On the Benefits of Withholding Knowledge in Organizations*

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Abstract

Transferring knowledge to an agent makes him more successful or productive, which is beneficial for the principal. However, knowledge transfer also increases the agent’s outside option. I identify two reasons for withholding knowledge – to reduce labor costs within a principal-agent relationship, and to weaken the agent in case of a separation. Moreover, the role of synergy is discussed both for building up a principal-agent relationship and for transferring knowledge. While synergy is decisive for knowledge transfer, cooperation between the principal and agent may even take place in the absence of synergy. Furthermore, I analyze whether the principal is more likely to transfer knowledge to a more able or to a less able agent. Finally, the advantages and disadvantages of a noncompetition clause are briefly discussed.

JEL classification: J3, M5.

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1 Introduction

In organizations, an employer or principal often has to decide about transferring knowledge to his agents. This knowledge may be about customers, about technology, or about competitors. However, the principal faces the following dilemma: on the one hand, more knowledge would make the agent more productive, which is beneficial from the principal’s point of view. On the other hand, knowledge transfer may raise the probability that the agent uses the knowledge to separate from the principal and to become a strong competitor.

In practice, we can find a long list of examples for such a separation between the principal and the agent: employed consultants or lawyers may separate to become self-employed and compete in the same market as their former employers. The same can happen with physicians, physiotherapists, or craftsmen. Rajan and Zingales (2001: 806) mention the interesting example of Integrated Electronics (Intel). Its founders, Robert Noyce and Gordon Moore, both previously worked for Fairchild Semiconductors where Moore’s R&D department developed the silicon-gate technique, now a key part of Intel’s product line. Rajan and Zingales also report that 71 per cent of the Inc 500 firms was founded by people using new ideas that had been developed at their former places of employment.

In this paper, I identify two reasons for withholding knowledge: (1) knowledge transfer increases the agent’s outside option and consequently the premium he can demand when signing a contract. If the enhanced-productivity effect is dominated by this distribution effect, the principal will prefer to
withhold knowledge. (2) If the principal does not want the agent to sign a contract, the agent will become a direct competitor of the principal. In this case, the principal will withhold knowledge to discourage his new opponent. The analysis of the model will show that both reasons are completely unrelated because the principal’s decision to hire an agent does not depend on knowledge transfer. In particular, the principal will not reject the agent only because the latter has become too costly for him due to the received knowledge.

Some earlier papers are related to the problem discussed here. Pakes and Nitzan (1983) also consider the case in which an agent is able to set up a rival firm after having received valuable knowledge. However, in the equilibrium of the main model the principal always chooses an optimal wage profile so that the agent will never become self-employed. In the paper by Stewart (1994), the principal cannot decide on the amount of knowledge he wants to transfer. The agent inevitably acquires the knowledge as a consequence of his employee-employer relationship. Stewart focuses on the role of investment by the principal as a precommitment device concerning future market competition. Barcena-Ruiz and Rubio (2000) consider the possibility of an agent becoming self-employed after having received information about the state of nature. In their model, however, the principal has to shut down his firm when the agent separates. The main result shows that the principal will not withhold information if the set-up costs of the agent are sufficiently high. Ronde (2001) emphasizes the importance of dividing labor into different tasks – in contrast to team production – to protect secret knowledge and thus to
limit competition with rival firms. Rajan and Zingales (2001) consider the relationship between the hierarchical structure of a firm and an agent’s incentive to use the firm’s information for a separation. Their results show that human capital-intensive industries consist of flat hierarchies whereas physical capital-intensive industries consist of large and steep ones. Kräkel (2002) discusses knowledge transfer in connection with a very special type of competition, namely contest or tournament competition. His results show that knowledge transfer may be a rational choice although the principal knows that the agent will separate. Here, knowledge transfer induces an implicit cartel between the principal and the agent in the subsequent tournament competition since equilibrium efforts of both principal and agent decrease in the scope of the knowledge transfer. In order to discuss endogenous technological spillovers, Gersbach and Schmutzler (2003a, 2003b) consider the strategic interaction of firms which can recruit workers from each other to acquire additional knowledge.

This paper particularly differs in two aspects from the previous literature: first, most of the theoretical work cited above (e.g. the main model in Pakes and Nitzan (1983), Stewart (1994), Barcena-Ruiz and Rubio (2000)) cannot explain the set up of rival firms in practice because in equilibrium the principal will always discourage a separation of the agent. However, in this paper separation will occur if cooperation with the agent is too costly for the principal. Second, here the principal is not only the party which chooses the optimal contract, he also influences the firm’s probability of being successful. Moreover, there are synergies between the principal and the agent which
add an extra value to the initial employment relationship. Nevertheless, the analysis shows that separation may occur in equilibrium.

The paper is organized as follows: in the next section, a principal-agent model is introduced in which the agent can separate from the principal to become a direct competitor. The optimal contract is derived in Section 3. In Section 4, the role of synergy, symmetry versus asymmetry between principal and agent and the use of a noncompetition clause are discussed. Furthermore, some related cases of knowledge transfer are considered. Section 5 concludes.

2 The model

I consider a principal-agent relationship in which both the risk-neutral principal and the risk-neutral agent can contribute to the success of the joint relationship. Here, success means, for example, the invention of a new product or a new technology, the acquisition of customers, or the acquisition of start-up capital. Being successful is a precondition for entering or staying in a given market. The success probability of the principal is exogenously given by \( s_P \in (0, 1) \). For example, \( s_P \) may be determined by the principal’s human capital or his reputation as incumbent in the market. However, the agent’s success probability \( s_A = k_A \cdot e_A \in (0, 1) \) is endogenously derived, as \( e_A \) denotes the agent’s effort. The variable \( k_A \) describes the knowledge that is transferred to the agent by the principal. The principal can either transfer a high \( (k_A = k_H) \) or a low \( (k_A = k_L < k_H) \) amount of knowledge to the agent. Effort entails costs for the agent which are given by \( c(e_A) = \frac{e_A^2}{2} \). To
guarantee equilibrium efforts that lie between zero and one, $c$ is assumed to be sufficiently large.\(^2\)

The joint success probability of the principal-agent relationship is given by $s_P + s_A - \tau s_P s_A$, where the technology parameter $\tau \in [0, 1]$ determines the degree of synergies between the principal and the agent. If $\tau = 1$, there will be minimal synergy. If, on the other hand, $\tau = 0$, there will exist high synergies between the principal and the agent (e.g. the principal and the agent form a real team and regularly communicate with each other to avoid duplicating the invention).\(^3\) Note that the joint success probability is always positive. To guarantee that the probability is not larger than one, I assume that $s_P + k_H \leq 1$.\(^4\)

The timing of events is as follows: at stage 1, the principal has to choose either $k_A = k_L$ or $k_A = k_H$. For example, we have a kind of probationary or trainee period in which the principal has to decide between withholding ($k_A = k_L$) or disclosing ($k_A = k_H$) knowledge.

At stage 2, the principal makes a take-it-or-leave-it offer $(\alpha, \beta)$ to the agent. $\alpha$ denotes a lump-sum payment by the principal to the agent. $\beta$ describes a bonus to be paid to the agent if he is successful in the sense introduced at the beginning of Section 2, for example, if the agent has invented a new product or a new technology for the principal. Furthermore, the agent is assumed to be wealth-constrained. Hence, a principal-agent model with limited liability is considered ($\alpha \geq 0$).

At stage 3, the agent has to decide between accepting or rejecting the principal’s offer. Then at stage 4, the agent chooses his effort level $e_A$ deter-
mining his success probability \(s_A = k_Ae_A\). A market game follows at stage 5. If the agent accepts the principal’s offer, we have a cooperative situation. Principal and agent form a joint entity and compete against other firms in the market. In this setting, the principal realizes profits \(\pi_P > 0\) with success probability \(s_P + s_A - \tau s_P s_A\), and zero otherwise. Hence, \(\pi_P\) will be the profits earned by the principal if the agent does not enter the market as an additional competitor.\(^5\)

If the agent rejects the offer, we have a competitive situation, i.e. the agent becomes a potential competitor of the principal. Now, there are four possible outcomes: (1) with probability \(s_P(1 - s_A)\), the principal is successful in entering or staying in the market and again gets \(\pi_P\), whereas the unsuccessful agent gains zero. In this case, we have the same market situation as in the case of a principal-agent relationship since again, besides other possible firms, only the principal remains an active competitor. (2) With probability \((1 - s_P)s_A\), the principal fails and gets zero whereas the successful agent enters the market and receives \(\pi_A > 0\). (3) With probability \((1 - s_P)(1 - s_A)\), both players fail and receive zero. (4) With probability \(s_P s_A\), both players are successful. The principal gets \(\hat{\pi}_P\) and the agent \(\hat{\pi}_A\). I assume \(\hat{\pi}_P < \pi_P\) and \(\hat{\pi}_A < \pi_A\) due to the competition between principal and agent.

Note that there are nearly no restrictions on the type of competition, i.e. the values of \(\pi_P, \pi_A, \hat{\pi}_P\) and \(\hat{\pi}_A\) can be generated by many types of oligopoly competition taking place at stage 5. We may for instance assume that successful firms compete on quantities. Then the fifth stage of the game will be a Cournot game. If the principal has a first mover advantage, the values of
$\pi_P$ and $\pi_A$ may result from a Stackelberg game. Similarly, Bertrand competition, a contest or any other kind of a symmetric or asymmetric competitive game between an arbitrary number $n$ (if both the principal and the agent are successful) or $n-1$ (if only one of them is successful) competitors with $n \geq 2$ may take place at this stage. I only assume that each player survives with a certain probability – the principal becomes an active competitor with success probability $s_P$ and the agent with probability $s_A$. Recall that in either situation the agent chooses his effort $e_A$ which then determines his success probability $s_A = k_A e_A$.

### 3 Optimal contract and knowledge transfer

The game is solved backwards beginning with stage 4 in the competitive situation in which principal and agent are opponents, because the agent has rejected the contract offer. The agent chooses his effort to maximize

$$EU_{A,\text{comp}}(e_A) = k_A e_A s_P \pi_A + k_A e_A (1 - s_P) \pi_A - c(e_A).$$

Hence, the optimal effort is described by

$$e_{A,\text{comp}}^* = \frac{k_A S}{c}$$

with $S := s_P \pi_A + (1 - s_P) \pi_A$. We can interpret $S$ as a measure for the agent’s separation incentives, since it describes his expected gains from separating from the principal (i.e. from rejecting the contract offer after having received
knowledge \( k_A \) given that the agent has success in the competitive situation.

Inserting (2) into (1) and into the principal’s expected utility \( EU_{P,\text{comp}} = k_A e_A s_p \hat{\pi}_P + (1 - k_A e_A) s_p \pi_P \) leads to

\[
EU_{A,\text{comp}}^* = \frac{k_A^2 S^2}{2c} \tag{3}
\]

\[
EU_{P,\text{comp}}^* = s_p \pi_P - \frac{s_p k_A^2 (\pi_P - \hat{\pi}_P) S}{c} \tag{4}
\]

Note that (3) defines the endogenous outside option of the agent when the principal has to choose the optimal contract in the cooperative situation.

Now we consider the last stage of the game in the \textit{cooperative} situation in which the agent has accepted the contract \((\alpha, \beta)\). Given \((\alpha, \beta)\), his optimal effort maximizes \( EU_{A,\text{coop}} = \alpha + k_A e_A \beta - c(e_A) \) which yields

\[
e_{A,\text{coop}}^* = \frac{k_A \beta}{c} \quad \Rightarrow \quad EU_{A,\text{coop}} = \alpha + \frac{k_A^2 \beta^2}{2c} \quad \text{and} \tag{5}
\]

\[
EU_{P,\text{coop}} = (s_p + k_A e_A - \tau s_p k_A e_A) \pi_P - k_A e_A \beta - \alpha
\]

\[
= s_p \pi_P + \frac{k_A \beta}{c} \left( (1 - \tau s_p) \pi_P - \beta \right) - \alpha. \tag{6}
\]

At stage 3, the agent will accept the contract if

\[
EU_{A,\text{coop}} \geq EU_{A,\text{comp}} \Leftrightarrow \alpha \geq \frac{k_A^2}{2c} (S^2 - \beta^2) \tag{7}
\]

At stage 2, if the principal prefers the cooperative situation to the competitive one, he will choose the optimal contract \((\alpha^*, \beta^*)\) that maximizes his
objective function (6) subject to the limited-liability constraint $\alpha \geq 0$ and the agent’s participation constraint (7). We obtain the following solution (see appendix for the proof):

**Lemma 1** If the principal prefers the cooperative situation, he will choose the contract

$$(\alpha^*, \beta^*) = \begin{cases} 
(0, \frac{(1 - \tau s_p) \pi_p}{2}) & \text{if } S \leq \frac{(1 - \tau s_p) \pi_p}{2} \\
(0, S) & \text{if } \frac{(1 - \tau s_p) \pi_p}{2} < S \leq (1 - \tau s_p) \pi_p \\
\left(\frac{k_A^2}{2 c} (S^2 - (1 - \tau s_p)^2 \pi_p^2), (1 - \tau s_p) \pi_p \right) & \text{if } S > (1 - \tau s_p) \pi_p.
\end{cases}$$

According to Lemma 1, the lower the principal’s success probability $s_p$ (i.e. the lower his ability or his human capital), the higher the incentives will be that he creates for the agent. This comparative-static result is also intuitively plausible, since the principal wants to compensate for low values of $s_p$ by inducing a high value of $e_A$ to obtain an appropriate joint success probability $s_p + k_A e_A - \tau s_p k_A e_A$.

The technical intuition for the results of Lemma 1 is as follows: first note that – using (5) – the bonus $\beta^* = (1 - \tau s_p) \pi_p = \beta^{FB}$ leads to first-best effort $e^{FB}$ with $e^{FB} = \arg \max_{e_A} (s_p + k_A e_A (1 - \tau s_p)) \pi_p - c(e_A)$. For small values of $S$, the principal does not want to choose $\beta^{FB}$ as this would be too costly. The corresponding lump-sum payment which exactly ensures that the agent gets his outside option (i.e. (7) holds with equality) would be negative – the principal would charge the agent an entrance fee. But due to the limited liability constraint ($\alpha \geq 0$) this is not possible. Instead, the
principal chooses $\alpha = 0$ and an optimal bonus that maximizes (6) which gives $\beta^* = (1 - \tau s_P) \pi_P/2$. Hence, due to limited liability the principal does not want to implement first-best incentives.

For intermediate values of $S$, we have a similar solution. Substituting for $\alpha$ according to (7) in the principal’s objective function (6) gives

$$EU_{P,coop} = s_P \pi_P + \frac{k_A^2}{c} \left( (1 - \tau s_P) \pi_P \beta - \frac{\beta^2}{2} - \frac{S^2}{2} \right).$$

(8)

The bonus that maximizes (8) is the first-best bonus $\beta_{FB} = (1 - \tau s_P) \pi_P$. Again, the principal does not want to choose this bonus because it would be too costly for him. But the larger $S$ becomes, the closer the implemented effort gets to the first-best solution as the limited-liability problem becomes less severe if the agent has to be compensated for a larger outside option. Since his objective function (8) is strictly concave with a global maximum at $\beta = \beta_{FB} = (1 - \tau s_P) \pi_P \geq S$, the principal optimally chooses the maximum bonus that makes the agent’s participation constraint just binding. Hence, $\beta^* = S$.

For large values of $S$, however, the principal is able to achieve an interior solution and implements first-best incentives by choosing $\beta = \beta_{FB}$. In addition, he offers the agent a positive lump-sum payment to compensate him for his large outside option.

However, the principal does not always prefer the cooperative situation to the competitive one. He will prefer the cooperative situation, if and only
if $EU_{IP,coop} \geq EU_{IP,comp} \Leftrightarrow$

$$\frac{k_A^2 \beta}{c}((1 - \tau s_P)\pi_p - \beta) - \alpha \geq -\frac{s_P k_A^2 (\pi_p - \hat{\pi}_p) S}{c}.$$  (9)

Combining this condition with the results of Lemma 1 yields:

**Lemma 2** The principal’s hiring decision is independent of his prior decision on knowledge transfer (i.e. whether choosing $k_A = k_H$ or $k_A = k_L$).

**Proof.** Rearranging (9) leads to

$$\frac{\beta}{c}((1 - \tau s_P)\pi_p - \beta) + \frac{s_P (\pi_p - \hat{\pi}_p) S}{c} \geq \frac{\alpha}{k_A^2}.$$  

Note that both the separation incentives $S$ and the bonus $\beta$ are independent of $k_A$. Lemma 1 shows that $\alpha$ is either zero or $\frac{k_A^2}{2c} \left(S^2 - (1 - \tau s_P)^2 \pi_p^2\right)$ so that $k_A$ cancels out.

The result of Lemma 2 is interesting, since it demonstrates that the knowledge transfer does not influence the principal’s choice between a cooperative and a competitive situation. In particular, it is impossible that the principal does not want to hire the agent simply because the latter has become too costly as a result of having received $k_H$. Of course, the inverse relation does not hold: if the principal anticipates that he will choose a competitive situation at the second stage, he will strictly prefer the strategy $k_A = k_L$ at the first stage to maximize his expected utility given by (4). In addition, the agent’s participation constraint (7) shows that in analogy to Lemma 2, his decision whether to accept or reject the principal’s contract offer does not
depend on $k_A$ either.

According to Lemma 1, condition (9) holds as long as $0 \leq S \leq (1 - \tau s_p) \pi_P$. For $S > (1 - \tau s_p) \pi_P$, the principal will prefer the cooperative situation if

$$S^2 - (1 - \tau s_p)^2 \pi_P^2 \leq 2s_P (\pi_P - \tilde{\pi}_P) S.$$

We can see that this inequality holds for sufficiently small values of $S > (1 - \tau s_p) \pi_P$ and will not hold if $S$ becomes large. Define $\tilde{S}$ as the value of $S$ which meets $S^2 - (1 - \tau s_p)^2 \pi_P^2 = 2s_P (\pi_P - \tilde{\pi}_P) S$. Then, the principal will prefer the cooperative situation to the competitive one, if $S < \tilde{S}$ with $\tilde{S} > (1 - \tau s_p) \pi_P$.

At the first stage of the game, the principal has to choose $k_A = k_H$ or $k_A = k_L$. Of course, according to (4), he will always choose $k_A = k_L$ if he anticipates a competitive situation. In a cooperative situation, the principal will choose $k_A = k_H$ if and only if $EU_{P,coop}^*(k_A = k_H) \geq EU_{P,coop}^*(k_A = k_L)$. Using (6), this condition can be rewritten as

$$(k_H^2 - k_L^2) \frac{\beta^*}{c} ((1 - \tau s_p)\pi_P - \beta^*) \geq \alpha^*(k_H) - \alpha^*(k_L) \quad (10)$$

with $\alpha^*(k_A)$ indicating that the lump-sum payment may depend on the amount of knowledge $k_A \in \{k_L, k_H\}$ as Lemma 1 has shown. According to Lemma 1, condition (10) always holds for $S \leq (1 - \tau s_p) \pi_P$. If $S > (1 - \tau s_p) \pi_P$, (10) can be rewritten as $(1 - \tau s_p) \pi_P \geq S$, a contradiction.

To sum up, I have proved the following proposition:
Proposition 1 (i) If $S \leq (1 - \tau s_P)\pi_P/2$, the principal chooses $k_A = k_H$ and offers the contract $(\alpha^*, \beta^*) = (0, (1 - \tau s_P)\pi_P/2)$. (ii) If $(1 - \tau s_P)\pi_P/2 < S \leq (1 - \tau s_P)\pi_P$, the principal chooses $k_A = k_H$ and offers the contract $(\alpha^*, \beta^*) = (0, S)$. (iii) If $(1 - \tau s_P)\pi_P < S \leq \tilde{S}$, the principal chooses $k_A = k_L$ and offers the contract $(\alpha^*, \beta^*) = \left(\frac{k_A^2}{2c} \left(S^2 - (1 - \tau s_P)^2\pi_P^2\right), (1 - \tau s_P)\pi_P\right)$. (iv) If $S > \tilde{S}$, the principal chooses $k_A = k_L$ and does not offer a contract to the agent.

To see the intuition for the results of Proposition 1, note that the transfer of knowledge to the agent has two effects in the cooperative situation. On the one hand, choosing $k_A = k_H$ instead of $k_A = k_L$ leads to a higher joint success probability $s_P + s_A - \tau s_P s_A$ (productivity effect). On the other hand, $k_A$ also has a distribution effect because it may determine the magnitude of the lump-sum payment $\alpha^*$ as well as that of the agent’s rent

$$R_A = EU_{A,coop}^* - EU_{A,comp}^* = \alpha^* + \frac{k_A^2}{2c} (\beta^* - S^2) \geq 0.$$ If $\alpha^* > 0$, this lump-sum payment will increase in $k_A$. The same holds for the agent’s rent $R_A$.

In case (i), the agent’s separation incentives $S$ and therefore his outside option are small enough so that it pays for the principal to cooperate with the agent. The principal chooses $k_A = k_H$, although this increases the agent’s rent $R_A = \frac{c_A^2}{2c} \left((1 - \tau s_P)^2\pi_P^2/4 - S^2\right) > 0$. In this situation, the productivity effect dominates the distribution effect.

In case (ii), again the agent is not too costly for the principal so that it
is still optimal to offer a contract. Now the agent neither receives a positive $\alpha^*$ nor a positive rent $R_A$. Since only the productivity effect works, it always pays for the principal to choose $k_A = k_H$.

In case (iii), the principal still wants to sign a contract with the agent. The agent does not get a positive rent $R_A$, but a positive lump-sum payment $\alpha^*$. In this situation, the distribution effect dominates the productivity effect so that the principal chooses $k_A = k_L$. In other words, the agent’s separation incentives $S$ are so high that the principal has to offer him a cooperation premium $\alpha^* > 0$. As this premium increases in $k_A$, the principal prefers to withhold knowledge and chooses $k_A = k_L$.

In case (iv), the agent is too costly for the principal because of his large separation incentives $S$. Now the principal always withholds knowledge in order to weaken his opponent as much as possible in the forthcoming competition so that his expected utility (4) is maximized.

Recall that $S = \pi_A - s_P(\pi_A - \hat{\pi}_A) = (1 - s_P)\pi_A + s_P\hat{\pi}_A$ and that the lower $S$, the less reluctant will be the principal to choose cooperation. Hence, the stronger the principal (i.e. the larger $s_P$) and the weaker the agent in the case of self-employment (i.e. the smaller $\pi_A$ and $\hat{\pi}_A$), the more likely there will be an agreement between principal and agent. In other words, if the principal’s ability is rather high and if the agent is more of a specialist without entrepreneurial talent (e.g. a pure researcher), the agent will only expect low profits when choosing separation. This implies a low outside option and hence, the principal will be more willing to hire the agent.

The intuition for knowledge transfer in case of cooperation can be seen
from condition (10) which can be rearranged to

\[
(1 - \tau s_P)\pi_P(k_H^2 \cdot k_L^2) \frac{\beta^*}{c} \geq (k_H^2 \cdot k_L^2) \frac{\beta^{**}}{c} + \alpha^*(k_H) - \alpha^*(k_L).
\]

The left-hand side of the inequality describes the principal’s additional expected gross profits implied by knowledge transfer and corresponds to the productivity effect. The right-hand side of the inequality, however, denotes additional labor costs implied by knowledge transfer and characterizes the distribution effect. As long as the optimal bonus is smaller than \((1 - \tau s_P)\pi_P\), the left-hand side of the inequality will always be larger than the right-hand side and the productivity effect dominates the distribution effect. However, for \(\beta^* \geq (1 - \tau s_P)\pi_P\) the opposite holds, i.e. the distribution effect dominates the productivity effect.

Altogether, we have two different reasons for withholding knowledge (i.e. \(k_A = k_L\)) – reducing labor costs in a cooperative situation, or discouraging the agent as a direct opponent in a competitive situation. Interestingly, the agent can gain a positive rent as is usual in limited-liability models which even rises with \(k_A\), but this effect does not make the principal withhold knowledge. Moreover, it is important to emphasize that both reasons for withholding knowledge are not related. As Lemma 1 has shown, the agent’s premium \(\alpha^*\) will depend on \(k_A\) if the premium is positive. However, according to Lemma 2, \(k_A\) completely cancels out in the principal’s”participation constraint” (9), since \(k_A\) has a similar impact on both the principal’s expected utility under a competitive and under a cooperative situation. The principal will prefer
the competitive situation if and only if the agent’s separation incentives $S$ which do not depend on $k_A$ are too high. He will not reject the agent because knowledge transfer has made him too costly. Of course, if at the first stage the principal anticipates that he will reject the agent at the next stage, he will always withhold knowledge. If, on the other hand, the principal anticipates that he will prefer cooperation at the next stage, the distribution and the productivity effect will be central for his knowledge decision: he will transfer (withhold) knowledge, if the productivity (distribution) effect dominates the distribution (productivity) effect.

Finally, the differences between the findings of this paper and the work of Barcena-Ruiz and Rubio (2000) and Kräkel (2002) can be highlighted. In the paper by Barcena-Ruiz and Rubio (2000), by assumption the agent does not have any chance of becoming a direct competitor of the principal after separation, because the principal immediately has to shut down his firm. This basic assumption stands in direct contrast to the assumptions of this paper and the endogenous result that the agent will indeed become a direct competitor, if hiring is too costly for the principal. Furthermore, because of their basic assumption Barcena-Ruiz and Rubio cannot cover all those cases (e.g. that of Intel) in which former agents compete in the same market with their former employers.

This paper and its results also stand in sharp contrast to Kräkel (2002). Kräkel identifies three effects which completely differ from the distribution and the productivity effect of the model analyzed here. Particularly, in Kräkel (2002) there is no productivity effect and the principal’s decision to hire the
agent directly depends on the amount of the knowledge transfer. Moreover, in this paper, the principal will never transfer knowledge if he anticipates a competitive situation. In Kräkel (2002), however, knowledge transfer may be rational despite anticipated separation. There – due to the special tournament competition – the principal may be interested to commit himself to an implicit collusion at the competition stage by transferring knowledge. Hence, this paper identifies two novel reasons for withholding knowledge that have not been discussed in the literature so far.

4 Discussion

In this section, the main result of Proposition 1 and its implications will be discussed in detail. First, I would like to analyze the role of synergy as this is a novel aspect here. Second, the model is simplified by assuming symmetry within the principal-agent relationship (i.e. principal and agent are homogeneous) to further investigate the role of synergy and to emphasize the impact of market size on the principal’s willingness to cooperate with the agent. Third, I will discuss the question whether knowledge transfer is more likely to occur if the agent is more able than the principal than vice versa. Next, I will introduce the possibility of including a noncompetition clause into the principal-agent contract and analyze the conditions under which the principal would make use of such a restrictive covenant. Finally, some related cases of knowledge spillovers are considered.
4.1 The impact of synergy

The results of Proposition 1 show that the measure of synergy $\tau$ has an important impact on the principal’s decision about cooperating with the agent as well as transferring knowledge. At first sight, one might expect that synergy will favor cooperation in the same way as knowledge transfer since the derivative of the joint success probability $s_P + s_A - \tau s_P s_A$ strictly decreases in $\tau$. Recall that synergy is higher, the smaller the value of $\tau$. We obtain the following results:

**Corollary 1** There exist two cut-off values $\hat{\tau}_1$ and $\hat{\tau}_2$ with $\hat{\tau}_1 < \hat{\tau}_2$ so that the following holds: if $\tau \leq \hat{\tau}_1$, the principal will choose a cooperative situation and $k_A = k_H$. If $\hat{\tau}_1 < \tau \leq \hat{\tau}_2$, the principal will choose a cooperative situation, but $k_A = k_L$. If $\tau > \hat{\tau}_2$, the principal will choose a competitive situation and $k_A = k_L$.

The corollary, for which the proof is given in the appendix, similar to Proposition 1, shows that we have to differentiate strictly between the cooperation and the knowledge decision of the principal. The lower $\tau$ (i.e. the higher synergy), the more likely the principal will both cooperate with the agent and transfer knowledge. Particularly, in the case of maximum synergy ($\tau = 0$) the principal chooses cooperation as well as knowledge transfer ($k_A = k_H$) and offers the lowest of the three bonuses mentioned in Lemma 1. However, for intermediate values of $\tau$ the two decisions can no longer be treated jointly. While the principal still prefers cooperation to competition, he no longer wants to transfer knowledge to the agent. Note that only in
this range $\hat{\tau}_1 < \tau \leq \hat{\tau}_2$ the right-hand side of condition (10) strictly increases in $\tau$, but synergies are still high enough so that the principal unambiguously prefers cooperation with the agent.

4.2 Symmetry

In this subsection, a symmetric situation is assumed in which principal and agent are homogeneous in the sense that each realizes the same profits $\pi_P = \pi_A =: \pi$ and $\hat{\pi}_P = \hat{\pi}_A =: \hat{\pi}$. Furthermore, I focus on the case of minimal synergy ($\tau = 1$) to analyze whether cooperation and knowledge transfer may still be a rational choice from the principal’s viewpoint. By using these simplifying assumptions the following results can be derived:

**Proposition 2** If there is symmetry between principal and agent and $\tau = 1$, (a) the principal will always choose $k_A = k_L$, but (b) he will still prefer cooperation to competition if and only if

$$s_P \leq \frac{2\pi (\pi - 2\hat{\pi})}{2\pi^2 - 6\pi \hat{\pi} + 3\hat{\pi}^2}. \quad (11)$$

The proposition, for which the proof appears in the appendix, shows that under minimal synergy the principal always chooses to withhold knowledge. Interestingly, the principal may still be interested in cooperating with the agent despite minimal synergy. Hence, both reasons for withholding knowledge are still relevant in this extreme situation – reducing labor costs in case of cooperation and weakening the agent in case of competition. According to result (b), the principal will cooperate with the agent if his success prob-
ability $s_P$ is sufficiently small (e.g. if his ability or his human capital is sufficiently small). In this case, he urgently needs the agent to ensure the survival of the firm.

It is plausible to suppose that market size has an important impact on whether condition (11) is met or not. In order to discuss the influence of market size, I now consider Cournot competition as a special form of oligopoly at the last stage of the game. Recall that in the competitive situation we have $n$ firms competing in the market, whereas competition takes place between $n - 1$ firms in case of cooperation. For the Cournot model with $n$ firms, a linear demand function $p = 1 - \sum_{i=1}^{n} q_i$ (here $p$ denotes the market price and $q_i$ the quantity of firm $i$) and zero marginal costs are assumed. The market equilibrium leads to profits

$$\hat{\pi} = \frac{1}{(n+1)^2} \quad \text{and} \quad \pi = \frac{1}{n^2}.$$  \hspace{1cm} (12)

Calculating condition (11) for the Cournot model yields

$$s_P \leq \frac{2(n^2 + 4n + 2)n^2}{n^4 - 12n^2 - 12n - 3}.$$  \hspace{1cm} (13)

The right-hand side is negative (positive and strictly greater than 1) for $n < (>) 3.9074$. Hence, we have the following result:

**Corollary 2** If there is symmetry between principal and agent and $\tau = 1$, under Cournot competition the principal will choose cooperation and $k_A = k_L$ if and only if $n \geq 4$.  

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The corollary shows that the market size has to be sufficiently large for cooperation. At first sight, this result seems to be puzzling considering the literature on mergers in oligopoly. In those models, the gains from reducing market size and, therefore, competition have to be sufficiently large for merging to be attractive for the principal. Since for the Cournot model gains from merging \((\frac{1}{n^2} - \frac{1}{(n+1)^2}) = \frac{2n+1}{n^2(n+1)^2}\) will be highest if the market consists of a small number of firms, merging only takes place in markets with few competitors. However, the effect of market size can be explained by the agent’s separation incentives \(S\). By inserting equilibrium profits of the Cournot model we obtain

\[
S = \frac{n^2 + (2n + 1)s_P}{(n + 1)^2 n^2}.
\]

Note that the right-hand side of (14) is monotonically decreasing in \(n\). Since the above cooperation condition \(S^2 - (1 - \tau s_P)^2 \pi_P^2 \leq 2s_P (\pi_P - \hat{\pi}_P) S\) is only satisfied by small values of \(S\), low separation incentives due to an initially large number of competing firms make cooperation more attractive from the principal’s viewpoint.

### 4.3 Knowledge transfer to agents of different ability

In this subsection, I discuss the question, whether the principal prefers knowledge transfer to a more or a less able agent. Suppose that both the principal and the agent are low or high ability players. An asymmetric situation is considered in which exactly one of the two players has a high ability and the
other one a low ability. A high-ability principal gains $\pi_P = \pi_H$ or $\hat{\pi}_P = \hat{\pi}_H$, whereas a low-ability principal receives $\pi_P = \pi_L$ or $\hat{\pi}_P = \hat{\pi}_L$ with the $H$-values being strictly greater than the corresponding $L$-values. In analogy, we have $\pi_A = \pi_H$ or $\hat{\pi}_A = \hat{\pi}_H$ for a high ability agent, and $\pi_A = \pi_L$ or $\hat{\pi}_A = \hat{\pi}_L$ for a low-ability one. Furthermore, I assume that in the cooperative situation the two players always adopt the better technology so that $\pi_H$ will be realized with success probability $s_P + s_A - \tau s_P s_A$. Now the results of Proposition 1 can be interpreted as the outcome of a game between a high-ability principal and a low-ability agent in which the principal’s technology is chosen in case of a contract. Then the condition $(1 - \tau s_P)\pi_P \geq S$ for choosing $k_A = k_H$ can be rewritten as

$$ (1 - \tau s_P)\pi_H \geq \pi_L - s_P(\pi_L - \hat{\pi}_L). \tag{15} $$

In a game between a low-ability principal and a high-ability agent the analogous condition is

$$ (1 - \tau s_P)\pi_H \geq \pi_H - s_P(\pi_H - \hat{\pi}_H), \tag{16} $$

because now the agent’s technology is chosen in a cooperative situation. Since (15) is more easily satisfied than (16), the following result has been proven:

**Corollary 3** Knowledge transfer (i.e. $k_A = k_H$) between a high-ability principal and a low-ability agent is more likely compared to the case of knowledge transfer between a low-ability principal and a high-ability agent.

Interestingly, a principal is more likely to transfer knowledge to a less able agent than to a more able one. Note that the left-hand sides of (15)
and (16) are identical, since the two players will always choose the better technology when they cooperate. Hence, adoption of a better technology does not play a role in the comparison. The only effect that remains is the higher outside option of a better agent. But from the discussion above we know that a higher $S$ makes an agent more costly for the principal when signing a contract and leads to a higher cooperation premium $\alpha^*$. This effect works against a knowledge transfer.

4.4 Noncompetition clauses

In practice, employers have the possibility including a so-called noncompetition clause into the labor contract. Under such an agreement, the employees agree not to compete with the employer by starting a business or by working for a competitor. This covenant is usually limited to a certain time after leaving the employer.

In the principal-agent model considered in this paper, a noncompetition clause means that the agent’s outside profits $\pi_A$ and $\tilde{\pi}_A$ are set to zero thereby reducing the agent’s separation incentives $S$ to zero, too. From the discussion above we know that low separation incentives of the agent are favorable for the principal. However, we have to examine each of the four cases of Proposition 1 as to whether the principal prefers to switch to an alternative situation with $S = 0$. This comparison leads to the following result:

**Proposition 3** If the principal is able to choose a noncompetition clause, he will always do so. In this case, he chooses $k_A = k_H$. 

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The intuition for this result (for which the proof appears in the appendix) is as follows: since the agent helps the principal to ensure the survival of the firm, in principle the latter is interested in cooperation. By setting the agent’s separation incentives to zero, the agent becomes as cheap as possible for the principal who will then avoid a separation in case of $S > \bar{S}$. Only if $S$ is rather low (i.e. $S \leq (1 - \tau s_P) \pi_P / 2$), the principal will be indifferent between using or not using a noncompetition clause as the agent will cooperate with the principal anyway. The separation incentives $S$ will not influence the agent’s compensation.

4.5 Related cases of knowledge spillovers

Besides the case of an agent who becomes self-employed and then competes against his former principal, there are other possibilities for knowledge spillovers which may not be in the interest of the principal ex post. We can relate the model above to these cases by now assuming that a separating agent will transfer important knowledge to a direct competitor of his present principal.

First, we can look at the case of licensing. Under a technology licensing agreement, the licensee is allowed to use the licensor’s technology within a certain specified context. Ex post, i.e. after the knowledge transfer, there may be room for opportunistic behavior by the licensee. For example, he can use the knowledge in domains in which he was not allowed to use it. The perils of opportunism by the licensee are quite high in the case of tacit knowledge, i.e. for knowledge which someone has acquired but which cannot
be described explicitly in order to become part of a written contract.\textsuperscript{11} If such knowledge is part of the licensing agreement and has been transferred to the licensee by the licensor via consultant services, technical assistance, training or personnel delegation, it will be irreversibly given to the licensee. Thus, by definition, the licensor will not have any chance to impose legal restrictions on the use and misuse of this knowledge.

Another case of involuntary knowledge spillover is given by industrial espionage. Here typically one firm infiltrates a person (the spy) as a regular employee into another firm. After having collected the desired information (e.g. about a new product or an innovative technology), this person quits and transfers the information to his/her client. There are many cases of industrial spying in practice. For example, in 2003 the U.S. Pentagon canceled a 1-billion-$ order to Boeing because of industrial spying against Lockheed Martin during a tendering procedure for satellite launches within the Air Force’s Evolved Expendable Launch Vehicle (EELV) programme.\textsuperscript{12} Lockheed Martin sued Boeing for stealing 25,000 confidential documents to win 21 of 28 tender offers. As another example, we can recall the case of industrial spying at the Swedish firm Ericsson in November 2002.\textsuperscript{13} Ericsson is well known as a telecom giant, in particular for mobile phones. However, the Swedish firm is also a major producer of military communication systems. In the given case, Ericsson employees were accused of illegally selling confidential technology to a foreign secret service.

Finally, we can consider employee poaching as another alternative form of knowledge spillover which is related to industrial spying. In the case of
employee poaching, one firm hires employees of another firm to acquire their human capital or confidential knowledge of their present employer. According to the empirical study by Levin (1988), poaching is a very effective instrument of transferring knowledge from other firms. This result particularly holds for high-technology industries that are not chemicals and pharmaceuticals (e.g. semiconductors, computers, communication equipment). As Girard (1999) reports, more than 10 years later the general findings of Levin still seem to hold: SAP America charged Siebel Systems with ”predatory hiring practices directed at SAP designed to injure SAP’s business and damage SAP’s ability to compete”. Other cases of poaching include the lawsuits of Wal-Mart vs. Amazon.com and Drugstore.com, Borland International vs. Microsoft, and Informix vs. Oracle.

5 Conclusion

In this paper, a principal-agent model with an endogenous outside option for the agent has been examined. After having received knowledge from the principal, the agent has to decide between staying with the principal or becoming self-employed. In the latter case, the agent competes with his former principal in the same market.

At first sight, one can imagine that withholding knowledge may be beneficial for the principal to prevent a separation of the agent. However, this paper highlights two other reasons: (1) in case of further cooperation with the agent, the principal may withhold knowledge to reduce labor costs as
more knowledge would increase the agent’s outside option. In this context, the interplay of two effects has been analyzed which is novel in the light of the existing literature. On one hand, knowledge transfer leads to a positive productivity effect. On the other hand, the transfer also has a negative distribution effect. Hence, when anticipating further cooperation with the agent the principal will withhold knowledge if the distribution effect dominates the productivity effect. (2) If the principal anticipates that he will not build up a permanent relationship with the agent, he will withhold knowledge to make his future competitor as weak as possible. It is important to stress that both reasons are completely unrelated, i.e. the principal’s decision whether to cooperate or not, does not depend on the knowledge transfer. In other words, he will not reject the agent because knowledge transfer has made him too costly.

Further discussion has emphasized the role of synergy, which is decisive both for the cooperation between principal and agent and for the knowledge transfer. However, cooperation may also take place with minimal synergy whereas knowledge transfer does not. Introducing the simplifying assumption of symmetry for this polar case, it can be shown that the principal will only cooperate with the agent if the market size (i.e. the number of competing firms) is sufficiently large. Furthermore, the analysis has shown that knowledge transfer from a strong principal to a weak agent is more likely than knowledge transfer from a weak principal to a strong agent because a strong agent has a larger outside option than a weak one. Finally, the possibility that the principal may opt to use a noncompetition clause has been
introduced. In the given model, the principal always includes the clause in the contract.
Appendix:

Proof of Lemma 1:

The result is proved by solving the Kuhn-Tucker conditions. Let \( \lambda_1 \geq 0 \) denote the corresponding Lagrange multiplier for condition (7) and \( \lambda_2 \geq 0 \) the one for \( \alpha \geq 0 \). Then, the first-order conditions require

\[-1 + \lambda_1 + \lambda_2 = 0 \quad (A1)\]

and

\[\lambda_1 = 2 - \frac{(1 - \tau s_P) \pi_P}{\beta} \geq 0. \quad (A2)\]

From (A1) and (A2) we obtain

\[\lambda_2 = \frac{(1 - \tau s_P) \pi_P}{\beta} - 1 \geq 0. \quad (A3)\]

Condition (A1) shows that at least one restriction must be binding. Hence, we have to distinguish three cases: (i) if \( \lambda_1 = 0 \) and \( \lambda_2 > 0 \), we get \( \lambda_2 = 1 \) from (A1), \( \alpha = 0 \) from the binding limited-liability constraint, \( \beta = (1 - \tau s_P) \pi_P / 2 \) from (A3), and \( S \leq (1 - \tau s_P) \pi_P / 2 \) from the agent’s participation constraint. (ii) \( \lambda_2 = 0 \) and \( \lambda_1 > 0 \) yields \( \lambda_1 = 1 \) from (A1), \( \beta = (1 - \tau s_P) \pi_P \) from (A2), and \( \alpha = \frac{k^2}{2e} \left( S^2 - (1 - \tau s_P)^2 \pi_P^2 \right) \) from the agent’s binding participation constraint which leads to \( S \geq (1 - \tau s_P) \pi_P \) because of \( \alpha \geq 0 \). (iii) If \( \lambda_1, \lambda_2 > 0 \), both restrictions have to be binding, which leads to \( \alpha = 0 \) and \( \beta = S \). In addition, (A2) and (A3) together require \( (1 - \tau s_P) \pi_P / 2 \leq S \leq (1 - \tau s_P) \pi_P \).
Proof of Corollary 1:

First, note that separation incentives $S$ are independent of $\tau$. The condition $S \leq (1 - \tau s_P) \pi_P / 2$ of Proposition 1 can be rearranged to

$$\tau \leq \frac{1}{s_P} - \frac{2S}{s_P \pi_P} =: \hat{\tau}_0.$$  

Rearranging $S \leq (1 - \tau s_P) \pi_P$ yields

$$\tau \leq \frac{1}{s_P} - \frac{S}{s_P \pi_P} =: \hat{\tau}_1 > \hat{\tau}_0.$$  

Finally, define $\hat{\tau}_2$ as the cut-off value for the above condition $S^2 - (1 - \tau s_P)^2 \pi_P^2 \leq 2s_P (\pi_P - \hat{\pi}_P) S$ to be met as long as $\tau < \hat{\tau}_2$. Note that this cut-off is larger than $\hat{\tau}_1$.

Proof of Proposition 2:

Under symmetry, the condition $S > (1 - \tau s_P) \pi_P$ simplifies to

$$\tau > \frac{\pi - \hat{\pi}}{\pi}$$  

which is always true for $\tau = 1$. Hence, we have to check whether condition $S^2 - (1 - \tau s_P)^2 \pi_P^2 \leq 2s_P (\pi_P - \hat{\pi}_P) S$ can be met under symmetry and $\tau = 1$. Inserting and rearranging gives inequality (11).
Proof of Proposition 3:

According to (7), the agent would accept any contract under \( S = 0 \). Hence, by using the noncompetition clause the principal’s expected utility would be

\[
EU_{P,coop}^1 = s_P \pi_P + \frac{k_H^2}{c} \left( \frac{(1 - \tau s_P) \pi_P}{2} \right)^2.
\]

Without a noncompetition clause, his expected utility is given by

\[
EU_{P,coop}^2 = s_P \pi_P + \frac{k_H^2}{c} (1 - \tau s_P) \pi_P - S
\]

if \( (1 - \tau s_P) \pi_P/2 < S \leq (1 - \tau s_P) \pi_P \), and

\[
EU_{P,coop}^3 = s_P \pi_P - \frac{k_L^2}{2c} \left( S^2 - (1 - \tau s_P)^2 \pi_P^2 \right)
\]

if \( (1 - \tau s_P) \pi_P < S \leq \bar{S} \). If \( S > \bar{S} \), without a noncompetition clause the principal would choose competition which leads to expected utility

\[
EU_{P,comp} = s_P \pi_P.
\]

Obviously, we have \( EU_{P,coop}^1 > EU_{P,comp} > EU_{P,coop}^3 \). Comparing \( EU_{P,coop}^1 \) and \( EU_{P,coop}^2 \) gives

\[
\frac{s_P \pi_P + \frac{k_H^2}{c} \left( \frac{(1 - \tau s_P) \pi_P}{2} \right)^2}{1} > \frac{s_P \pi_P + \frac{k_H^2}{c} ((1 - \tau s_P) \pi_P - S)}{1} \iff \frac{1}{4} ((1 - \tau s_P) \pi_P - 2S)^2 > 0,
\]

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which is always true.
End notes

1 As Stewart (1994: 1792) takes it, ”... in practice individuals do sometimes leave to set up rivals and an obvious topic for future research is to explain why such separations occur.”

2 In terms of the parameters given below, we assume \( c > k_A(\pi_A - s_P(\pi_A - \hat{\pi}_A)) \) and \( c > k_A(1 - \tau s_P)\pi_P \).

3 Moreover, if both the principal and the agent have the same qualification and were awarded their diplomas by the same university, it is more likely that both will make the same invention. Such ”cannibalization effects” stand for low synergy. However, if principal and agent have different qualifications and/or come from different universities, it is more likely that they will be successful in different dimensions so that cannibalization is minimized.

4 In the worst case, we have \( \tau = 1 \) and, therefore, \( s_P + s_A \leq 1 \). The calculations in the next section yield \( s_P + k_A \epsilon_{A,coop} \leq 1 \Leftrightarrow s_P + \frac{k_A^2 \beta}{c} \leq 1 \). The parameter conditions given in the last footnote show that in the worst case we have \( c = k_A(1 - \tau s_P)\pi_P \) (note that – due to the cooperation condition of the principal given below – this cut-off is the relevant one here). Inserting into the inequality gives \( s_P + \frac{k_A^2 \beta}{(1 - \tau s_P)\pi_P} \leq 1 \). According to Lemma 1, the maximal bonus will be \( \beta = (1 - \tau s_P)\pi_P \). Using this result and the worst case \( k_A = k_H \) leads to \( s_P + k_H \leq 1 \).

5 The principal’s net profits are given by \( \pi_P \) minus the agent compensation.

6 Note that \( S \) is strictly decreasing in \( s_P \).

7 Note that \( \epsilon'_{A,comp} \) is strictly increasing in \( k_A \).

9 See, for example, Kamien and Zang (1990), Gonzalez-Maestre and Lopez-Cunat (2001).

10 Of course, gains from merging will be highest if a duopoly becomes a monopoly.

11 See, for example, Arora (1996) on licensing and tacit knowledge.

12 See the news release "Boeing punished for spying" at http://news.bbc.co.uk/1/hi/business/3094825.stm.

13 See the news release "Ericsson dragged into spy scandal" at http://news.bbc.co.uk/2/hi/business/2420737.stm.
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