Efficient Compensation for Employees' Inventions. An Economic Analysis of a Legal Reform in Germany.[†]

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Abstract

The German law on employees' inventions requires employees to report to their employer any invention made in relation with the work contract. An employer claiming the right to the invention is obliged to pay a compensation to the employee. Up to now, this compensation is a matter of negotiations. A reform proposal seeks to introduce a combination of a fixed payment and a share of the project value. Regulations like this can also be found at U.S. universities. Up to now, German scholars enjoyed the privilege of not having to report their inventions to their universities. The new German law concerning inventions made by university scholars has abolished this privilege. Universities now have the right to claim the invention in exchange for a mandatory 30-percent share of the project value.

Our model draws on Principal-Agent theory and combines elements of moral hazard and hold-up. We derive a unique efficient payment scheme that consists only of a lump-sum payment. We show that freedom to negotiate over the compensation after the invention has been done provides inefficient incentives. Efficient incentives would require the compensation to be fixed ex-ante, as it is provided by both the proposed law (concerning employees in general) and the new law (concerning university scholars). However, both set the payment schemes in an inefficient way. With suboptimal incentives to spend effort into inventions, the government's goal, an increase in the number of patents, is likely to be missed.

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Contents

1 Introduction

We analyze a proposed reform of the German law concerning the adequate compensation for employees' inventions.[1] The current law, as well as the proposed reform, requires employees to report to their employer any invention made in relation with the work contract. If, under the current law, the employer claims the rights to the invention, then he is obliged to file for a patent and to pay a compensation to the employee. This compensation is subject to negotiation, yet the parameters that are relevant for bargaining are regulated by accompanying legal rules.

The old law has often led to legal action between the two parties. The federal Government has amended the law by guidelines for the determination of an adequate compensation; even though these guidelines are not binding, many firms seem to try to comply with them.[2] Therefore, the reform proposal aims at introducing a clearly defined compensation scheme. It shall consist of several components: first, the employer is supposed to pay a fixed compensation, the amount of which is independent of the project value. In addition to that fixed payment, the employee is eligible for a share of the project value if it, eight years after the invention, exceeds a threshold.

Regulation provisions like this can also be found at, e.g., several U.S. universities. German scholars, however, did enjoy a privilege under the old law.[3] They were exempt from the obligation to report their inventions to their universities, which had no right to the inventions. This privilege was based on the constitutional right of scholars on the results of their research. The reform of this part of the old law has already been decided upon in the German Bundestag.[4] From now on, German scholars have to report their inventions to their universities; if the university claims the right on the invention, it has to file for a patent.

There is an enormous body of literature concerning patent law in general,[5] but only little attention has been paid to the incentive effects of the employers' property rights to their employees' inventions. Our model aims at filling this gap, drawing on Principal-Agent theory, combining elements of moral hazard

[1] "Gesetz über Arbeitnehmererfindungen" (ArbEG). The draft of the proposal was published by the German Federal Department of Justice on October 25th, 2001, in German language, download under *http://www.bmj.bund.de/images/10333.pdf*.

[2] The guidelines propose to take into account three criteria: the compensation is proposed to be low if the employee is a) ordered to make inventions, b) has enjoyed many helpful resources of the employer, and has contributed only a small amount of knowledge, and c) if the hierarchical position of the employee is intermediate. See Kesten (1996, 657), who gives an extensive and critical analysis of the guidelines. See also Schade/Schippel/Reimer (1993) for the lawyers view on the law and the guidelines.

[3] See §§42 f. of the ArbEG.

[4] "Gesetz zur Änderung des Gesetzes über Arbeitnehmererfindungen", Bundesgesetzblatt Teil I, Nr. 4, January 24th 2002. The initiative of the Federal Government is published as Bundestags-Drucksache 14/7565, Nov. 23rd, 2001, *http://www.ipjur.com/data/1407565.pdf*, which is identical with the initiative of the parties that support the Federal Government (Social Democrats, Green): Bundestags-Drucksache 14/5975, May 5th, 2001, *http://www.ipjur.com/data/1405975.pdf*.

[5] See Kitch (1998) for an overview.

and hold-up. We derive a unique efficient payment scheme that consists of a lump-sum payment only. We show that freedom to negotiate over the compensation after the invention has been made provides inefficient incentives for the employees to spend effort into inventions.[6]

Insofar, our result deviates from Brockhoff (1997), who argues informally that "collective regulation" (by legislation) are neither necessary, nor effective in order to motivate employees to make inventions. Individual agreements or collective agreements (on the firm level) are preferable.[7] According to our model, a collective ex-ante agreement is necessary to implement efficient effort. Negotiations over the compensation if the invention already has been made put the employer into a hold-up position; if this is anticipated by the employee, his incentives to spend effort into making the invention in the first place are suboptimal.

Insofar, the reform points towards the right direction. However, efficient incentives would also require the compensation to be strictly increasing in the project value. Thus, the compensation level in the proposal is suboptimal in most cases and can only be judged as a second-best solution.

In the second section of this paper we introduce the notation of the model and two different games that describe the possible interaction between employer and employee. In the first game, the payment scheme is fixed ex ante when the interaction starts, in the second game, the parties negotiate about the compensation scheme after the invention has been made. We also derive the socially optimal solution and demonstrate under which conditions the optimal solution is the equilibrium of the two games we analyze. The numerical example in section three highlights the abstract results of section 2. In section 4, we apply the theoretical results to the reform proposal concerning employees in general, and to the new law concerning university scholars in Germany. In section 5, we discuss some assumptions of our model and draw conclusions.

2 Our model

2.1 Outline of the model

We consider an interaction between two players, the employee (denoted as E) and the Firm (F) that has employed E. The timing of events and actions is as follows:

1. E decides about his effort, denoted as e with $e \in [0, 1]$, to spend into a research project.[8] Effort raises cost, denoted as $c(e)$, with $c(0) = 0$,

[6]Thus, our model follows the view of Kitch (1977, 265) who points out that the function of the patent law is to increase the output from resources devoted to technological invention.

[7]See Brockhoff (1996, 685).

[8]Note that our model is not only applicable to the case of an employee who does research as his main job. It also covers the case of an employee who makes an invention by chance, but has to spend some effort in order to evaluate what he has discovered. His outside option

$dc/de > 0$, $dc(0)/de = 0$, and $d^2c/de^2 \geq 0$.

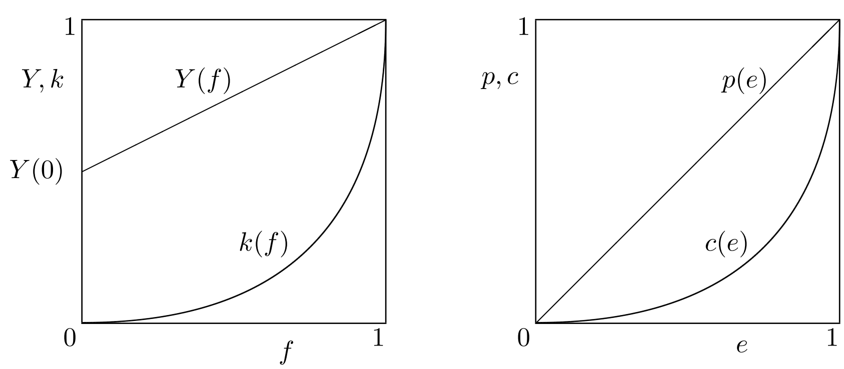
2. A chance move decides whether the project is successful or not. The probability of success is denoted as $p(e)$, with $dp/de > 0$ and $d^2p/de^2 \leq 0$. Thus, the probability of an unsuccessful project is $1 - p(e)$. In this case the game ends.

3. If the project turns out to be successful, then F decides whether to claim the invention or not. If not, then the game ends.

4. If F decides to claim the results, then she chooses her effort to promote the project (and thereby to further increase its value). We denote this effort as f, with $f \in [0,1]$, and the value of a successful project as $Y(f)$, with $Y(0) > 0$ and $dY/df > 0 > d^2Y/df^2$. $Y(0)$ is the value of a successful project that E is left alone with. F's effort also raises cost, denoted as $k(f)$, with $k(0) = 0$, $dk(0)/df = 0$ and $dk/df > 0 \leq d^2k/df^2$ for $f > 0$.

These assumptions can be interpreted in a way that both parties' effort causes convex cost and a concave output. The output generated by E's effort is the success probability, and the output generated by F's effort is the additional project value. Both of these outputs contribute to an increase in the expected project value. The differences $Y(f) - k(f)$ and $p(e) - c(e)$ are both concave functions. Let us furthermore assume that Y(f), k(f), p(e), and c(e) are twice differentiable and continuous. **Figure 1** demonstrates examples for the assumed input and output functions of the two parties.[9]

Figure 1: Inputs and outputs of F and E



would be to simply neglect the discovery.

[9]The functions used in figure 1 are identical with those used in the example in section 3 below.

We assume the parties to be rational and risk-neutral, hence they maximize their expected monetary payoff. If the project is not a success, then the parties' payoffs amount to $-c(e)$ for E and 0 for F. If the project is successful, and F does not claim the research results, then the payoffs are $Y(0) - c(e)$ for E and 0 for F. In case of a cooperation between F and E, the parties' payoffs depend on the payment F has to make in order to obtain the project results. We limit our view to payment schemes that consist of two components, a fixed part (denoted as Φ), and a share of the final project value (denoted as α, with $\alpha \in [0, 1]$). Thus, the payoffs of the parties in case of cooperation are $\alpha Y(f) + \Phi - c(e)$ for E and $(1-\alpha)Y(f) - \Phi - k(f)$ for F.[10] In the subsequent analysis, we distinguish three cases how these payment parameters can be determined:

- in section 2.2 we derive the first-best efforts, neglecting possible conflicts between E and F as well as the structure of the interaction;
- in section 2.3 we examine the case in which the payment parameters are exogenously given (be it by a third party, e.g. a regulator, or by an ex-ante agreement between E and F);[11]
- in section 2.4, we assume that the parties negotiate over the payment parameters as soon as the project has turned out to be successful, i.e. during stage 3 of the interaction described above.

2.2 First-best solution

In this section we derive the socially optimal strategies for F and E. The decision of player F to purchase the results of E's research has no impact on the social value of the project: if F's effort is productive, then it is socially optimal that her investment is made, regardless of who owns the project returns. The social value only depends on the employee's investment into the success probability and the firm's promotion of the project value. As the (expected) social benefit, we define the sum of the parties' payoffs, irrespective of the positive analysis of the interaction. We denote the expected social benefit as $\Sigma(e, f)$. The optimal effort of the two parties is determined by

$$(e^*, f^*) = \arg\max \; p(e)[Y(f) - k(f)] - c(e) \tag{1}$$

which leads to our first result.

Lemma 1: e^* and f^* satisfy the following conditions:

[10] Thus, it is assumed that motivation is mainly extrinsic. See Orbach (2002, 93) for a discussion of intrinsic motivation in the context of employees' inventions.

[11] Thus, we do not analyze the setting of the payment parameters in this paper, but limit our view to the interaction, given these parameters. For now, we would simply assume that the parties or the Government have incentives to choose the payment that implements efficient effort. The positive analysis of the pre-interaction stage would be worth a sequel paper.

$$\frac{dc(e^*)/de}{dp(e^*)/de} \stackrel{!}{=} Y(f^*) - k(f^*) \tag{2}$$

and

$$\frac{dY(f^*)}{df} \stackrel{!}{=} \frac{dk(f^*)}{df} \tag{3}$$

Proof: straightforward.

Furthermore, we can derive that the optimal efforts of the parties are positive:

Proposition 1: $e^*, f^* > 0$.

Proof: see Appendix.

Thus, some cooperation between the parties is socially desirable. This implies that, even under the rather general assumptions we made, any equilibrium without cooperation cannot be optimal. Leaving aside strategic considerations, the parties should always be able to benefit from an agreement. In section 3.1 we present a more specific model that enables us to derive exact values of (e^*, f^*). This will allow us to compute the value of $\Sigma(e^*, f)$ as well.

Note that, if the condition in Proposition 1 if fulfilled, this does not imply that F actually claims the project and chooses her optimal effort. Even if her contribution to the project value is socially desirable, her individual incentives may keep her from doing so. Her actual decision only depends on her incentives and not on the social desirability of her options.

2.3 Equilibrium if payment is exogenously given

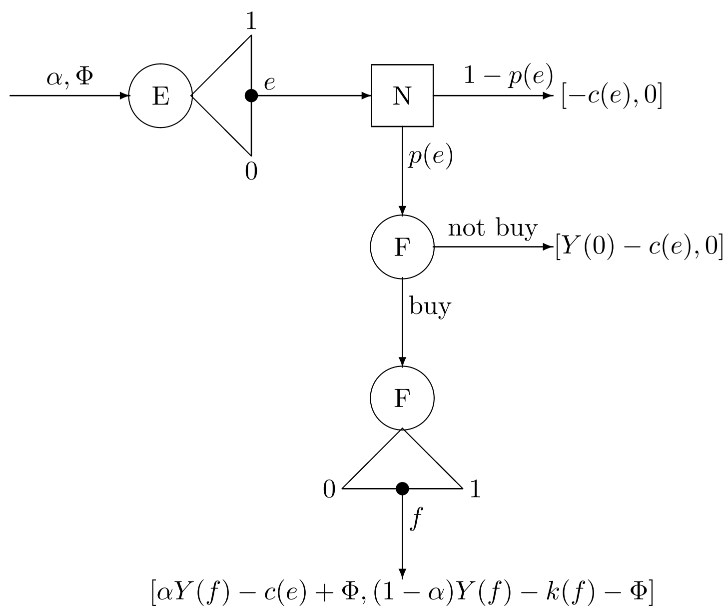
In this section, we assume that the payment components α and Φ are set exogenously. This can have been done by a contract between F and E, by a collective wage agreement, or by governmental regulation.

Figure 2 demonstrates the interaction. At the beginning of the game, the players E and F know the exogenous values of the payment parameters α and Φ. First, E chooses the effort e, then "Nature" (N) chooses the success of the project. In case of success, F decides whether to buy or not, and in case she has bought the project, she chooses her effort f. We denote the equilibrium strategy profile as $(\hat{e}, buy, \hat{f})$. Lemma 2 states the conditions under which optimal efforts (as derived in the previous section) are implemented, i.e., ($\hat{e} = e^*$ and $\hat{f} = f^*$).

Lemma 2: If the payment parameters are exogenously given, then $\alpha = 0, \Phi = Y(f^*) - k(f^*)$ is the only parameter combination that implements the first-best solution (e^*, buy, f^*).

Proof: See Appendix.

Figure 2: Game with exogenous payment parameters (α, Φ)



The result of Lemma 2 is rather obvious as far as it concerns the variable component of the payment. If an invention turns out to be successful, E takes over the role of the principal in a Principal-Agent-relationship with F. Then, F is the agent who needs incentives to spend efficient promotional effort. In such a simple Principal-Agent setting with two risk-neutral actors, a "sell the shop" contract is clearly efficient. This contract is realized by setting $\alpha = 0$, since this makes F the residual claimant of the project.

More surprising is the result according to which the efficient fixed wage is unique. In the most simple Principal-Agent setting, any fixed wage would be efficient, and it is the assumed first-mover advantage of the principal that allows him to claim the whole cooperation rent as a (negative) fixed wage in equilibrium.[12] In our model, only the complete transfer of the cooperation rent to the principal E is efficient, since this is required to implement incentives for E to spend efficient effort into research.

A straightforward consequence of Lemma 2 is that the principal E collects the highest possible payment if α and Φ are set efficiently. Any $\alpha \neq \alpha^*$ would implement less than efficient effort on F's side, which leads to a smaller than

[12]Inderst (2002) points out that the first-mover advantage is an assumption according to which the bargaining power is assigned to the Principal only. The paper relaxes this assumption in the context of a hidden-type model.

efficient net value of F's contribution. This net value is the maximum possible fixed payment, since F would otherwise choose not to buy the project. This result is

> **Proposition 2:** If $\Phi < \Phi^*$ and $\alpha > \alpha^*$, the total payment to E is smaller than in the efficient case.

2.4 Equilibrium if parties bargain over payment

Now we assume that the payment components α and Φ are subject to negotiation as soon as the project of E has turned out to be successful. In other words, the contract between F and E has to be specified after the research has been done. **Figure 3** demonstrates this interaction. At the beginning of the game, E chooses effort e and "Nature" (N) chooses the success of the project. In case of success, E and F bargain over the payment scheme. We employ the symmetric Nash bargaining solution, according to which the parties share the net benefit of an agreement evenly. If an agreement is closed, then F may decide upon her effort f. We denote the equilibrium strategy profile as $(e^n, f^n, \alpha^n, \Phi^n)$. Lemma 3 states the predicted result for these negotiations.[13]

> **Lemma 3:** If the payment parameters are subject to bargaining, then the parties choose $\alpha^n = 0$, $f^n = f^*$. The predicted fixed payment component is
>
> $$\Phi^n = \frac{Y(f^*) - k(f^*) + Y(0)}{2} \tag{4}$$
>
> and e^n satisfies the condition
>
> $$\frac{dc(e^n)}{de} \stackrel{!}{=} \Phi^n \tag{5}$$

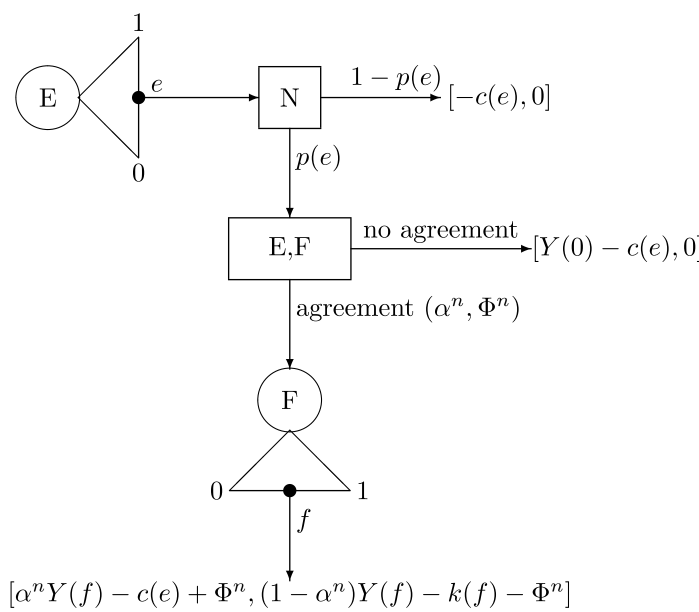
2.5 Comparison of the results

Obviously, it is a simple task for either a regulator or the parties of an ex-ante agreement concerning α and Φ to implement the first-best effort. To determine the equilibrium payment scheme via negotiations, however, appears to be more demanding. Proposition 3 demonstrates that the efficient outcome is unlikely to occur if the payment parameters are subject to negotiations.

> **Proposition 3:** If the parties negotiate about the payment scheme, then the negotiated variable payment is efficient ($\alpha^n = \alpha^*$), whereas the negotiated fixed payment is smaller than the efficient one, i.e., $\Phi^n < \Phi^*$.
>
> **Proof:** see Appendix.

[13] The proof is in the Appendix.

Figure 3: Game with negotiation over payment parameters (α, Φ)



Proposition 3 says that the agreed upon fixed payment will only be greater than (or equal to) the fixed wage that implements efficient effort $e = e^*$ if the net gain derived out of F's contribution is negative, i.e., if cooperation is not beneficial. On the contrary, if the contribution of F to the project's value is beneficial, then the agreed upon wage Φ^n is smaller than the efficient Φ^*. Note that this result would also be true if a asymmetric Nash solution is applied, as long as the Agent F has at least some bargaining power. Only in case the bargaining power of F is zero, negotiations over Φ would lead to the efficient solution. The effect on E's effort choice is described in Proposition 4.

> **Proposition 4:** If the parties negotiate about the payment scheme, then the effort of E is suboptimal low $(e^n < e^*)$.
>
> **Proof:** straightforward consequence of Lemma 3 and Proposition 3.

Due to the assumptions made in the outline of the model, the optimal effort choice of E is suboptimal small if he anticipates the negotiation result $(\alpha^n = 0, \Phi^n < \Phi^*)$. While the exogenously given payment scheme can be set (by ex-ante agreement or by law) such that first-best efforts are implemented on both sides, the freedom to negotiate over the payment scheme leads to suboptimal payoff on E's side. Therefore, the freedom to negotiate leads to a smaller social benefit, compared to a world in which the payment scheme is fixed before E chooses his effort. This result which is similar to hold-up or renegotiation.

3 An example

3.1 Parameter setting and social optimum

Making use of the following specifications, in this section we derive concrete results of our model: let the probability of success be $p(e) = e$ and E's cost function be $c(e) = e^2$. Set furthermore $k(f) = f^2$ and $Y(f) = 0.5 + 2f$. Thus, the project value without a contribution by the firm is $Y(0) = 0.5$. These settings are in accordance with the outline of the model in section 2.1.

If, F chooses "buy", then her optimal effort, according to Lemma 1, satisfies the following condition:

$$2 = 2f^*.$$

Thus, $f^* = 1$. The optimal effort of the employee satisfies

$$0.5 + 2f^* - f^{*2} \stackrel{!}{=} 2e^*.$$

Given $f^* = 1$, this conditions yields $e^* = 3/4$.The social benefit then is computed as

$$\Sigma(3/4, 1, buy) = \frac{3}{4}\left[\frac{1}{2} + 2 - 1\right] - \frac{9}{16} = \frac{3}{8} - \frac{9}{16} = \frac{9}{16}.$$

If, on the other hand, F were choosing "not" to claim the invention, then the optimal effort of E would satisfy

$$0.5 \stackrel{!}{=} 2\tilde{e}$$

which yields $\tilde{e} = 1/4$. Anticipating "not", E's optimal effort would be smaller than the optimal effort if "buy" were anticipated (namely e^*). In this case, the social benefit would amount to

$$\Sigma(1/4, 0, not) = 1/4 * 1/2 - 1/16 = 1/16.$$

Comparison of the two cases shows clearly that "buy", combined with e^* and f^*, is welfare superior.

3.2 Exogenously fixed payment scheme

We now turn to the positive analysis of our example. Let us start with the case in which the payment scheme is exogenously given. This model allows to derive the payment parameters that implement highest social benefit. Using Lemma 3, we already know that $\alpha = 0$ is necessary to motivate F to choose $f = f^* = 1$. The optimal fixed component Φ^* implements optimal effort on E's side, namely $e^* = 3/4$, if

$$\Phi^* = Y(f^*) - k(f^*) = 0.5 + 2 - 1 = 3/2.$$

Thus, the payment scheme ($\alpha = 0, \Phi = 3/2$) implements optimal effort (and F's decision to buy). The expected social benefit then is $\Sigma(3/4, 1, buy) = 9/16$. This surplus is distributed rather unevenly among F and E: While F receives zero, E "skims" the complete social (net) benefit.

3.3 Negotiation over payment parameters

If the parties bargain over a wage agreement, then the optimal variable payment parameter α is zero, as we have shown in Lemma 3, since this is necessary to implement f^* in order to produce the greatest possible social benefit. When bargaining, the parties thus set $\alpha = 0$ and anticipate $f = 1$ in case of an agreement. The generated output is divided among the parties by the negotiated fixed payment Φ^n. Thus, an agreement would yield $\Phi - e^2$ as the individual payoff for E (note that, at the time of the negotiations, E's effort e is already sunk), and $0.5 + 2 - 1 - \Phi = 3/2 - \Phi$ for F.

The non-agreement payoffs (or threat points) are $0.5 - e^2$ for E and zero for F. Therefore, negotiation over the fixed payment maximizes the following Nash product:

$$[(\Phi - e^2) - (0.5 - e^2)] \cdot [(1.5 - \Phi) - 0] = [\Phi - 0.5] \cdot [1.5 - \Phi]$$

Thus, the symmetric Nash bargaining solution is the fixed payment Φ^n with

$$\Phi^n = \arg\max \ (\Phi - 0.5)(1.5 - \Phi)$$

which yields (in accordance to Lemma 3) $\Phi^n = 1$. Obviously, the bargaining result is much smaller than the socially optimal fixed payment: $\Phi^n < \Phi^*$. The anticipation of this bargaining result motivates E to choose an effort e^n that satisfies

$$e^n = \arg\max \ e \cdot \Phi^n - e^2 = \frac{1}{2}$$

with $\Phi^n = 1$. This effort choice is smaller than $e^* = 3/4$. This effect is a consequence of Assumption 1, according to which the yield function of E is concave. The expected social benefit generated by the bargaining solution is

$$\Sigma(1/2, 1, buy) = p(e^n)[Y(f^*) - k(f^*)] - c(e^n) = 3/4 - 1/4 = 1/2.$$

Obviously, this surplus is smaller than the one under exogenously fixed payment parameters. However, the smaller social benefit is distributed more evenly: Both parties receive 1/4.

An interesting conclusion is that, despite it being inefficient, negotiation over payment schemes, compared to exogenously fixed payment parameters, seems to be in F's interest. The firm collects a much greater piece of a smaller cake.

The negotiation rule leaves room for Pareto-improvements which cannot be internalized, due to the sequential structure of the game (an internalization would require to include an agreement about E's effort into the bargaining package). Furthermore, the comparison of the two social outcomes allows to calculate the social cost of the freedom to negotiate as $\Sigma(3/4, buy, 1) - \Sigma(1/2, buy, 1) = 1/8$.

4 Analysis of the German reform proposal

In this section, we make use of the results derived in section 2 above, and evaluate the two German legal reforms under scrutiny: the proposed reform of the complete law on employees' inventions, concerning employees in general, and the new legislation concerning university employees only. The latter has already passed the German Bundestag. Compared to the old law, both these reforms do not anymore require the parties to negotiate about the compensation, which is clearly an advantage in terms of efficiency. However, the payment parameters set are suboptimal in both cases.

4.1 The proposed reform for non-university employees

According to the draft of the legislative proposal that was published by the German Federal Ministry of Justice, an employee who makes an invention has to reveal this to his employer. If the employer claims the rights to the invention, the employee is entitled to a financial compensation in three steps:

1. 750 Euro immediately;
2. 2,000 Euro 3.5 years after the employer has claimed the invention;[14]
3. a share of the returns if the project exceeds a threshold value.[15]

Leaving aside the fact that the fixed payment is due in two parts, it amounts to 2,750 Euro in case the employer makes use of the invention, and only 1,250 Euro if he has claimed it in order not to use it. Thus, in both cases, the fixed payment is independent of the actual project value or of the net value of the employer's contribution. As we have shown above, the efficient fixed wage equals this net value: $\Phi^* = Y(f^*) - k(f^*)$. Obviously, this efficiency criterion is met by the legal provision only in exceptional cases.

In cases where the law prescribes a fixed payment that is higher than the efficient one, the employer will not claim the invention even though his effort contribution

[14] If the employer has claimed the invention, but does not make use of it, i.e. if he stores it as a business secret, then the employee is entitled to an additional payment of 500 Euro only.

[15] Returns greater than 5,000,000 Euro, or profit greater than 125,000 Euro eight years after the invention was claimed.

may be efficient. In cases where the legal fixed payment is smaller than the efficient one, the employee is motivated to spend less than the efficient amount of effort.

The third payment component in the proposal adds another distortion: The employee is entitled to a share of the project returns. Even though the occurrence of this share is uncertain, the expected value is positive and therefore exceeds the efficient share ($\alpha^* = 0$). A positive share of the (expected) returns induces the firm to spend less than efficient effort.

Compared to the old law, the reform proposal helps to save legal costs by introducing a certain standard. This standard, however, is inefficient in most cases. It is an empirical question whether the legal costs of the old system or the inefficiency of the new proposal lead to higher losses.

4.2 The special law concerning university employees

The current German law contains a privilege concerning inventions made by university scholars. According to this rule, professors did not have to announce their inventions to their employer, the university. In particular, the university did not have any right to the invention.

Even though the reform proposal discussed above has not been brought into the German parliament yet, a law on this particular privilege has already passed the German Bundestag recently. The new regulation provides a right for the universities to any invention made by university employees (not only scholars), and introduces a payment scheme that is different from the one for employees in general. The employee receives 30 percent of the returns, and no fixed fee.

In the terms of our model, the new law sets $\Phi = 0$ and $\alpha = 0.3$. According to our analysis, this implements too little effort on the employers side: $f < f^*$. In addition to this, Proposition 2 demonstrates that the incentives for the employee are suboptimal as well, since the resulting payment will be smaller than the efficient fixed fee.

The main idea why the Federal Government has brought forward this legal initiative was its concern that the number of patents, compared to the number of inventions made at the universities, is too small nowadays. Two reasons for this are considered: First, the universities do not have installed patent bureaus yet; the shift of property rights shall induce them to build up such institutions. If patent files are a matter of scale economies, then this idea may lead to efficiency.

The second problem is that researchers often have no interest in filing for a patent, but rather want to publish their results in scientific journals. According to German law, a patent on already published results cannot be granted (the published results are considered “state of the art”). Furthermore, the German constitution grants researchers a basic right to their scientific results. While the shift of the patent rights to the universities is not considered a violation of the researchers constitutional rights, an obstacle for publication would certainly be a violation. The new law, therefore, allows the researcher to publish his results after a period of two months after the university has filed for a patent.[16] This procedure intends to make both filing for patent and scientific publication of the results possible.

The explicit intention of the new law is to increase the number of patents. However, the incentive structure of the new law leads to inefficient effort. Thus, the total number of inventions may decrease, and the total number of patents may decrease even if the rate of patents increases substantially.

5 Conclusion

We have analyzed a sequential interaction between an employee E (who is engaged in research and may produce an invention) and an employer F (who may purchase the invention in case of a successful project). We have distinguished two institutional settings, namely exogenously fixed payment schemes vs. negotiation over payment after the project has turned out to be successful.

We have set up a simple Principal-Agent model with complete information and two risk-neutral players. In both settings, we have derived the optimal marginal payment to E that implements the optimal effort of the agent F. In both cases, the optimum is zero. However, there is a clear difference in the outcomes as to the fixed payment and the effort of E. Under negotiation (as well as renegotiation over exogenously fixed payment), both the agreed upon fixed payment and E's effort are smaller than optimal.

Thus, the optimal contract between employer F and employee E should give F the residual claim to the project value. This motivates F to invest efficient effort into the promotion of the project, which generates the maximum cooperation rent. E should receive a fixed fee (in case of a successful invention) that equals the net value of this cooperation rent. Neither a variable payment, nor ex-post negotiations implement efficient effort on both sides.

Our analysis demonstrates that both laws, the new one concerning universities, and the proposed one concerning employees in general, sets inefficient incentives to spend effort into inventions. Thus, the goal of the law-makers (Federal Government, majority coalition in the German Bundestag), i.e. to increase the number of patents in Germany, is likely to fail: perhaps the new legislation increases the rate of patents, but the number of inventions can be expected to decrease. If the number of inventions decreases stronger than the rate of patents is increased, then not only the number of inventions, but even the number of patents will be decreased by the new laws.

[16] A proposal made by the legal committee of the German Bundestag, see Bundestags-Drucksache 14/7573, Nov 26th, 2001, *http://dip.bundestag.de/btd/14/075/1407573.pdf*.

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Appendix

Proof of Proposition 1

$f^* > 0$ follows from Lemma 1 and the assumptions $dY(0)/df > 0 \geq d^2Y/df^2$ and $dk(0)/de = 0$. Furthermore, recall that $Y(0) - k(0) = Y(0) > 0$ and $Y(f^*) - k(f^*) > Y(0)$; hence, $e^* > 0$ is implied by Lemma 1, q.e.d.

Proof of Lemma 2

When choosing her effort f, F solves the following maximization problem:

$$\max_f \ (1-\alpha)Y(f) - k(f) - \Phi$$

The first-order condition is

$$(1-\alpha)\frac{dY}{df} - \frac{dk}{df} \stackrel{!}{=} 0.$$

The second-order condition guarantees a maximum:

$$(1-\alpha)\frac{d^2Y}{df^2} - \frac{d^2k}{df^2} < 0.$$

Comparison of the first-order condition with the second condition of Lemma 1, i.e. equation (3), shows that f^* is implemented if, and only if, $\alpha = 0$.
F prefers buy over not buy if, and only if, $(1-\alpha)Y(f) - k(f) - \Phi > 0$. Given $\alpha = 0$, this implies that

$$\Phi < Y(f^*) - k(f^*)$$

Given $\alpha = 0$ and $\Phi < Y(f^*) - k(f^*)$, E chooses his effort by solving the following maximization problem:

$$\max_e \ p(e)[\alpha Y(f^*) + \Phi] - c(e)$$

which yields the first-order condition

$$\frac{dp}{de}\Phi - \frac{dc}{de} \stackrel{!}{=} 0$$

The second-order condition $\Phi d^2p/de^2 - d^2c/de^2 < 0$ guarantees a maximum. The first-order condition is equivalent to

$$\frac{dc/de}{dp/de} \stackrel{!}{=} \Phi$$

Comparison of this expression with the first part of Lemma 1, i.e. equation (2), demonstrates that E is motivated to spend optimal effort if, and only if, $\Phi = Y(f^*) - k(f^*)$, q.e.d.

Proof of Lemma 3

Given a bargaining result (α^n, Φ^n), F solves the same maximization problem as demonstrated in the proof of Lemma 2. Thus, it is only $\alpha^n = 0$ that would implement optimal effort f^*. Hence, the bargaining problem is reduced to determine Φ^n. Given $\alpha = 0$, the symmetric Nash bargaining solution maximizes the Nash product

$$[\Phi^n - c(e) - Y(0) + c(e)] \cdot [Y(f^*) - k(f^*) - \Phi^n - 0]$$

which can be reduced to $[\Phi^n - Y(0)][Y(f^*) - k(f^*) - \Phi^n]$. This Nash product is maximized by

$$\Phi^n = \frac{Y(f^*) - k(f^*) + Y(0)}{2},$$

q.e.d.

Proof of Proposition 3

Recall that, according to Lemma 2, the optimal effort e^* is implemented if, and only if, $\Phi^* = Y(f^*) - k(f^*)$. Recall furthermore that, by assumption, $Y(f^*) - k(f^*) > Y(0)$, which implies $\Phi^* > 0$. The comparison of the results in Lemma 2 and 3 therefore yields $\Phi^n < \Phi^*$, q.e.d.