality because the quality of work of applicants and colleagues makes it possible for a given staff member to master a larger workload. This will play a major role for our analysis of the risks involved in introducing incentives that put more stress on quantity.

3.6.5 Time allocation across different work tasks

A final set of results refers to the question of time needed for different steps in the production process. We confronted the staff with the following hypothetical situation: Suppose you need 100 time units for "search plus written opinion". We then asked the following. (i) How much time do you *actually need* for the remainder of the procedure? The average response was 94 time units if the patent is granted and 167 time units if the patent is refused. (ii) How much time do you think you *should spend* for the remainder of procedure? The average response was 89 time units if the patent is granted and 154 time units if the patent is refused.

3.6.6 Summary

The survey establishes clearly a number of things.

[25] In particular this is the case for examiners, 85% of whom report a big impact of this on their work time – see Table 20.

1. Staff are satisfied with compensation, but there is disagreement about the role of quality of work in evaluations.

2. Examiners believe that more time should be allocated to examination than it currently the case.

3. There seems to be little connection between top management and the rest of the hierarchy, and levels of trust in management's competence are low.

4. Mutual help between agents within and across the departments is important.

5. Frequency of interactions between supervisors and subordinates depend on the agreement about the goals of work and perceptions of competence.

6. The quality of work of patent applicants is crucial for an examiner to be able to work fast. Put differently, quality does not matter only because examiners seem to care for it in the abstract. Potentially more importantly, it matters for the costs and the speed of the examination process

3.7 Responding to the challenges

The EPO faces a rapidly growing number of patent applications, a trend witnessed by the USPTO and other patent offices as well. This has created a backlog and there is mounting pressure to move applications faster through the system. The situation is further complicated because of the multilateral nature of the EPO: within the group of member states there are differing views both on the importance of moving faster and on how to achieve this.

We here try to assess the feasibility of the proposal to link the compensation of examiners directly to measures of applications processed by referring to the lessons from the scientific literature, experiences with incentive systems and implications from reforms at the USPTO

as well as the knowledge about the specificities of the EPO that we have gained through the survey.

Our approach is based on the principal-agent framework discussed in Section 3.2 and on the survey that we carried out. The survey points to some striking facts that are specific to the EPO and help to identify the risks that are associated with changes in the Human Resource System.

To make clear the perspective: the principal in our analysis is the management of the EPO. We abstract here from the fact that management itself responds as an agent to various stakeholders in the patent system, and simply presume that they want to further the goals for the patent system outlined in Chapter 2. The agents in our study are the EPO staff. They often have information about a patent application that management does not have. They also know better than management how much effort they actually put into various tasks that their work involves and what their aptitude for particular tasks is. Moreover, examiners gain a better understanding than management of the strengths and weaknesses of each individual patent application as well as the characteristics of the applicant and his or her representatives. As discussed in Section 3.2 these information asymmetries are the very reason why a Human Resource System needs to include some form of explicit or implicit incentives to ensure that staff members' behavior is in line with the goals of the organization.

The EPO management seems aware of the asymmetric information problem between staff and themselves. Indeed, if management had all the information needed it would simply make examiners work the desired way, i.e., use its authority to force staff to work harder, produce more and better patent examination outcomes, *etc.* – all of course subject to the constraint that staff would still be willing to work for the EPO.

In practice however, using authority in this crude command-and-control fashion is not possible – precisely because of the information asymmetries that exist within the organization.

It is therefore fully consistent with incentive theory that the management is thinking about a system of indirect instruments – management by objectives – by which to make staff adopt behavior more in line with management's objectives. A complicated system of incentive pay, management by objectives, time budgeting, evaluation *etc.* is planned to overcome information asymmetries and to induce people to work in the way management wants them to.

In adapting an incentive-theory approach, we recognize the fact that examiners and others in the office may not always do the things in the way that management wants them to. Our goal, at least in this part of the report, is not to evaluate in a normative way who has the more appropriate ideas of how the EPO should be run. Rather, we take a simpler, more realistic approach: given that there are information asymmetries and that there is scope for strategic behavior of the individuals employed by the EPO, we ask "what might be the potential consequences of increasing both the implicit and explicit incentives for quantity?" – these are central aspects of the type of reforms that are currently under discussion.

To this end we first present some general conclusions from the scientific literature that lead to a framework of tests that can be applied to the EPO.

3.7.1 General lessons from the scientific literature

Several general conclusions emerge from the scientific literature on agency theory (Section 3.2) and the empirically founded comparative perspective on incentives in organizations (Section 3.3). The most important lesson is that no Human Resource System can solve perfectly all problems of asymmetric information in organizations. The designer of such a system must always balance the costs of providing incentives for appropriate behavior against the potential gains from changes in outcomes that result. Nevertheless, the use of explicit incentives can be successful in influencing individual's behavior.

Conclusion 1

Explicit monetary incentives can be a powerful tool for overcoming problems arising from information asymmetries between the management of an organization and its members. These incentives can help motivate the members of the organization and thereby induce them to work harder, and to take decisions that are more aligned with the interests of management, owners, or other stakeholders in the organization.

Conclusion 1 says that appropriately designed explicit incentives "work." In the review of comparative experiences we have pointed to successful experiments with explicit incentive schemes. For instance, in the Safelite windshield factory, explicit incentives induced an increase in productivity. Explicit individual incentives tend to work well under certain conditions. First, there must be good and not too complex measures of performance; second, the rules according to which incentives are paid must be transparent and stable. In particular, the staff must trust management that there will not be renegotiation of incentive contracts.

An important insight from both the theory and practical experiences with incentive systems is that the use of incentives that are directly or exclusively tied to quantitative performance measures can backfire under other circumstances.

Conclusion 2

Reward schemes that tie different levels of compensation to individual performance measures (explicit incentives) can lead to behavior that is detrimental to the goals of the organization. This is more likely when work is complex, when it requires balancing diverse criteria, when the results of the work are subject to much uncertainty, when the activities of different individuals are highly interconnected, or when there is lacking credibility of long-term commitment to the incentive system.

It is precisely the fact that explicit incentives "work" – that is, are powerful in influencing behavior – which creates problems. Reward schemes that are not well adapted to the

organizational environment involve the risk of inducing behavior that has a positive impact on *measured* performance but may have a negative impact on *desired performance* outcomes. Therefore, before implementing such explicit incentives it is important to fully understand the information asymmetries and the discretion that members in an organization possess. Most notably, this involves the following aspects:

- Sometimes, *performance can only be measured imprecisely.* For example, rewarding a fund manager for high returns may be bad if this induces excessively risky strategies. Paying teachers for higher test scores of their students may be a bad idea because teachers may then "teach to the test"or even cheat outright.

- Often, the people involved in providing the incentives do not have the same detailed knowledge about the *complexity of the task* as the person who actually carries it out. Exposure to explicit incentives may then unexpectedly shift effort to other dimensions of the work, for instance from the task of helping each other to simply doing one's own narrow task.

- *Explicit incentives come at a cost because they expose people to risk*: in most jobs performance is influenced by factors that are beyond the control of the person carrying out a task so that explicit incentives then expose the person to volatility of income. Explicit incentives can be quite expensive because people dislike such volatility and demand compensation in form of a higher average level of earnings.

It is important to understand that *explicit incentives* are not the only motivators in human resource systems. Even in the absence of explicit pay for performance, organizations may have a system of instruments in place which provide strong motivation.

Conclusion 3

A system of implicit incentives consisting of external labor market career opportunities, an

internal promotion-based hierarchy of positions and social interactions at the workplace (peer pressure) may give staff strong motivation to work.

A substantial literature has documented how firms can design systems of motivation that do not build on explicit incentives such as pay for performance, but rather on implicit incentives in the form of promotion opportunities. Promotions do of course have a monetary element as well, as they are usually accompanied by an increase in pay, but it appears from the literature that there is more to it. Often, workers have a desire to move up in the hierarchy, they want to do a good job or to be appreciated by their peers. These driving forces can be used to design a system of evaluation and promotions which can successfully align the individuals' objectives with the goals of the organization. They can hence be a substitute for explicit incentives, but can also be complemented by explicit pay for performance.

Organizations should not be regarded in isolation from the environments they operate in. In particular, they are embedded in a labor market. The next conclusion relates to the effect of incentive systems on the pool of individuals that apply for jobs.

Conclusion 4

The incentive structure explicitly or implicitly embedded in an organization can have strong effects on the composition of the members of an organization in terms of important factors such as the productivity, the degree of aversion to risk, and preferences over other job characteristics. This is known as the "sorting effect" of incentives.

An example for the sorting effect is that a substantial part of the productivity gains observed in the previously mentioned Safelight study arose because better workers were attracted by the prospect of getting higher pay for higher performance in the company.

Summarizing, incentive systems *require a well-designed balance* of different direct and indirect instruments. Conclusions 1 to 4 suggest that there are a seven "tests" that should be met

by the suggested measures to restructure the Human Resource System in the EPO. Explicit incentives should only be introduced (or reinforced) when all the conditions below are met.

Test 1: *Effective implicit incentives for desired behavior are not already in place.*

Test 2: *The link between an individual's effort and desired outcomes of the production process is not too complex.*

Test 3: *The available performance measures capture all aspects of individuals' actions that are relevant to the goals of the organization.*

Test 4: *Each performance measure is closely aligned to a subgoal of the organization and cannot be increased through actions that are detrimental to the organization's goals.*

Test 5: *There is little variation in the extent to which individual performance measures respond to the efforts of the individual.*

Test 6: *The organization can credibly commit to keep in place the parameters of the explicit incentive scheme (e.g., production quotas).*

Test 7: *The introduction of explicit incentives does not lead to any undesired changes in the decisions of individuals to join or to leave the organization.*

3.7.2 Applying the "tests" to the proposed reforms at EPO

The USPTO and EPO are faced with quite similar challenges concerning the quantity of work and the backlog of applications. Compensation of examiners at the USPTO relies to a significant extent on meeting measured performance targets, which is in contrast to the present situation at the EPO. It appears that a number of specific problems that the USPTO experienced – most notably issues regarding patent quality, recruitment and staff attrition – have been made more acute by the current evaluation and compensation system.

The challenge should hence be to design a Human Resource System at the EPO that not only tackles directly the challenges posed by the increased quantity of work and the backlog,

but also maintains or even improves the balance between quality and quantity of work. This is important in particular because there are subtle interactions between quality and quantity of work as highlighted in Section 3.6.6 summarizing the survey results.

To meet this challenge any change in the Human Resource System that makes use of explicit incentives should meet the tests outlined in the previous section. Here we apply these tests to the current situation at the EPO.

Test 1: Effective *implicit* incentives for desired behavior are *not* in place?

The motivation underlying the suggested changes is to influence patent examiners and other staff working at EPO to process more patent applications, that is, to work faster or harder. Comparative experience shows that a system of implicit incentives, such as internal labor markets with promotion possibilities, career concerns for an external market, and peer pressure can provide powerful incentives.

All of these are present at EPO, but in the view of the management, EPO staff does not exhibit the required level of productivity. In other words, the management believes that it is necessary to address a perceived weakness in the current incentive system by increasing the weight on quantity in performance evaluations and complementing the system of implicit incentives with explicit incentives.

As one would expect in the case of an agency problem, the survey points to a quite different perception by staff. Their view is that the current reporting and promotion system puts *too much* emphasis on quantity relative to quality. Staff also says that the time allocated for most actions is not sufficient in general. This again is consistent with the view that the management wants to go faster than staff; but it also shows that in the current system of implicit incentives there are some built-in forces that do induce effort towards quantity rather than quality.

Overall, from the point of view of management, Test 1 would indeed appear to be satisfied.

There is one important caveat, though: the management itself is an agent of the member states of European Patent Organization. These states, however, do not seem to agree on the relative importance of quantity and quality, a problem that we discuss in Chapter 2.

Test 2: Is the link between the effort of individuals and desired outcomes of the production process clear?

Incentives should induce behavior by members of the organization that is in line with the organization's goals. For this to work, the designer of these incentives needs a high degree of understanding of the specificities of the production process, that is, of how different actions taken by individuals affect measurable outcomes. The more complex the work process is, the more difficult it is to fine tune the behavior of people through the use of payments.

The survey shows that the work at EPO is quite complex along a number of dimensions.

- First, for any individual agent, there are links between the effort spent on search and the ease with which examination can take place. In a nutshell, a better job on search facilitates examination.

- Second, much of the work in the EPO relies on cooperation between people in a given department, across departments and also with people from outside of the EPO.

We will return later to the importance of help given and received among EPO staff, putting the emphasis here on the complex interaction between examiners and applicants.

Both our survey among EPO staff and the experiences at the USPTO show that the ease, speed and precision with which an examiner can do his or her work depends crucially on the quality of applications that the patent office receives. To substantiate this claim: 63% of the examiners at EPO say that high quality of patent applications saves a lot of their working time. This is a value three times higher than the comparative value stated for the inputs from

cooperation with national patent offices.

As pointed out by Jaffe and Lerner (2004), the leading experts on the US patent system, the quality of work by the patent office affects applicants' behavior and thus feeds back into the future workload for the office. They write (Chapter 7, p. 175): "To put it crudely, if the patent office allows bad patents to issue, this encourages people with bad applications to show up." The same point was made by Caillaud and Duchêne (2005) (see Section 2.3.1). Jaffe and Lerner point to two possibilities in the context of the USPTO, depending on what policies are pursued:

- A *vicious circle*, in which the attempt to move faster by lowering quality standards induces people to try to obtain patent protection on the basis of dubious applications who would not have done so under the former quality standards. Therefore, the measure leads to even higher numbers of applications and contributes to backlogs. This, in turn, puts pressure on the office to increase even more the throughput of patent applications and thus exacerbates the problem in a downward spiral of quality and an upward spiral of workload.

- A *virtuous circle*, where stricter examination leads to fewer and better quality applications. While initially more resources are required to implement the tough quality standards, the measure in the long run frees up resources. Therefore, to increase the amount of time that examiners can devote to an application by $x\%$ ultimately requires increasing total patent office capacity by far less than $x\%$ more examiner hours.

The vicious circle sketched out above is one example of how the complexity of the relationship between effort of examiners and other staff and outcomes of the EPO may result in counterproductive effects in the long run. Test 2 hence speaks against the introduction of simple pay-for-quantitative-performance schemes, unless these are accompanied by schemes

appropriately governing the motivation of other important parties, in particular the patent applicants.

Test 3: Do the available performance measures capture all aspects of individuals' actions that are relevant to the goals of the organization?

Explicit incentives – like the ones planned for the EPO – or stronger emphasis on quantity in evaluation and promotions, reward the fulfilment of one task – working fast. The theoretical literature and empirical work has shown that in a situation in which there is only one task, incentives work well. However, if individuals carry out more than one task, and the incentives offered are not balanced, then a shift of effort from the tasks that are not rewarded to the ones that are rewarded will occur.

The impact on the quality dimension will be discussed under the next point. What is particularly important here is that explicit incentives based on individual performance measures could induce behavior where rather then cooperating, people would minimize their own private costs of effort.

To be concrete, consider the following example from the USPTO (NAPA 2005, p.49): "Reclassification is an important function... USPTO staff report that they may spend more time on a search in areas if classifications have not been updated. In the past, senior examiners received temporary reclassification assignments, which provided them the opportunity to learn more about their art area. However, such opportunities are not as prevalent now as in the past." In the documentation of the EPO's work we made clear that classifications are an important element of examiners' work.

There are many other such tasks that are very important for the overall efficiency of EPO and which would not be rewarded under individual incentive schemes. Examples include training of new staff, hiring of new staff and simply the day to day help colleagues provide

to each other if they have some flexibility in allocating their time. This flexibility would be greatly reduced in a system putting excessive stress on quantity. The problem cannot easily be solved by tying explicit compensation to measures of these tasks because they are much more difficult to gauge – leading to problems with Tests 2 and 4.

In such situations, subjective evaluation in conjunction with other implicit incentives such as promotion are usually preferable to explicit incentives. In contrast to the USPTO, employees are currently attached to the EPO for a long time, which is extremely important for long-term implicit incentives (for example through promotions) to be effective. It is interesting to note that the current implicit incentive system at the EPO provides a basis for considering the multi-dimensionality of efforts and the need for cooperation by placing quantity next to the quality and attitude variables in reporting.

We conclude that unless accompanied by group incentive schemes and efforts to monitor the quality of work, explicit incentive schemes may involve a shift of effort from tasks involving quality and cooperation to mere speed. This would mean that only part of the objectives of the organization would be achieved.

Test 4: Is each performance measure aligned with a subgoal of the organization? Can it be increased through actions that are detrimental to the organization's goals?

In our survey it has become quite clear that accepting an application takes less time than refusing an application. On average, for 100 time units needed for search, examiners say they need another 94 if the patent is granted and 167 if it is refused. Consider now that explicit incentives are given for any processed grant, without taking into account whether the final decision was to grant or to refuse. A rational examiner would then know that the additional effort required to persuade the applicant to narrow the claims in the patent application, or

to make a case against granting a patent, would not be rewarded. The experiences at the USPTO suggest that this would therefore involve an excessive number of accepted grants, and could ultimately make useless the procedure of awarding grants.

The conclusion from this simple argument is that one would need to give a stronger reward for refusals than for grants, but yet again, this involves risks: the time needed for refusals versus grants may differ across specialties, but also over time, and it is difficult to track down such changes.

It is important to note that a similar problem to that described here arises with the quantity measure in the current reporting system. However, the system allows for a counterbalance to prevent detrimental effects on examiner behavior because the overall rating depends on a subjective evaluation that takes into account other criteria such as quality and aptitude.

TEST 5: Is the variation in the extent to which performance measures respond to individual effort sufficiently small?

Agency theory tells us that any uncertainty that is outside of the control of an employee makes it hard or at least costly to give strong incentives. The reason is that most people are risk averse and would like a stable flow of income. Therefore, when faced with performance contracts where much of the measured performance depends on chance, individuals will either not accept the contract and choose to work elsewhere, or they will demand a risk premium in terms of higher average pay. We will come back to the former sorting effects of incentives below and focus here on an evident reaction to providing the same incentive contract for tasks of varying difficulty.

For the US case it has been noted that there is a temptation to focus on easy cases. If there is some explicit pay per completed case, any rational examiner will focus on the easy cases. Detailed monitoring would then be needed to learn about the difficulty of cases and

allocate the cases in a fair way across staff. Similarly, on a more aggregate level, a weighting system can control for the average difficulty in examining applications in different fields.

Such a system is complicated and it can be quite costly, but in the absence of it, incentives would reward the luck of agents. Even worse, it may reward the skill of examiners to select the easiest cases, rather than the effort put into examining an application. This would further undermine the required cooperative culture at the EPO and hurt its ability to provide consistent patent examination for all filed innovations.

It is interesting to note that weighting systems are in place in the USPTO and have been in place in the EPO. The move of the EPO to abolish such schemes seems to be the wrong avenue. To work, explicit incentives would at a minimum need precisely such a weighing system.

Test 6: Can the organization credibly commit itself to keeping in place the parameters of the explicit incentive scheme (e.g., work quotas)?

From our earlier discussion of the ratchet effect we know that if an organization cannot commit to its incentive system there is the danger that its employees are reluctant to work hard because this would then lead to tougher standards. It is interesting to note that the USPTO has not modified their production quotas since 1976, even though a majority of examiners exceeds 100 percent of their target. An important factor for the ability of an organization to credibly commit to a new system of incentives is the trust that management has with staff and the perception that there will be no major changes in the top management of the organization that could influence the future incentive system. Our survey suggests this might be problematic in the current environment at the EPO.

Test 7: Does the introduction of explicit incentives not lead to undesired outcomes in terms of individuals' willingness to join or leave the organization?

Any organization is embedded in markets, and one of the most important ones is the labor market. The empirical literature makes quite clear that it is unwise to consider incentives in an isolated way – the study on incentives in Safelite discussed above shows that 50% of the positive effects of explicit incentives were caused by attracting a more productive workforce.

In the case of the EPO such a positive sorting effect cannot be expected. To see why, it is important to note that most of the staff at the EPO are highly educated and often have significant work experience. The high number of expatriates at the EPO points to geographical mobility of staff. These are all characteristics that make individuals very attractive to the labor market. As we have seen, EPO employees thus far remained with the organization for much or in most cases even all of their remaining working life.

Given the alternative options open to them, EPO employees have deliberately chosen a career at the EPO instead of a career in the private sector which would likely have offered higher earnings potential. The reason why the EPO can attract these people is among other things that they value the security and stable flow of income that their job offers. This explains the low turnover rate. Explicit incentives may therefore reduce the attractiveness of the EPO as a workplace. Then the EPO will either need to increase average earnings or lower the recruitment standard to be able to attract sufficient numbers of employees.

The current low turnover rate is an extremely important asset for the EPO. The USPTO loses a majority of the staff it hires within five years – the time needed to become a fully proficient patent examiner. This is one of the biggest problems that the agency faces, as it loses the access to these employees' human capital and millions of dollars in investments that it makes in training. Moreover, there is a substantial time burden for the more experienced staff

to train examiners who then leave quickly and are replaced by new cohorts of inexperienced examiners, who then require training again. There is some evidence that the emphasis on production in the incentive system of the USPTO – a significant portion of earnings depends on meeting certain production thresholds – is a contributor to staff attrition.

3.7.3 Summary

This section examined proposals for introducing explicit incentives, based on measures of patent applications processed, in terms of their ability to further the goals of the EPO. The literature on incentives is awash with examples of outcomes from such schemes that were harmful to the organizations that introduced them. Consequently, changing the system of incentives in the EPO is a decision that goes beyond the simple management of financial risks and tackling the backlog – it may be decisive for the ability of the EPO to fulfill its mission in the future and for its role in the European and global system of intellectual property right protection.

Overall, it appears that the EPO currently employs a system of motivation, evaluation and compensation practices that provides staff with a reasonably balanced mix of implicit incentives. The EPO has managed to maintain a reputation for high quality patent examination and faces no problems with staff attrition, in stark contrast to the USPTO. The first factor is important because it influences the behavior of patent applicants and prevents the office from becoming flooded with frivolous applications in the future. The second factor is important because the substantial investments in recruiting and training new examiners are lost when staff move to the private sector. The USPTO, which has in place a system of explicit incentives combined with implicit incentives, is struggling to fix problems that it faces along exactly these two dimensions.

The risks from introducing explicit incentives must be weighed against the potential gains

that may result from such reforms in enhanced productivity as measured in terms of patent applications processed. The biggest risks for the future operation of the EPO that we identified are the feedback effects from the patent system of potential shifts in the quality of patent examination outcomes – possibly even creating a vicious circle of downward spiraling quality and increasing workload – and the detrimental effects on staff recruitment and retention. Such potential negative effects on the ability of the EPO to fulfill its mission have direct bearing on the intellectual property protection system as a whole and its role in promoting innovation and economic growth in Europe and beyond.

Chapter 4

Conclusions

This report has examined the effectiveness of the current Human Resource System within the European Patent Office (EPO) in terms of the incentives that it creates for staff members to work in a way that advances the goals of the organization. We have drawn attention to the risks that may arise when greater emphasis is placed upon rewarding EPO staff according to quantitative measures of productivity.

The basis of the report are a review of the relevant scientific literature, recent experiences at the U.S. Patent and Trademark Office (USPTO), and the results of a questionnaire survey of EPO staff conducted by the authors. The scientific literature in question falls into two main categories.

- First, there is a literature on the objectives of the system of intellectual property and the role of patent examination within such a system: we have reviewed this literature in order to clarify what the incentives of the EPO staff should be trying to achieve.

- Second, there is a literature on the role of incentives within organizations, and the extent to which different kinds of incentives may be appropriate according to the nature and goals of the organization in question. This literature combined with recent experiences

at the USPTO has suggested a number of questions that need to be answered before a judgment can be made about the potential impact that reforms to the incentive system in the EPO would have. The purpose of our questionnaire has been to discover the answers to those questions.

Our enquiries have yielded the following main findings. First of all, the scientific literature on the role of patents within a system of intellectual property has shown that it is not desirable for a patent office to award patents to as many innovators as possible, regardless of the importance or quality of their innovation. Thus, ensuring that standards in terms of patentability requirements are met is an important part of the goals for the EPO.

It is true that an overly restrictive interpretation of patentability requirements can have important costs (notably through failing to grant intellectual property protection for inventors of innovations of small and medium importance). Not every innovator is an Einstein who is motivated by the joy of discovery only, and IP protection is arguably more important for those who are not geniuses than for those who are: indeed economic progress takes place chiefly through the accretion of many small innovations rather than through single revolutionary breakthroughs.

However, too lax an interpretation of patentability requirements can have a stifling effect on innovation as well. By encouraging a "land grab" on what would otherwise be the common property of ideas and techniques that are widely diffused and available, it may deter future innovators from sinking investments into ventures that may turn out to yield their profits to someone else who happens to hold the right early patent (this has also been called the problem of the "patent thicket"). In a world in which future innovators knew exactly which existing patents they might infringe, and could bargain costlessly and efficiently with their owners, such a land grab would not be a problem: innovators would invest when the benefits

of doing so exceeded the known costs, and rational patent-holders would charge licensing fees that siphoned off some of the associated profits but never so much as to dissuade inventors from making the investments in the first place. Unfortunately the real world does not work this way because of information problems and frictions in bargaining, and therefore the setting off of an "ideas grab" would potentially seriously stifle innovation thereafter.

These conclusions underline the importance for the EPO of ensuring that its procedures continue to give adequate weight to patentability requirements in the examination process. Unfortunately, however, the literature does not provide guidance as to what exactly is the appropriate weight to give them. We draw from this the conclusion that the procedures of the EPO need to be capable of responding to feedback from outside the Office (from the courts, the legislature, from scientific studies and so on) about the extent to which its procedures have the balance right or may be erring in one direction rather than another. In practice, this means that staff need to be given budgeted time to spend on reviewing case precedents (both in the prior decisions of the EPO and in judicial review by the courts), and the incentive to keep up to date with the work of their peers.

The literature on incentives within organizations indicates that patentability requirements may come under particular threat from pressures to increase the quantity of patent applications that the Office can process in any given period of time. This is an aspect of a well-known quantity-quality trade-off within organizations in which "multi-tasking" is inherent to the nature of the work carried out. There are many cautionary tales of organizations who based compensation on what appeared at first impression to be sensible measures of performance and then, once these were explicitly rewarded, experienced very undesirable outcomes. The reason was that employees found ways to "game" the system – pursuing these measures for their own sake rather than for the sake of advancing the goals of the organization. A famous example is the case of secretaries paid by Lincoln Electric according to the numbers of keystrokes on

their computers, who then spent their lunch breaks repeatedly hitting keys to improve their performance.

There is an additional risk arising from the fact that the EPO is just one part of the overall system of intellectual property protection: applicants may respond to any perceived decline in stringency of the Office's examination procedure by a reduction in the threshold quality for submitted applications. Thus, more emphasis on quantity measures may ultimately increase the Office's workload both because its impact on examination quality is likely to lead to more applications which then are of lower quality on average, and because such low-quality applications could be more difficult to evaluate. So pressure to increase the Office's work-rate may actually increase rather than reduce its applications backlog.

Our questionnaire survey has highlighted an important aspect of the Office's work: tasks carried out by different examiners and other staff are highly interdependent. Poor quality work by one staff member increases the load on his or her colleagues (the same is true of poor quality work by applicants and their legal representatives). Consequently changes in incentives that encourage individual examiners to increase speed at the expense of quality could paradoxically slow down the procedure by imposing additional delays on the work of other examiners. This perverse result of increasing incentives for speed of processing applications is an example of a more general phenomenon: incentives to improve individual performance may have a damaging effect on team-work if individuals neglect their (weakly-rewarded) team contribution in favor of their (strongly-rewarded) individual contribution. Therefore, the finding of our survey that effective patent examination is very much a team activity is very significant.

None of this means that incentives for speedy, efficient processing of applications are unimportant. We have discussed at some length the kinds of incentive system that are most likely to achieve such outcomes without compromising other desirable organizational objectives. We have distinguished systems of "implicit" incentives – those that function via performance ap-

praisal, the esteem of peers and the criteria for promotion – from "explicit" incentives – such as performance-related pay where remuneration responds automatically to some measurable criterion (e.g., the number of applications processed). We have emphasized that effective incentive systems in an organization such as the EPO need to strike the right balance between implicit and explicit incentives. To strengthen explicit incentives without paying careful attention to implicit incentives can therefore be counter-productive.

The evidence we have gathered suggests that the current mixed system of incentives in the EPO works fairly well, given the complex and multi-dimensional nature of the Office's objectives and criteria of excellence. Any proposal to strengthen the explicit component of such a system needs to take care not to undermine the implicit components.One might hope that a culture of professionalism, as it undoubtedly exists at the EPO, might prevent explicit "gaming" of the system of the kind we described above. However, a culture of professionalism is itself one of those implicit incentives that can be undermined by changes to the incentive system. There is ample evidence that professionals resent being given excessive explicit incentives and treat such gaming as an appropriate response to what they perceive as a lack of trust signalled by such systems.

There seems at present to be an important divergence of perception between management and staff of the EPO about the relative role and relative importance of explicit and implicit incentives in ensuring that the Office meets the legitimate demands of European businesses and European citizens for a speedy, flexible and high-quality system of patent examination. Such a divergence is not in itself evidence in favor of the views of one or other side, but it is an obstacle to the effective functioning of implicit incentives, which require a significant degree of consensus about what the goals of the Office are, and about how the performance of individuals will be evaluated in relation to those goals. It is our view that the Office needs to give high priority to the re-establishment of such a consensus.

Appendix

A.1 Staff survey: questionnaire

The survey could be taken in three different languages (English, French, and German). The English version is given here for the "examiner" version of the survey. These questions were administered when the participant answered "yes" to Question 4. The other versions are shorter because examiner relevant questions are not included. Participants could add comments to their answers in each section of the survey.

1. Which DG are you working in?

   Possible answers: DG 0 (President, Controlling, Internal Audit, etc,); DG 1 (Operations, e.g., examiners); DG 2 (Operational Support, e.g., formalities officers, IS staff); DG 3 (Appeals); DG 4 (Administration); DG 5 (Legal).

2. Which joint cluster are you working in?

   Possible answers: Audio, Video, Media; Biotechnology; Civil Engineering & Thermodynamics; Computers; Electricity & Semiconductors; Electronics; Handling & Processing; Human Necessities; Industrial Chemistry; Measuring & Optics; Polymers; Pure & Applied Organic Chemistry; Telecommunications; Vehicles & General Technology; PD Means; PD ISDS.

3. Which Principal Directorate are you working in?

Possible answers: Quality Management; Patent Administration; Tools and Documentation; Information Systems.

4. Are you an examiner?

5. What is your grade in EPO?

   Possible answers: A; B; C.

6. Please indicate your gender.

7. Please indicate your age.

   Possible answers: Under 30; 30-39; 40-49; 50 or above.

8. When you joined the EPO did you:

   Possible answers:

   - Stay in the country you were living in before?
   - Move away from your home country?
   - Move away from a country other than your home country?

9. For how long have you been at the EPO?

   Possible answers: 0-5 years; 6-10 years; 11-15 years; 16-20 years; More than 20 years.

10. Please indicate any type of prior experience you had when you joined the EPO (multiple responses are possible).

    Possible answers: Completed secondary education; Completed post-secondary professional training or other non-university qualification; Undergraduate university education: B.A., B.Sc. or equivalent; Postgraduate university education: M.A., M.B.A., M.Sc. or equivalent; Ph.D. (doctorate); More than one year in research job; More than one year in private-sector job; More than one year in public-sector job; Other (please specify).

11. Please indicate any type of additional qualification that you have obtained after joining the EPO (multiple responses are possible).

    Possible answers: European Qualifying Examination; Law degree; Economics degree; M.B.A. or comparable; Ph.D.; None; Other (please specify).

12. If applicable, please indicate the length of previous non-EPO employment.

    Possible answers: No prior experience; Less than 1 year; 1-3 years; 4-6 years; 7-10 years; More than 10 years.

13. If applicable, please indicate the characteristics of previous non-EPO employment (multiple responses possible).

    Possible answers: Administrative work; Coaching or training of others; IT support, development and maintenance; Managing the work of others; Academic scientific research (including Ph.D. work); Research and development in industry; Examining patent applications; Preparing patent applications; Preparing other legal documents; Technical work (e.g., repair and maintenance of buildings and equipment); Other (please specify).

14. How much patent examination expertise does your director have (both within your field and in other fields)?

    Possible answers: None; Very little expertise; Some expertise; A lot of expertise.

15. According to what you know, would your supervisor/director/chairman of Board be able to carry out the various tasks that your job entails?

    Possible answers: Lacks the required technical expertise or field knowledge that my job demands; Would be less qualified for my job than I; Would be equally qualified for my job as I; Would be more qualified for my job than I; Cannot say.

	Position	
	Current	Previous (if applicable)
Administrative work		
Attending industrial fairs/academic conferences		
Chairing oppositions		
Coaching or training of others		
Examining appeals		
Formalities work		
IT support, development and maintenance		
Managing the work of others		
Searching and examining patents		
Technical work, e.g., repair and maintenance of buildings and equipment		
Other, please specify below		

Table 1: Possible answers for Question 16

16. Please tick all applicable aspects of your current job and, if relevant, of your most recent previous job at the EPO, on which you spend at least 5% of your annual work time. Please fill in the "Previous position" column only in cases where there has been a change in your function (e.g., from formalities officer to SIS unit manager, from DG2 director to DG1 director, from examiner to director, etc.).

    Possible answers: see Table 1.

17. Following on from the previous question, is the allocation of time across the various tasks that your job involves stable over time (rating = 1 very unstable / 10 very stable)?

18. How much flexibility do you have to allocate your time to the different tasks that your job involves (rating = 1 very little flexibility / 10 a lot of flexibility)?

19. Please indicate the percentage of your work time that you are spending on average on the following four methods of work (the total must add to 100

    Possible answers: see Table 2.

20. On average, how often do you discuss formal/procedural issues regarding your work with your supervisor/director/chairman of Board (please tick closest description)?

Working with a computer	
on individual tasks interacting with others or undertaking joint tasks (e.g., using email, joint drafting of documents)	
Not working with a computer	
on individual tasks interacting with others (e.g., phone calls, face-to-face meetings)	
Sum	100

Table 2: Possible answers for Question 19

Possible answers: Once or less per year; Once every 6 months; Several times a year; Once every 3 months; Once a month; Several times a month; Once a week; Several times a week; Once a day; Several times a day.

21. On average, how often do you discuss details of your work (e.g., complex technical or legal issues) with your supervisor/director/chairman of Board (please tick closest description)?

    Possible answers: Once or less per year; Once every 6 months; Several times a year; Once every 3 months; Once a month; Several times a month; Once a week; Several times a week; Once a day; Several times a day.

22. If you spend more time on search does this save time on your own examination work? More time spent on search

    Possible answers: Saves a lot of time on substantive examination; Saves some time on substantive examination; Has no significant effect on time spent on substantive examination; Slightly increases time spent on substantive examination; Increases a lot time spent on substantive examination.

23. We would like to have an idea of the variability of time needed as first examiner for the different stages of patent examination. Suppose you need on average 100 time units to complete a search with a written opinion. Relative to this, please indicate approximately what time you need:

For the search with written opinion	
Actual Minimum time needed (e.g., "50" units) Actual Maximum time needed (e.g., "200" units)	
For the remainder of procedure, when this ends in a grant	
Actual Minimum time needed (e.g., "50" units) Actual Maximum time needed (e.g., "200" units)	
For the remainder of procedure, when this ends in a refusal	
Actual Minimum time needed (e.g., "50" units) Actual Maximum time needed (e.g., "200" units)	

Table 3: Possible answers for Question 23

Ideal time (on average) for the search with written opinion	
Ideal time (on average) for the remainder of the procedure, when this ends in a grant	
Ideal time (on average) for the remainder of the procedure, when this ends in a refusal	

Table 4: Possible answers for Question 24

Possible answers: see Table 3.

24. Suppose (as in the previous question) that you need on average 100 time units for the search with written opinion. In your technical field, what do you believe is the amount of time that you should spend as a first examiner on the remainder of the procedure, expressed in time units relative to the time needed for the search with written opinion?

    Possible answers: see Table 4.

25. What effect does higher quality of the work of staff with whom you work in your directorate/department/unit/Board have on the time you need to spend on your work?

    Possible answers: Saves a lot of time on my work; Saves some time on my work; Has no significant effect on the time I need to spend on my work; Slightly increases the time I need to spend on my work; Increases a lot the time I need to spend on my work; Not relevant.

26. What effect does higher quality of the work of other EPO staff from outside your directorate/department/unit/Board have on the time you need to spend on your work?

Possible answers: Saves a lot of time on my work; Saves some time on my work; Has no significant effect on the time I need to spend on my work; Slightly increases the time I need to spend on my work; Increases a lot the time I need to spend on my work; Not relevant.

27. What effect does higher quality of the work of patent applicants and their representatives have on the time you need to spend on your work?

    Possible answers: Saves a lot of time on my work; Saves some time on my work; Has no significant effect on the time I need to spend on my work; Slightly increases the time I need to spend on my work; Increases a lot the time I need to spend on my work; Not relevant.

28. What effect does higher quality of the work of staff from national patent offices (e.g., through search reports) have on the time you need to spend on your work?

    Possible answers: Saves a lot of time on my work; Saves some time on my work; Has no significant effect on the time I need to spend on my work; Slightly increases the time I need to spend on my work; Increases a lot the time I need to spend on my work; Not relevant.

29. For similar reasons as in the preceding question, we are interested in your perception of the extent to which senior managers in the EPO have the ability to understand the quality of your work:

    Possible answers: Cannot understand at all; Can understand basics; Can more or less understand; Perfectly understand; I don't know.

30. What is the extent to which your current supervisor/director/chairman of Board, in the EPO, has the ability to understand the quality of your work:

Possible answers: Cannot understand at all; Can understand basics; Can more or less understand; Perfectly understands; I don't know.

31. What is of the extent to which the colleagues in your directorate/department/unit/Board, in the EPO, have the ability to understand the quality of your work:

    Possible answers: Cannot understand at all; Can understand basics; Can more or less understand; Perfectly understand; I don't know.

32. What is the extent to which the colleagues from other joint clusters/principal directorates in your DG, in the EPO, have the ability to understand the quality of your work:

    Possible answers: Cannot understand at all; Can understand basics; Can more or less understand; Perfectly understand; I don't know.

33. What is the extent to which the colleagues from other DGs, in the EPO, have the ability to understand the quality of your work:

    Possible answers: Cannot understand at all; Can understand basics; Can more or less understand; Perfectly understand; I don't know.

34. What is the extent to which patent applicants and their representatives have the ability to understand the quality of your work:

    Possible answers: Cannot understand at all; Can understand basics; Can more or less understand; Perfectly understand; I don't know.

35. What is the extent to which the public has the ability to understand the quality of your work:

    Possible answers: Cannot understand at all; Can understand basics; Can more or less understand; Perfectly understand; I don't know.

36. Do you have access to all resources such as technical or scientific literature, on-line services, that you feel are necessary for your work? Please tick the option that best describes your situation.

    Possible answers: With most files I can not access at least one essential resource; With most files I can not access at least one minor resource; With some files I can not access an essential resource; With some files I can not access an minor resource; I always have access to all the resources needed to perform my work.

37. How do you feel that your compensation package measures against what you could expect outside the EPO, given your qualifications, the type of work you do and what is expected of you?

    Possible answers: Much worse than elsewhere; Slightly worse than elsewhere; Competitive; Somewhat better than elsewhere; Much better than elsewhere.

38. Please rank the following aspects in terms of how important you feel they are at the moment for reporting and promotion decisions in your directorate/department/unit/Board,

39. Please rank the following aspects in terms of how important you feel they ideally should be for reporting and promotion decisions in your directorate/department/unit/Board.

    Possible answers: see Table 5.

40. Do you feel that the existing reporting and promotion system supports you in finding the right balance between different objectives in your work?

    Possible answers: Reporting and promotion system puts much too much emphasis on quantity; Reporting and promotion system puts a bit too much emphasis on quantity; Reporting and promotion system strikes the right balance; Reporting and promotion system puts a bit too much emphasis on quality; Reporting and promotion system puts

	Question	
	38	39
Chairing oppositions		
Coaching or training of others		
Good relationship with colleagues		
Good relationship with superior		
Help/input provided to colleagues' work		
High quality of work		
High quantity of output		
Legal expertise		
Management skills		
Technical expertise		
Time spent in current position (i.e. experience in grade)		
Other (please specify below)		

Table 5: Possible answers for Question 39

much too much emphasis on quality.

41. Do you feel that you are able to predict how your professional decisions, time allocation across tasks and work results influence the reporting and promotion decisions that affect you (rating = 1 cannot predict at all / 10 can predict with certainty)?

42. Are you aware of any peer pressure that may influence your work positively or negatively? Please tick the best description of your overall perception of the situation in your directorate/department/unit/Board.

    Possible answers: Strong negative influence of peer pressure; Some negative influence of peer pressure; Not aware of any peer pressure; Some positive influence of peer pressure; Strong positive influence of peer pressure.

43. To what extent do you feel that you and your current supervisor/director/chairman of Board agree on the goals that your work should achieve (rating = 1 complete disagreement / 10 complete agreement)?

A.2 Staff survey: detailed results

The staff survey was carried out online using the Opinio software. A total of 7,073 staff members of the EPO received an invitation to complete the survey. Respondents could complete the sections in the survey in several steps by logging on to the system. While participants remain anonymous the software prevents the same person from completing the survey more than once. A total of 4,269 staff members answered questions in the survey, of which 3,201 completed all sections of the survey. The number of responses in the tables below do not have to add up to either of these numbers because some questions allowed for multiple responses and questions could be left unanswered.

The survey questions are related to the following topics: staff characteristics, compensation and evaluation, staff's perception of the workplace, interactions between staff, and time allocation across different work tasks.

Overview of tables on survey results by topic:

Topic	Tables
Staff characteristics	6, 7, 8, 9, 10
Compensation and evaluation	11, 12, 13, 14, 15
Perception of the workplace and interactions with others	16, 17, 18, 20, 19
Time allocation	21, 22, 23, 24

Overview of tables on survey results by question number:

Question	Table	Question	Table	Question	Table
1-5	6	19	17	37	12
6-9	7	20,21	18	38,39	13
10,11	8	22	22	40	14
12,13	9	23,24	23	41	15
14,15	16	25-28	20	42	19
16	10	29-35	11	43	15
17,18	21	36	24		

	Frequency	Percentage	Cumulated
Staff according to DG (Question 1)			
DG0	64	1.6	1.6
DG1	2548	62.2	63.8
DG2	820	20.0	83.8
DG3	109	2.7	86.5
DG4	437	10.7	97.2
DG5	116	2.8	100
Staff according to Joint Clusters (Question 2)			
Audio Video Media	169	6.8	7.8
Biotechnology	173	6.9	13.7
Civil Engineering	129	5.2	18.8
Computers	216	8.6	27.4
Electricity & Semiconductors	204	8.1	35.6
Electronics	143	5.7	41.3
Handling & Processing	168	6.7	48
Human Necessities	219	8.7	56.7
Industrial Chemistry	206	8.2	65
Measuring and Optics	160	6.4	71
Polymers	90	3.6	74.9
Pure and applied Organic Chemistry	189	7.5	82.5
Telecommunication	232	9.3	91.7
Vehicles and General Technology	180	7.2	98.9
PD Means	21	0.8	99.8
PS ISDS	6	0.2	100
Staff according to PD (Question 3)			
Quality Management	22	3.5	3.5
Patent Administration	341	53.5	57.0
Tools and Documentation	84	13.2	70.2
Information Systems	190	29.8	100
Examiners (Question 4)			
No	134	5.3	5.3
Yes	2378	94.7	100
Staff according to grade (Question 5)			
A	2376	73.8	73.8
B	771	23.9	97.7
C	74	2.3	100

Table 6: EPO staff organization

	Frequency	Percentage	Cumulated
Gender (Question 6)			
Female	1154	29	29
Male	2829	71	100
Age (Question 7)			
under 30	312	7.8	7.8
30-39	1679	42.2	50
40-49	1254	31.5	81.5
50 or above	737	18.5	100
Expatriates (Question 8)			
Moved away from a country other than home country	549	13.8	13.8
Moved away from home country	1905	47.9	61.6
Stayed in the same country	1527	38.4	100
Length of employment at the EPO (all staff) (Question 9)			
0-5 years	1472	37	37
6-10 years	908	22.8	59.8
11-15 years	348	8.7	68.5
16-20 years	777	19.5	88.1
more than 20 years	475	11.9	100
Length of employment at the EPO (examiners only) (Question 9)			
0-5 years	915	38.6	38.6
6-10 years	686	29	67.6
11-15 years	176	7.4	75
16-20 years	412	17.4	92.4
more than 20 years	179	7.6	100

Table 7: Staff characteristics

Prior experience when joining the EPO (all staff)
(Question 10: 3684 respondents – multiple responses possible)

	Frequency	Percentage of staff
Completed secondary education	1648	44.7
Completed post-secondary professional training or other non-university qualification	662	18
Undergraduate university education	1054	25.2
Post-graduate university education	1702	46.2
Ph.D.	1001	27.2
More than one year in research job	876	23.8
More than one year in private sector job	1680	45.6
More than one year in public sector job	684	18.6

Research background (all staff) (Question 10 recoded[a])

	Frequency	Percentage	Cumulated
No research background	2408	65.4	65.4
Some experience in research	1276	34.6	100

Prior experience when joining the EPO (examiners)
(Question 10: 2253 respondents – multiple responses possible)

	Frequency	Percentage of examiners
Completed secondary education	832	37
Completed post-secondary professional training or other non-university qualification	126	5.6
Undergraduate university education	696	28
Post-graduate university education	1335	59.2
Ph.D.	872	38.7
More than one year in research job	771	34.2
More than one year in private sector job	1096	48.7
More than one year in public sector job	381	17

Research background (examiners) (Question 10 recoded[a])

	Frequency	Percentage	Cumulated
No research background	1145	50.8	51.8
Some experience in research	1108	49.2	100

Qualifications obtained after joining the EPO (all staff)
(Question 11: 2691 respondents – multiple responses possible)

	Frequency	Percentage of staff
European Qualifying Examination	183	6.8
Law degree	70	2.6
Economics degree	35	1.3
M.B.A. or comparable	68	2.5
Ph.D.	88	3.3
none	2155	80.1

[a] Yes if "more than one year in research job" or "Ph.D."; no otherwise.

Table 8: Education and experience

Length of previous non-EPO employment (Question 12)			
	Frequency	Percentage	Cumulated
No prior experience	293	7.8	7.8
Less than 1 year	281	7.5	15.2
1-3 years	823	21.8	37
4-6 years	1021	27.1	64.1
7-10 years	751	19.9	84
More than 10 years	604	16	100
Characteristics of previous non-EPO employment (Question 13: 3195 respondents – multiple responses possible)			
		Frequency	Percentage of relevant staff
IT support		502	15.7
Administrative work		896	28
Coaching or training of others		528	16.5
Managing the work of others		582	18.2
Academic scientific research (including Ph.D work)		1027	32.1
R&D in industry		1098	34.4
Examining patent applications		163	5.1
Preparing patent applications		190	6
Preparing other legal documents		141	4.4
Technical work		249	7.8

Table 9: Previous non-EPO employment

Aspects requiring at least 5% of annual work time in	**current job** (3469 respondents)		**most recent previous job at the EPO** (729 respondents)	
	Frequency	Percentage of staff	Frequency	Percentage of relevant staff
Administrative work	1592	45.9	378	51.9
Attending industrial fairs & academic conferences	202	5.8	201	27.6
Chairing oppositions	372	10.7	75	10.3
Coaching or training of others	1007	29	285	39.1
Examining appeals	165	4.8	22	3
Formalities work	476	13.7	85	11.7
IT support	405	11.7	157	21.5
Managing the work of others	462	13.3	219	30
Searching and examining patents	2190	63.1	165	22.6
Technical work	58	1.7	73	10

Table 10: Aspects of EPO jobs (Question 16)

	senior managers (Question 29)			**current supervisor/director/ chairman of Board** (Question 30)		
	Frequ.	Percent.	Cum.	Frequ.	Percent.	Cum.
Cannot understand at all	1220	37.9	37.9	93	2.9	2.9
Can understand basics	1044	32.5	70.4	530	16.5	19.4
Can more or less understand	426	13.3	83.6	1060	33	52.3
Perfectly understand	129	4	87.7	1450	45.1	97.4
I don't know	397	12.3	100	84	2.6	100

	colleagues in the same unit (Question 31)			**colleagues in the same DG** (Question 32)			**colleagues from other DGs** (Question 33)		
	Frequ.	Percent.	Cum.	Frequ.	Percent.	Cum.	Frequ.	Percent.	Cum.
Cannot understand at all	20	0.6	0.6	376	11.8	11.8	822	25.6	25.6
Can understand basics	207	6.4	7.1	707	22.2	34	986	30.8	56.4
Can more or less understand	996	30.9	38	977	30.7	64.7	632	19.7	76.1
Perfectly understand	1928	59.9	97.8	659	20.7	85.3	198	6.2	82.3
I don't know	70	2.2	100	467	14.7	100	569	17.7	100

	patent applicants and their representatives (Question 34)			**the public** (Question 35)		
	Frequ.	Percent.	Cum.	Frequ.	Percent.	Cum.
Cannot understand at all	246	7.8	7.8	970	30.7	30.7
Can understand basics	444	14.1	21.9	908	28.8	59.5
Can more or less understand	995	31.6	53.5	400	12.7	72.1
Perfectly understand	1014	32.2	85.7	129	4.1	76.2
I don't know	451	14.3	100	751	23.8	100

Table 11: Perception of the respective group's ability to understand the quality of individual's work

	Frequency	Percentage	Cumulated
Much worse than elsewhere	39	1.3	1.3
Slightly worse than elsewhere	148	4.7	6
Competitive	932	29.8	35.7
Somewhat better than elsewhere	1069	34.1	69.9
Much better than elsewhere	943	30.1	100

Table 12: Compensation package (Question 37)

Ranking of aspects in terms of importance for reporting and promotion decisions				
	at the moment (Question 38)		**ideal** (Question 39)	
	Average rank	Std.dev	Average rank	Std.dev
Chairing opposition	5.8	3.4	5.3	3.4
Coaching or training others	4.6	2.5	4.1	2.4
Good relationships with colleagues	4.7	2.8	4.1	2.5
Good relationships with superiors	3.4	2.4	5.4	3.2
Help/input provided to colleagues work	5	2.8	3.6	2.2
High quality of work	3.7	2.7	1.4	1.1
High quantity of output	1.8	1.9	3.4	2.4
Legal expertise	5.1	2.9	3.5	2.5
Management skills	6.1	3.4	5.5	3.5
Technical expertise	4.2	2.7	2.5	1.8
Time spent in current position (i.e. experience in grade)	3.8	2.9	5.3	3.2

Table 13: Reporting and promotion decisions I

Does the existing reporting and promotion system help find the right balance between different work objectives? (Question 40)			
	Frequency	Percentage	Cumulated
Much too much emphasis on quantity	1562	55.8	55.8
A bit too much emphasis on quantity	740	26.4	82.2
Strikes the right balance	457	16.3	98.6
A bit too much emphasis on quality	27	1	99.5
Much too much emphasis on quality	13	0.5	100

Table 14: Reporting and promotion decisions II

Predictability how professional decisions, time allocation across tasks and work results influence the reporting and promotion decisions (Question 41)			
	Frequency	Percentage	Cumulated
Cannot predict at all: 1	451	15.2	15.2
2	245	8.3	23.5
3	412	13.9	37.4
4	221	7.5	44.9
5	401	13.5	58.4
6	265	9	67.4
7	372	12.6	79.9
8	394	13.3	93.3
9	117	3.9	97.2
Can predict with certainty: 10	83	2.8	100
Agreement with current supervisor/director/ chairman of Board on the work goals (Question 43 – recoded)			
	Frequency	Percentage	Cumulated
Disagreement (answer ≤ 5)	1024	34.1	34.1
Agreement (answer > 5)	1975	65.9	100

Table 15: Predictability of reporting and promotion decisions

Patent expertise of relevant director (Question 14)			
	Frequency	Percentage	Cumulated
None	101	4.7	4.7
Very little expertise	221	10.2	14.9
Some expertise	758	35.1	50
A lot of expertise	1080	50	100
Ability of supervisor/director/ chairman of Board to carry out the various tasks that subordinate's job entails (Question 15)			
	Frequency	Percentage	Cumulated
Lacks the required technical expertise	735	21.1	21.1
Less qualified than I	727	20.9	42
Equally qualified as I	1155	33.2	75.2
More qualified than I	424	12.2	87.4
Cannot say	440	12.6	100

Table 16: Perceived expertise/ability of superior

Percentage of work time spent on average on the following four methods of work		
	Average response	Standard deviation
Working with a computer		
on individual tasks	64	22.6
interacting with others	14.9	15.8
Not working with a computer		
on individual tasks	21.7	17.2
interacting with others	12.9	12.5

Table 17: Interaction with others (Question 19)

Frequency of discussions with supervisor/director/chairman of Board regarding						
	formal/procedural issues (Question 20)			**work details (e.g., complex technical or legal issues)** (Question 21)		
	Frequ.	Percent.	Cum.	Frequ.	Percent.	Cum.
Once or less per year	635	19.2	19.2	827	25.1	25.1
Once every 6 months	413	12.5	31.6	386	11.7	36.9
Several times a year	522	15.8	47.4	473	14.4	51.2
Once every 3 months	313	9.4	56.8	268	8.1	59.4
Once a month	538	16.2	73	441	13.4	72.8
Several times a month	433	13.1	86.1	390	11.9	84.6
Once a week	221	6.7	92.8	201	6.1	90.7
Several times a week	189	5.7	98.5	258	7.8	98.6
Once a day	27	0.8	99.3	25	0.8	99.3
Several times a day	24	0.7	100	22	0.7	100

Table 18: Interaction with superior

Perceived peer pressure			
	Frequency	Percentage	Cumulated
Strong negative influence	219	7.6	7.6
Some negative influence	857	29.4	37
Not aware of any peer pressure	1309	45	82
Some positive influence	430	14.8	96.8
Strong positive influence	93	3.2	100

Table 19: Perceived peer pressure (Question 42)

	Effect of higher quality work of					
	EPO staff in your directorate/department/unit/Board (Question 25)			**EPO staff from outside** (Question 26)		
	Frequency	Percentage	Cumulated	Frequency	Percentage	Cumulated
Saves a lot of time on my work	1031	32.9	32.9	759	24.4	24.4
Saves some time on my work	1073	34.3	67.2	1010	32.4	56.8
No significant effect on my working time	515	16.5	83.7	755	24.3	81.1
Slightly increases my working time	177	5.6	89.3	94	3	84.1
Increases a lot my working time	81	2.6	91.9	58	1.9	85.9
Not relevant	253	8.1	100	438	14.1	100
	patent applicants and their representatives on non-examiners (Question 27)			**on examiners** (Question 27)		
Saves a lot of time on my work	1968	63.5	63.5	1682	85.3	85.3
Saves some time on my work	356	11.5	74.9	191	9.7	95
No significant effect on my working time	169	5.5	80.4	25	1.3	96.3
Slightly increases my working time	39	1.3	81.7	14	0.7	97
Increases a lot my working time	55	1.8	83.4	40	2	99
Not relevant	514	16.6	100	20	1	100
	national patent offices (e.g., through search reports) (Question 28)					
Saves a lot of time on my work	605	19.7	19.7			
Saves some time on my work	724	23.6	43.3			
No significant effect on my working time	774	25.2	68.5			
Slightly increases my working time	78	2.5	71.1			
Increases a lot my working time	42	1.4	72.5			
Not relevant	845	27.5	100			

Table 20: Interdependence of work

Stability of time allocation across the various tasks that job involves (Question 17)			
	Frequency	Percentage	Cumulated
very unstable: 1	83	2.4	2.4
2	83	2.4	4.9
3	274	8	12.9
4	207	6.1	19
5	328	9.6	28.6
6	250	7.3	35.9
7	365	10.7	46.6
8	678	19.9	66.5
9	426	12.5	79
very stable: 10	718	21	100
Flexibility in time allocation across the various tasks that job involves (Question 18)			
	Frequency	Percentage	Cumulated
very little: 1	161	4.7	4.7
2	125	3.7	8.4
3	201	5.9	14.4
4	152	4.5	18.9
5	323	9.5	28.4
6	286	8.4	36.8
7	475	14	50.8
8	787	23.2	74
9	445	13.1	87.2
a lot: 1	435	12.8	100

Table 21: Stability and flexibility of time allocation

More time spent on search			
	Frequency	Percentage	Cumulated
saves a lot of time on substantive examination	309	16.3	16.3
saves some time on substantive examination	692	36.5	52.7
has no significant effect on time spent on substantive examination	564	29.7	82.5
slightly increases time spent on substantive examination	194	10.2	92.7
increases a lot time spent on substantive examination	139	7.3	100

Table 22: Relation between search and substantive examination (Question 22)

	Suppose that 100 time units are needed on average to complete a search with a written opinion. Relative to this the average time for the remainder of the procedure							
	that is actually used is (Question 23)				**that should ideally be used is** (Question 24)			
when this ends	Mean	Std.dev.	Max.	Min.	Mean	Std.dev.	Max.	Min.
in a grant	94.2	51.9	1000	1	89	50.7	400	0
in a refusal	167	109.3	3000	0	149	347	10000	2

Table 23: Relation between time required for search and substantive examination

	Frequency	Percentage	Cumulated
With most files I cannot access			
at least one essential resource	88	4.5	4.5
at least one minor resource	109	5.6	10.1
With some files I cannot access			
an essential resource	410	21	31.1
a minor resource	861	44.1	75.2
I always have access to all resources needed to perform my work	484	24.8	100

Table 24: Access to resources (Question 36)

A.3 List of abbreviations

CAFC	–	Court of Appeals for the Federal Circuit
DG	–	Directorate General
EPC	–	European Patent Convention
EPO	–	European Patent Office
GAO	–	United States Government Accountability Office
HRS	–	Human Resource System
NAPA	–	National Academy of Public Administration
NPO	–	national patent office
OIG	–	U.S. Department of Commerce Office of Inspector General
PCT	–	Patent Cooperation Treaty
POPA	–	Patent Office Professional Association
SUEPO	–	Staff Union of the European Patent Office
USPTO	–	U.S. Patent and Trademark Office

List of Figures

List of Tables

Index

Bibliography

Ackerberg, Daniel A., and Maristella Botticini, 2002, Endogenous matching and the empirical determinants of contract form, *Journal of Political Economy* 110, 564–591.

Akers, N., 1999, The European patent system: An introduction for patent searchers, *World Patent Information* 21, 135–63.

Arya, Anil, and Brian Mittendorf, 2005, Offering stock options to gauge managerial talent, *Journal of Accounting & Economics* 40, 189–210.

Asch, Beth J., 1990, Do incentives matter? The case of navy recruiters, *Industrial and Labor Relations Review* 43, 89S–106S.

Auriol, Emmanuelle, Guido Friebel, and Lambros Pechlivanos, 2002, Career concerns in teams, *Journal of Labor Economics* 20, 289–307.

Auriol, Emmanuelle, and Régis Renault, 2000, The costs and benefits of symbolic differentiation in the work place, *IDEI Working Paper no. 101.*

Auriol, Emmanuelle, and Régis Renault, 2001, Incentive hierarchies, *Annales d'Economie et de Statistique* 63, 261–282.

Baker, George, 1992, Incentive contracts and performance measurement, *Journal of Political Economy* 100, 598–614.

Baker, George, 2002, Distortion and risk in optimal incentive contracts, *Journal of Human Resources* 37, 728–751.

Baker, George, Robert Gibbons, and Kevin J. Murphy, 1994, Subjective performance measures in optimal incentive contracts, *Quarterly Journal of Economics* 109, 1125–1156.

Baker, George, Michael Gibbs, and Bengt Holmström, 1994a, The internal economics of the firm: Evidence from personnel data, *Quarterly Journal of Economics* 109, 881–919.

Baker, George, Michael Gibbs, and Bengt Holmström, 1994b, The wage policy of a firm, *Quarterly Journal of Economics* 109, 921–955.

Bandiera, Oriana, Iwan Barankay, and Imran Rasul, 2005, Social preferences and the response to incentives: Evidence from personnel data, *Quarterly Journal of Economics* 120, 917–962.

Bandiera, Oriana, Iwan Barankay, and Imran Rasul, 2006, Incentives for managers and inequality among workers: Evidence from a firm level experiment, IZA Discussion Paper No. 2062.

Barnard, Chester I, 1938, *The Functions of the Executive* (Harvard University Press: Cambridge, MA).

Baron, David P., and David Besanko, 1984, Regulation, asymmetric information, and auditing, *RAND Journal of Economics* 15, 447–470.

Baron, David P., and Roger B. Myerson, 1982, Regulating a monopolist with unknown costs, *Econometrica* 50, 911–930.

Benabou, Roland, and Jean Tirole, 2003, Intrinsic and extrinsic motivation, *Review of Economic Studies* 70, 489–520.

Berliner, Joseph S., 1957, *Factory and Manager in the Soviet Union* (Harvard University Press: Cambridge, MA).

Besley, Tim, and Maitreesh Ghatak, 2003, Incentives, choice, and accountability in the provision of public services, *Oxford Review of Economic Policy* 19, 235–249.

Booth, Alison L., and Jeff Frank, 1999, Earnings, productivity and performance-related pay, *Journal of Labor Economics* 17, 447–463.

Booz-Allen & Hamilton Inc., 1995, PTO goal study – task one: An assessment of the current performance measurements and rewards system.

Burgess, Simon, and Marisa Ratto, 2003, The role of incentives in the public sector: Issues and evidence, CMPO Working Paper No. 03/071.

Caillaud, Bernard, and Anne Duchêne, 2005, Patent office in innovation policy: Nobody's perfect, mimeo available at `http://ceco.polytechnique.fr/COLLOQUES/ETAPE/duchene.pdf`.

Carmichael, H. Lorne, and W. Bentley MacLeod, 2000, Worker cooperation and the ratchet effect, *Journal of Labor Economics* 18, 1–19.

Chang, Howard F., 1995, Patent scope, antitrust policy, and cumulative innovation, *RAND Journal of Economics* 26, 34–57.

Che, Yeon-Koo, and Seung-Weon Yoo, 2001, Optimal incentives for teams, *American Economic Review* 91, 525–541.

Chen, Kong-Pin, 2003, Sabotage in promotion tournaments, *Journal of Law, Economics, and Organization* 19, 119–140.

Chevalier, Judith, and Glenn Ellison, 1997, Risk taking by mutual funds as a response to incentives, *Journal of Political Economy* 105, 1167–1200.

Chevalier, Judith, and Glenn Ellison, 1999, Career concerns of mutual fund managers, *Quarterly Journal of Economics* 114, 389–432.

Coase, Ronald H., 1937, The nature of the firm, *Economica* 16, 386–405.

Cockburn, Iain M., Samuel Kortum, and Scott Stern, 2002, Are all patent examiners equal? The impact of examiner characteristics, NBER Working Paper No. 8980.

Cornelli, Francesca, and Mark Schankerman, 1999, Patent renewals and R&D incentives, *RAND Journal of Economics* 30, 197–213.

Courty, Pascal, and Gerald Marschke, 1997, Measuring government performance: Lessons from a federal training program, *American Economic Review, Papers and Proceedings* 87, 383–388.

Courty, Pascal, and Gerald Marschke, 2004, An empirical investigation of gaming responses to explicit performance incentives, *Journal of Labor Economics* 22, 23–56.

Courty, Pascal, and Gerald Marschke, 2005, Making government accountable: Lessons from a federal job training program, *Public Administration Review* p. forthcoming.

Cyert, Richard M., and James G. March, 1963, *A Behavioral Theory of the Firm* (Prentice-Hall: Englewood Cliffs, NJ).

Deci, Edward L., Richard Koestner, and Richard M. Ryan, 1999, A meta-analytic review of experiments examining the effects of extrinsic rewards on intrinsic motivation, *Psychological Bulletin* 125, 627–668.

Denicolò, Vincenzo, 1996, Patent races and optimal patent breadth and length, *Journal of Industrial Economics* 44, 249–265.

Denicolò, Vincenzo, 2000, Two-stage patent races and patent policy, *RAND Journal of Economics* 31, 488–501.

Denicolò, Vincenzo and Piercarlo Zanchettin, 2002, How should forward patent protection be provided, *International Journal of Industrial Organization* 20, 801–827.

Dewatripont, Mathias, Ian Jewitt, and Jean Tirole, 1999, The economics of career concerns, part II: Application to missions and accountability of government agencies, *Review of Economic Studies* 66, 199–217.

Dewatripont, Mathias, Ian Jewitt, and Jean Tirole, 2000, Multitask agency problems: Focus and task clustering, *European Economic Review* 44, 869–877.

Dixit, Avinash, 2002, Incentives and organizations in the public sector: An interpretative review, *Journal of Human Resources* 37, 696–727.

Doeringer, Peter B., and Michael J. Piore, 1971, *Internal Labor Markets and Manpower Analysis* (Heath Lexington Books: Lexington, MA).

Drago, Robert, and Gerald T Garvey, 1998, Incentives for helping on the job: Theory and evidence, *Journal of Labor Economics* 16, 1–25.

Dubner, Stehphen J., and Steven D. Levitt, 2005, *Freakonomics: A Rogue Economists Exploring the Hidden Side of Everything* (William Morrow: New York).

European Patent Office, 2005, Annual report 2004, available at `http://annual-report.european-patent-office.org/2004/index.en.php`.

European Patent Office, 2006, Annual report 2005, available at `http://annual-report.european-patent-office.org/2005/index.en.php`.

Falk, Armin, and Andrea Ichino, 2006, Clean evidence on peer effects, *Journal of Labor Economics* 24, 39–57.

Fama, Eugene F., 1980, Agency problems and the theory of the firm, *Journal of Political Economy* 88, 288–307.

Fast, Norman, and Norman Berg, 1975, The Lincoln Electric Company, Harvard Business School Case 376-028.

Fehr, Ernst, and Armin Falk, 2002, Psychological foundations of incentives, *European Economic Review* 46, 687–724.

Gallini, Nancy T., 1992, Patent policy and costly imitation, *RAND Journal of Economics* 23, 52–63.

GAO – United States Government Accountability Office, 2005, Intellectual property USPTO has made progress in hiring examiners, but challenges to retention remain, available at `http://www.gao.gov/new.items/d05720.pdf`.

Gibbons, Robert, and Kevin J. Murphy, 1992, Optimal incentive contracts in the presence of career concerns: Theory and evidence, *Journal of Political Economy* 100, 468–505.

Gibbons, Robert, and Michael Waldman, 1999, Careers in organizations: Theory and evidence, in Orley Ashenfelter, and David Card, ed.: *Handbook of Labor Economics*, vol. 3B . chap. 36, pp. 2373–2437 (Elsevier: Amsterdam).

Gilbert, Richard, and Carl Shapiro, 1990, Optimal patent length and breadth, *RAND Journal of Economics* 21, 106–112.

Ginarte, Juan C., and Walter G. Park, 1997, Determinants of patent rights: A cross-national study, *Research Policy* 26, 283–301.

Graham, Stuart JH, and Dietmar Harhoff, 2006, Would the US benefit from patent post-grant reviews? Evidence from a 'twinning study', SFB/TR 15 Governance and the Efficiency of Economic Systems Discussion Paper No. 38.

Graham, Stuart J. H., Bronwyn H. Hall, Dietmar Harhoff, and David C. Mowery, 2003, Post-issue patent "quality control": A comparative study of US patent re-examinations and European patent oppositions, in Wesley M. Cohen, and Stephen A. Merrill, ed.: *Patents in the Knowledge-Based Economy* (The National Academies Press: Washington, D.C.).

Green, Jerry R., and Suzanne Scotchmer, 1995, On the division of profit in sequential innovation, *RAND Journal of Economics* 26, 20–33.

Hall, Bronwyn H., and Dietmar Harhoff, 2004, Post-grant patent reviews in the U.S. patent system – design choices and expected impact, *Berkeley Technology Law Journal* 19, 989–1016.

Holmström, Bengt, 1979, Moral hazard and observability, *Bell Journal of Economics* 10, 74–91.

Holmström, Bengt, 1982, Moral hazard in teams, *Bell Journal of Economics* 13, 324–340.

Holmström, Bengt, 1982/99, Managerial incentive problems: A dynamic perspective, *Review of Economic Studies* 66, 169–182; originally published in: *Essays in Economics and Management in Honour of Lars Wahlbeck*, Helsinki, Finland.

Holmström, Bengt, and Paul Milgrom, 1987, Aggregation and linearity in the provision of intertemporal incentives, *Econometrica* 55, 303–328.

Holmström, Bengt, and Paul Milgrom, 1991, Multitask principal-agent analyses: Incentive contracts, asset ownership, and job design, *Journal of Law, Economics and Organization* 7, 24–52.

Hopenhayn, Hugo A., and Matthew F. Mitchell, 2001, Innovation variety and patent design, *RAND Journal of Economics* 32, 152–66.

Itoh, Hideshi, 1991, Incentives to help in multi-agent situations, *Econometrica* 59, 611–636.

Jacob, Brian, and Steven D. Levitt, 2003, Rotten apples: An investigation of the prevalence and predictors of teacher cheating, *Quarterly Journal of Economics* 118, 843–877.

Jaffe, Adam B., and Josh Lerner, 2004, *Innovation and its Discontents: How our Broken Patent System is Endangering Innovation and Progress, and What to Do About It* (Princeton University Press: Princeton, NJ).

Jeon, Seonghoon, 1996, Moral hazard and reputational concerns in teams: Implications for organizational choice, *International Journal of Industrial Organization* 14, 297–315.

Kandel, Eugene, and Edward P. Lazear, 1992, Peer pressure and partnerships, *Journal of Political Economy* 100, 801–817.

Kanemoto, Yoshitsugu, and W Bentley MacLeod, 1992, The ratchet effect and the market for secondhand workers, *Journal of Labor Economics* 10, 85–98.

Kerr, Steven, 1975, On the folly of rewarding A, While Hoping for B, *Academy of Management Journal* 18, 769–783.

Klemperer, Paul, 1990, How broad should the scope of patent protection be?, *RAND Journal of Economics* 21, 113–130.

Knez, Marc, and Duncan Simester, 2001, Firm-wide incentives and mutual monitoring at Continental Airlines, *Journal of Labor Economics* 19, 743–772.

Koch, Alexander K., and Albrecht Morgenstern, 2005, From team-spirit to jealousy: The pitfalls of too much transparency, IZA Discussion Paper No. 1661.

Kortum, Samuel, and Josh Lerner, 1999, What is behind the recent surge in patenting?, *Research Policy* 28, 1–22.

Laffont, Jean-Jacques, and Jean Tirole, 1993, *A Theory of Incentives in Procurement and Regulation* (MIT Press: Cambridge, MA).

Langinier, Corinne, and Philippe Marcoul, 2003, Patents, search of prior art, and revelation of information, Iowa State University, Department of Economics Staff General Research Papers No 10489.

Lavy, Victor, 2002, Evaluating the effect of teachers' group performance incentives on pupil achievement, *Journal of Political Economy* 110, 1286–1317.

Lavy, Victor, 2003, Paying for performance: The effect of teachers' financial incentives on students' scholastic outcomes, CEPR Discussion Paper No. 3862.

Lazear, Edward P., 1989, Pay equality and industrial politics, *Journal of Political Economy* 97, 561–580.

Lazear, Edward P., 1986, Salaries and piece rates, *Journal of Business* 59, 405–431.

Lazear, Edward P., 2000, Performance pay and productivity, *American Economic Review* 90, 1346–1361.

Lazear, Edward P., 2006, Speeding, tax fraud, and teaching to the test, *Quarterly Journal of Economics* 121, 1029–1061.

Lemley, Mark A., 2001, Rational ignorance at the patent office, *Northwestern University Law Review* 95, 1495–1532.

Lerner, Josh, 2002, 150 years of patent protection, *American Economic Review, Papers and Proceedings* 92, 221–225.

Lerner, Josh, 2005, 150 years of patent office practice, *American Law and Economics Review* 7, 112–143.

MacDonald, Glenn, and Leslie Marx, 2001, Adverse specialization, *Journal of Political Economy* 109, 864–899.

Marx, Leslie, and Francesco Squintani, 2003, Individual accountability in teams, University of Rochester.

Matutes, Carmen, Pierre Regibeau, and Katharine Rockett, 1996, Optimal patent design and the diffusion of innovations, *RAND Journal of Economics* 27, 60–83.

Maurer, Stephen M., and Suzanne Scotchmer, 2002, Independent invention defence in intellectual property, *Economica* 69, 535–547.

Mirrlees, James A, 1971, An exploration in the theory of optimum income taxation, *Review of Economic Studies* 38, 175–208.

Moldovanu, Benny, Aner Sela, and Xianwen Shi, 2005, Contests for Status, mimeo available at `http://papers.ssrn.com/sol3/papers.cfm?abstract_id=764625`.

Mookherjee, Dilip, and Ivan Png, 1989, Optimal auditing, insurance, and redistribution, *Quarterly Journal of Economics* 104, 399–415.

Myerson, Roger B., 1982, Optimal coordination mechanisms in generalized principal-agent problems, *Journal of Mathematical Economics* 10, 67–81.

NAPA -National Academy of Public Administration, 2005, U.S. Patent and Trademark Office: Transforming to meet the challenges of the 21st century, available at: `http://www.napawash.org/Pubs/PTO-8-25-05.htm`.

Nash, John F., 1950, Equilibrium points in n-person games, *Proceedings of the National Academy of the USA* 36, 48–49.

Nordhaus, William D., 1969, *Invention, Growth, and Welfar: A Theoretical Treatment of Technological Change* (MIT Press: Cambridge, MA).

O'Donoghue, Ted, 1998, A patentability requirement for sequential innovation, *RAND Journal of Economics* 29, 654–79.

O'Donoghue, Ted, Suzanne Scotchmer, and Jacques-François Thisse, 1998, Patent breadth, patent life and the pace of technological progress, *Journal of Economics and Management Strategy* 7, 1–32.

OIG - U.S. Department of Commerce Office of Inspector General, 2004, United States Patent and Trademark Office – USPTO should reasses how examiner goals, performance appraisal plans, and the award system stimulate and reward examiner production, Final Inspection Report No. IPE-15722, available at `http://www.oig.doc.gov/oig/reports/2004/USPTO-IPE-15722-09-04.pdf`.

OIG - U.S. Department of Commerce Office of Inspector General, 2006, Top 10 management challenges, Semiannual report to Congress, available at `http://www.oig.doc.gov/oig/reports/other_publications/March%202006%20Ch%allenges.pdf`.

Oxoby, Robert J., 2002, Status characteristics, cognitive bias, and incentives in teams, *Journal of Socio-Economics* 31, 301–316.

Oyer, Paul, 2004, Why do firms use incentives that have no incentive effects?, *Journal of Finance* 59, 1619–1649.

Paarsch, Harry J., and Bruce Shearer, 2000, Piece rates, fixed wages, and incentive effects: Statistical evidence from payroll records, *International Economic Review* 41, 59–92.

Parent, Daniel, 1999, Methods of pay and earnings: A longitudinal analysis., *Industrial & Labor Relations Review* 53, 71–86.

Pekkarinen, Tuomas, and Chris Riddell, 2006, Performance pay and earnings: Evidence from personnel records, IZA Discussion Paper No. 2253.

POPA - Patent Office Professional Association, 2006, Union and agency collaborate, reach agreement, available at: `http://www.popa.org/pdf/newsletters/2006_07.pdf` Newsletter.

Prendergast, Canice, 1993, The role of promotion in inducing specific human capital acquisition, *Quarterly Journal of Economics* 108, 523–534.

Prendergast, Canice, 1999, The provision of incentives in firms, *Journal of Economic Literature* 37, 7–63.

Prendergast, Canice, 2000, What trade-off of risk and incentives?, *American Economic Review Papers and Proceedings* 90, 421–425.

Prendergast, Canice, 2002a, The tenuous trade-off between risk and incentives, *Journal of Political Economy* 110, 1071–1102.

Prendergast, Canice, 2002b, Uncertainty and incentives, *Journal of Labor Economics* 20, S115–S137.

Prendergast, Canice, and Robert H Topel, 1996, Favoritism in organizations, *Journal of Political Economy* 104, 958–978.

President of the European Patent Office, 2005, The increased voluminosity of patent applications received by the EPO and its impact on the European Patent System, document for the Administrative Council CA/73/05 , available at `http://ac.european-patent-office.org/strategy_debate/documentation/index.en.php`.

Quillen, Jr., Cecil D., and Ogden H. Webster, 2001, Continuing patent applications and performance of the U.S. patent office, *Federal Circuit Bar Journal* 11, 1–21.

Reitzig, Markus, 2004, What do patent indicators really measure?, available at `http://www.druid.dk/ocs/viewpaper.php?id=10&cf=1`.

Rosen, Sherwin, 1974, Hedonic prices and implicit markets: Product differentiation in pure competition, *Journal of Political Economy* 82, 34–55.

Rosen, Sherwin, 1986, The theory of equalizing differences, in O. Ashenfelter, and R. Layard, ed.: *Handbook of Labor Economics*, vol. 1 . chap. 12, pp. 641–692 (Elsevier Science/North Holland: Amsterdam).

Rothschild, Michael, and Joseph Stiglitz, 1976, Equilibrium in competitive insurance markets: An essay on the economics of imperfect information, *Quarterly Journal of Economics* 90, 629–649.

Sampat, Bhaven N., 2004, Examining patent examination: An analysis of examiner and applicant generated prior art, Georgia Institute of Technology, working paper.

Sanyal, Paroma, 2005, Peanut butter patents versus the new economy: Does the increased rate of patenting signal more invention or just lower standards?, available at `http://ideas.repec.org/p/wpa/wuwpio/0504013.html`.

Scotchmer, Suzanne, 1996, Protecting early innovators: Should second-generation products be patentable?, *RAND Journal of Economics* 27, 322–331.

Scotchmer, Suzanne, 1999, On the optimality of the patent renewal system, *RAND Journal of Economics* 30, 181–196.

Scotchmer, Suzanne, and Jerry Green, 1990, Novelty and disclosure in patent law, *RAND Journal of Economics* 21, 131–146.

Seabright, Paul, 2000, Skill versus judgement and the architecture of organisations, *European Economic Review* 44, 856–868.

Seabright, Paul, 2002, Blood, bribes and the crowding-out of altruism by financial incentives, mimeo, avaialable at `http://idei.fr/doc/by/seabright/blood_bribes.pdf`.

Shavell, Steven, 1979, Risk sharing and incentives in the principal and agent relationship, *Bell Journal of Economics* 10, 55–73.

Shearer, Bruce, 2004, Piece rates, fixed wages and incentives: Evidence from a field experiment, *Review of Economic Studies* 71, 513–534.

Simon, Herbert A., 1947, *Administrative Behavior: A Study of Decision-Making Processes in Administrative Organizations* (Macmillan: New York).

Spence, Michael, 1973, Job market signaling, *Quarterly Journal of Economics* 87, 355–374.

Strel, Biserka, 1997, Obtaining a patent in Slovenia, *World Patent Information* 19, 31–35.

Taylor, Frederick W., 1911, *The Principles of Scientific Management* (Harper Bros.: New York).

The Trilateral Co-operation, 2004, Trilateral statistical report, Available at http://www.trilateral.net/tsr/tsr_2004/.

Townsend, Robert M., 1979, Optimal contracts and competitive markets with costly state verification, *Journal of Economic Theory* 21, 265–293.

USPTO, 2003, The 21st century strategic plan, available at http://www.uspto.gov/web/offices/com/strat21/stratplan_03feb2003.pdf.

USPTO, 2005, Performance and accountability report for fiscal year 2005, available at http://www.uspto.gov/web/offices/com/annual/2005/2005annualreport.pdf.

USPTO, 2006, Interim adjustments to the 21st century strategic plan, available at http://www.uspto.gov/web/offices/ac/comp/budg/iad-strat.pdf.