

Talent Competition, Labor Mobility, and Anti-Poaching Agreements*

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Abstract

We analyze talent competition among wage-setting firms. The firms can design poaching offers with higher wages to workers who switch from rivals relative to wages paid to own existing employees. We evaluate the effects on profits and welfare of anti-poaching agreements, which eliminate poaching offers as a recruiting method. Anti-poaching agreements are profitable provided that workers face sufficiently high switching costs, whereas the workers are made worse off. The gains to firms from an anti-poaching agreement outweigh the associated losses to workers if the switching costs exceed a threshold significantly higher than that for the agreement to be profitable.

Keywords: Anticompetitive behavior, talent acquisition, wage competition, poaching, switching employers, labor mobility

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1. Introduction

Firms operating in industries that rely heavily on continuous research and development, such as in the high-tech sector, compete aggressively to recruit experienced high-skilled workers. Software engineers, researchers in biotechnology, and chip designers provide good examples. One commonly-used recruiting method is to contact successful employees of rival firms and make them attractive poaching offers with the aim of inducing such employees to switch. In fact, salary differences play a major role in a worker's decision to switch employers. However, the firms might have a collective interest to prevent such a recruitment strategy by forming an anti-poaching agreement or a so-called "no cold call" agreement. A recent high-profile antitrust case in the Silicon Valley has attracted a considerable amount of attention to this practice.

In 2010, the US Department of Justice Antitrust Division filed a complaint against Adobe, Apple, Google, Intel, Intuit, and Pixar for having formed bilateral anti-poaching agreements in violation of Section 1 of the Sherman Act. The argument was that these anti-poaching agreements were anticompetitive because they "eliminated a significant form of competition to attract high-tech employees and overall substantially diminished competition to the detriment of the affected employees."¹ In 2012, the parties reached a USD 324 million settlement, which was subsequently rejected as insufficient by Judge Koh of the District Court in San Jose California, meaning that the case has to go on trial unless the parties can reach another settlement.²

Our study analyzes a duopoly model of wage competition within a framework where firms can design poaching offers, different from the wages paid to their own existing workers, in order to induce switching. We assume that switching employers is associated with uncertain productivity changes and that workers bear heterogeneous switching costs. In particular, we evaluate the effects on profits and welfare of anti-poaching agreements, whereby the firms eliminate poaching offers as a recruitment method. We show analytically that firms benefit (suffer) from anti-poaching agreements if and only if the employees face sufficiently high (low) switching costs. Further, we

¹See, <http://www.justice.gov/atr/cases/f262600/262654.pdf>

²The anti-enticement laws in Southern U.S. states in the period 1875–1930 raised somewhat related issues within a very different institutional framework. The anti-enticement laws imposed financial fines on planters trying to poach workers with an existing employment contact. Naidu (2010) has empirically estimated the effects of these anti-enticement laws, finding that these laws softened competition between firms and reduced labor mobility.

establish that workers are unambiguously made worse off under such agreements. Finally, we find that there is a threshold for the switching costs above which an anti-poaching agreement increases total welfare, and this threshold is significantly higher than the threshold required for the agreement to enhance profits.

As exemplified by Cappelli (2000), the management literature has attracted attention to strategic poaching as an important practice to promote competitiveness in talent markets relevant for a whole spectrum of industries. Boudreau (2014) comments on the heated poaching competition between the app-based car services Uber and Lyft from such a perspective. Ciapanna (2011) emphasizes that strategic poaching constitutes a particularly serious challenge to consulting firms and other similar types of firms which assign their employees to clients. She analyses strategic poaching for such industries by constructing a random matching model, showing that client firms tend to poach productive consultants whenever a match between the consultant and the client firm is formed.

In its focus on strategic competition between firms for human capital, our study is linked to the literature on wage determination with imperfect competition in monopsonistic and oligopsonistic labor markets. This approach is highlighted in Manning (2003), Bhaskar, Manning, and To (2002), and Bhaskar and To (2003) and surveyed in Manning (2011) and Booth (2014). Fox (2010) provides empirical support for our emphasis on switching costs as a source of market power in labor markets for skilled workers. Fox (2010) estimates that a majority of experienced Swedish engineers has high switching costs, and are therefore rather insensitive to outside wage offers. He also presents evidence for heterogeneous switching costs among Swedish engineers with the particular feature that younger engineers have lower switching costs.

Our model of talent competition introduces differentiated wage offers that separate poaching offers targeted to switching workers from wages within existing employment relationships. This approach offers a number of interesting insights. (a) We find that there is a wage premium for switching workers and our characterization of this wage premium complements that of Sliwka and Kampkötter (2014). (b) We find that switching occurs in equilibrium also under circumstances where it is more likely that switching leads to a decline, not an increase, in productivity. (c) We

characterize the factors determining labor mobility. And, most importantly, (d) we demonstrate how each firm, by differentiating the wage directed to the rival's worker from that offered to its own employees, can implement history-based wages with the effect of softening competition in the industry.

Our analysis of the effects of an anti-poaching agreement involves a comparison of an equilibrium where firms can implement a history-based wage structure with an equilibrium where firms pay uniform wages. Such a comparison mirrors the literature on behavior-based pricing in industrial economics and marketing that focuses on product markets rather than on labor markets. This literature includes, for example, Chen (1997), Fudenberg and Tirole (2000), Gehrig, Shy, and Stenbacka (2011), Esteves (2010) and it is surveyed in Fudenberg and Villas-Boas (2007) and Esteves (2009). Typically, behavior-based pricing intensifies competition compared with uniform pricing, meaning that equilibrium profits are higher with uniform pricing (see, for example, Chen (1997)). In our study, the effects on profits of implementing poaching wages that are higher than wages paid to existing employees depend on the switching costs facing workers.

The analysis of anti-poaching agreements in this paper differs substantially from the literature on non-compete clauses. The literature on non-compete clauses explores the effects of contracts whereby one party (typically an employee) signs an agreement not to start a professional career or a business in competition with another party (typically a present employer). Contrary to such a configuration, our study analyzes the effects of agreements between employers not to poach key employees from each other.

This article is organized as follows. Section 2 constructs a model of wage competition with labor mobility. Section 3 solves and investigates the equilibrium wages, labor mobility, output, profits, and worker surplus when firms (employers) compete on talented workers by making attractive poaching offers. Section 4 analyzes profits, worker surplus, and total welfare in a poaching equilibrium. Section 5 analyzes the effects of an anti-poaching agreement between the two firms and provides a discussion of the role played by the magnitude and heterogeneity of workers' switching costs. Section 6 summarizes the results. Appendix A briefly demonstrates how our general results carry over to a model which separates the expected magnitude from the dispersion

of the switching costs.

2. A model of employment and job switching

Consider an industry with two firms (employers) labeled as A and B . There are $2n$ workers. Initially, n workers are employed by firm A . Similarly, n workers are employed by firm B .

2.1 Workers and productivity

Each worker supplies exactly one unit of labor (say, full-time employment). The workers are initially homogeneous so that each worker generates k units of output within the framework of their initial employment relationship. However, if a worker switches to the competing employer, there is uncertainty as to whether the switch makes the worker more or less productive. We capture this uncertainty about the change in productivity associated with a switch of employers with the following assumption.³

ASSUMPTION 1. *Each worker who chooses to switch employers (either from A to B or from B to A),*

(a) becomes more productive with probability δ^H and less productive with probability δ^L , where

(b) a more productive switching worker generates $k+k'$ units of output, whereas a less productive switching worker generates $k - k'$ units of output.

In the above $0 \leq k' \leq k$ and $\delta^L + \delta^H = 1$.

The parameter k' captures the magnitude of the productivity change associated with switching from one employer to another. Consider a worker who switches from employment in one firm to employment in its rival. We adopt the following terminology.

DEFINITION 1. *We say that the*

*(a) **switch is productive** if switching increases the worker's productivity (from k units of output to $k+k'$);*

³Burguet, Caminal, and Matutes (2002) characterize contractual switching costs via quitting fees and show that quitting fees are useful only when workers' performance is public information. In contrast, our paper does not analyze the contractual sources of switching costs, but focuses on the disutility faced by a switching employee in the form of moving expenses, effort required to adjust to a new professional environment, effort and expenses associated with the adjustment of family life to a potentially new working environment. Furthermore, our model emphasizes the uncertainty regarding the productivity match between the employee and the new working environment. A priori, it seems unclear whether potential informational advantages exist with the old or the new employer with respect to the post-switch productivity change.

(b) *switch is unproductive* if switching decreases the worker's productivity (from k units of output to $k - k'$);

(c) *the switch is more (less) likely to be productive* if $\Delta \geq 0$ ($\Delta < 0$), where we define $\Delta \stackrel{\text{def}}{=} \delta^H - \delta^L$.

It is worthwhile to point out that Δ could be positive or negative. Since $\delta^H + \delta^L = 1$, we can also write $\Delta = 2\delta^H - 1$, meaning that the sign of Δ is determined by whether δ^H exceeds $1/2$ or not.

Let w_A denote the wage paid by firm A to an existing employee. Also, let v_A be the wage firm A pays to a worker who switches from firm B to firm A . Firm B 's wages, w_B and v_B , are defined analogously. We refer to w_A and w_B as *loyalty* wages (paid to worker who do not switch to the rival). The wages v_A and v_B are targeted to employees of the rival firm. We refer to those as *poaching* wages.

2.2 Labor mobility and switching costs

Contingent on the inherited worker employment relationships, all workers, regardless of their type, can remain loyal to their initial employer, or switch to the competing employer. Switching is costly to workers. For each worker, with an employment relationship with $i = A, B$, switching costs are heterogeneous as follows: Let s be uniformly distributed on the unit interval $[0, 1]$. Then, the switching cost of a worker indexed by s is σs .

The parameter $\sigma > 0$ serves as a key component of our analysis of labor mobility of talented workforce, as it measures two frictions in the labor market:

Magnitude effect : σ measures the overall magnitude of workers' cost of switching employers.

An increase in σ increases the switching costs of all workers indexed by $s \in (0, 1]$ by the same factor. A reduction in σ reduces the switching costs of all workers, and $\sigma = 0$ (ruled out) would mean that all workers could move without cost from one employer to another.

Heterogeneity effect : σ measures the heterogeneity of the switching costs in the sense that high values of σ generate higher switching cost differentiation across all workers indexed on $s \in [0, 1]$.

Because the two effects operate simultaneously and in the same direction, we may refer to either

one of these when we interpret our results. We will subsequently refer to both effects jointly as the *switching cost effect*. As we show below, an increase in σ results in weaker (softer) wage competition among employers as it makes it more costly for workers to switch employers.⁴

2.3 Workers' choice of employment

The utility function of a worker s who initially works for firm i is defined by

$$U_i(s) = \begin{cases} w_i & \text{if continues to work for firm } i \\ v_j - \sigma s & \text{switches to work for firm } j, \end{cases} \quad (1)$$

where $i, j = A, B$ and $i \neq j$.

In view of the utility function (1), a worker who was initially matched with firm A and is now indifferent between staying loyal to firm A and switching to firm B , denoted by s_A , is determined by $w_A = v_B - \sigma s_A$. Similarly, a worker who was initially matched with firm B and is now indifferent between staying loyal to firm B and switching to firm A , denoted by s_B , is determined by $w_B = v_A - \sigma s_B$.

Figure 1 shows that workers with high switching costs (high values of s) stay loyal to firm i , whereas workers indexed with low s switch employers.

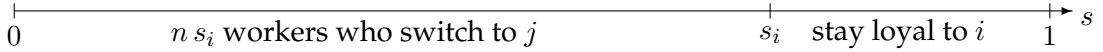


Figure 1: Allocation of firm i 's loyal and switching workers, $i = A, B$.

The utility function (1) implies that the switching cost thresholds are given by

$$s_A = \frac{v_B - w_A}{\sigma} \quad \text{and} \quad s_B = \frac{v_A - w_B}{\sigma}. \quad (2)$$

The model has the feature that firms and workers face the same uncertainty regarding the change of productivity of a worker switching from one firm to another. In this respect neither the firms nor the workers have any informational advantage. In contrast, the worker has an informational advantage regarding the idiosyncratic switching cost, which is known to the worker prior

⁴In Appendix A we modify the distribution of switching costs so as to facilitate an analysis which separates the effects of the expected magnitude of the switching costs from those associated with the dispersion of the switching costs. We briefly comment on the implications of such a separation after Result 1.

to deciding whether to stay loyal in the present employment relationship or accept a poaching offer from the rival.

2.4 Costs, output, and profit

We focus on an environment with labor as the only production factor, meaning that the cost function is determined by the labor costs. In view of Figure 1, total labor costs of firm $i = A, B$ are given by

$$c_i(w_i, w_j, v_i, v_j) = \underbrace{n(1 - s_i)w_i}_{\text{loyal workers' wages}} + \underbrace{ns_jv_i}_{\text{poached workers' wages}}. \quad (3)$$

The first component in (3) is firm i 's total wage bill paid to its loyal workers who do not switch to the competing firm due to high switching costs. The second component in (3) is i 's total wages paid to workers who switch employment from firm $j \neq i$ because of an attractive wage offer v_i and sufficiently low switching costs. Formally, the cost function depends on all the loyalty and poaching wages. In particular, it can directly be verified that firm i 's costs are strictly increasing as a function of its own loyalty wage, its own poaching wage and its rival's loyalty wage, whereas it is strictly decreasing as a function of its rival's poaching wage.

Next, we compute total output of each firm taking into consideration that the firm's labor force is composed of loyal workers as well as those it has succeeded to attract with its poaching activities. Formally, firm i 's *expected* production level is given by

$$q_i(w_i, w_j, v_i, v_j) = \underbrace{n(1 - s_i)k}_{\text{loyal workers}} + \underbrace{ns_j [\delta^H(k + k') + \delta^L(k - k')]}_{\text{new from } j\text{'s workers}} = n(1 - s_i)k + ns_j [k + k'\Delta], \quad (4)$$

where Δ is characterized in Definition 1. According to (4), the output level of firm i has two components. The first term in (4) is the output produced by loyal workers who do not switch. There is no uncertainty regarding this output component. The second term in (4) is uncertain because the output is produced by workers who switched from firm j . The expected output per switching worker may be the same, higher, or lower than that produced by a loyal worker depending on the sign of Δ , that is depending on whether it is more likely that the switch is productive or unproductive. Straightforward calculations show that firm i 's production is strictly increasing as

a function of its own loyalty and poaching wages, whereas it is strictly decreasing as a function of its rival's loyalty and poaching wages.

Models of imperfect competition typically focus on configurations where firms have market power in the product market, whereas factor markets, like labor markets, are viewed as competitive. However, in certain industries such as high-tech industries, the strategic competition among firms for human capital constitutes an integral component of firms' strategic behavior. In the present analysis we want to analyze precisely this type of competition. For that reason we downplay the competition in the product market by assuming that each unit of output is sold for a fixed price p . Related approaches to the analysis of imperfect competition in labor markets have been applied by, for example, Bhaskar, Manning, and To (2002), and Bhaskar and To (2003). Manning (2011), and Booth (2014) offer extensive surveys of this literature.

Focusing on this type of imperfect competition for human capital, each firm $i = A, B$ takes the wage rates paid by firm j (w_j and v_j) as given, and chooses its own wage rates (w_i and v_i) to maximize profit. Hence, the optimization problem facing firm i is

$$\max_{w_i, v_i} \pi_i(w_i, w_j, v_i, v_j) = pq_i - c_i, \quad (5)$$

where the output level q_i is defined in (4), the firm's total labor cost c_i in (3), and the market shares are derived in (2). The profit function (5) exhibits an interesting strategic interaction between the competing firms, because production (4) and cost (3) depend on both, the loyalty and poaching wage decisions taken by both firms.

3. Equilibrium wage rates and job switchings

The following restrictions on σ are sufficient for obtaining interior equilibria with job switching in both directions.⁵

ASSUMPTION 2. *The switching cost parameter σ is bounded. Formally,*

$$\frac{k'p|\Delta|}{2} \stackrel{\text{def}}{=} \sigma^{\min} < \sigma < \sigma^{\max} \stackrel{\text{def}}{=} \frac{p(3k + k'\Delta)}{2}.$$

⁵Of course, configurations without job switching could emerge as corner solutions and the study of these configurations would require appropriate modifications of the analytical model.

The upper bound in Assumption 2 ensures strictly positive equilibrium wage rates. The lower bound ensures an equilibrium configuration where some workers switch and others stay loyal, as depicted in Figure 1.⁶

3.1 Analysis of equilibrium wages

Solving the profit maximizing problems (5) yields the unique Nash equilibrium wages

$$w_A = w_B = \frac{3kp + k'p\Delta - 2\sigma}{3} \quad \text{and} \quad v_A = v_B = \frac{3kp + 2k'p\Delta - \sigma}{3}. \quad (6)$$

From (6) we can directly conclude that $v_i - w_i = (k'p\Delta + \sigma)/3 > 0, i = A, B$, by Assumption 2. This means that in equilibrium there is a wage premium for switching workers. This feature is consistent with the theoretical and empirical findings explored in Sliwka and Kampkötter (2014) who examine labor mobility within the German banking industry. Although firms also want to retain workers by paying them high wages, the switching costs prevent some workers from accepting poaching offers. Thus, the switching costs enable firms to lower the loyalty wages as they provide strong protection against competition for workers with high switching costs. We summarize this property as well as a number of comparative statics properties of the equilibrium wages in the following result.

Result 1. (a) *Loyalty wages as well as poaching wages are strictly decreasing as functions of the switching costs (σ), but poaching wages decline at a faster rate.*

(b) *There is a wage premium ($v_i > w_i, i = A, B$) for switching workers. This premium is strictly increasing in the switching costs (σ) and it is strictly increasing in the probability of a productive switch relative to the probability of an unproductive switch (Δ).*

(c) *All equilibrium wages increase with the output price (p) and the productivity parameter (k). Further, the wages increase as a function of the productivity change due to switching (k') if and only if the probability of a productivity improvement exceeds that of productivity decline ($\Delta > 0$).*

By setting a different wage for the rival's workers relative to the wage paid to its own workers, the firm can implement history-based wage discrimination. By applying this strategy, the firms

⁶Note that the range of σ in Assumption 2 is nonempty, because $k' < k$ implies that $\sigma^{\min} < \sigma^{\max}$.

can exploit workers' heterogeneity with respect to their switching costs. Result 1(a) implies that higher and more differentiated switching costs generate softer wage competition between firms. Furthermore, this effect is stronger for poaching wages than for loyalty wages. The next section explores the effects of this mechanism for industry profit, worker surplus, and total welfare.

In Appendix A we extend our characterization of the equilibrium wages and the wage premium to a switching cost distribution which distinguishes between the expected magnitude and the dispersion of the switching costs. We demonstrate that the loyalty wages (poaching wages) are strictly increasing (decreasing) as functions of the mean of the switching costs. In addition, all equilibrium wages are strictly decreasing as functions of the dispersion of the switching costs. Further, the wage premium targeted towards switching workers is strictly increasing in the mean of the switching costs, whereas it is invariant to the dispersion of the switching costs. In all other respects, the equilibrium properties reported in Result 1 are unaffected by a switching cost distribution that separates between the expected magnitude and the heterogeneity of the switching costs.

3.2 Equilibrium switching and implications for labor mobility

We next explore the implications of the model for labor mobility. For that purpose we examine the equilibrium market shares.

As illustrated in Figure 1, for each firm i , all workers with low switching costs $s \in [0, s_i]$ switch to firm j , whereas the remaining proportion $1 - s_i$ of the workers is retained at the initial workplace. Formally, substituting the equilibrium wages into the firms' market shares (2) yields

$$s_A = s_B = \frac{1}{3} + \frac{k'p\Delta}{3\sigma}. \quad (7)$$

Assumption 2 implies that in equilibrium $0 < s_i < 2/3$, meaning that a wide range of the fraction of switching workers is consistent with equilibrium. According to (7), in the absence of any productivity change induced by switching ($k' = 0$), the fraction of switching workers is $1/3$. In the presence of productivity changes induced by switching ($k' > 0$) this fraction could be above or below $1/3$ contingent on whether the probability of a productivity improvement exceeds that of productivity decline ($\Delta > 0$ or $\Delta < 0$).

We summarize our findings of labor mobility between firms with the following result.

Result 2. (a) *In the presence of productivity changes induced by switching ($k' > 0$), the fraction of switching workers is above or below $1/3$ contingent on whether the probability of a productivity improvement exceeds that of productivity decline ($\Delta > 0$) or not ($\Delta < 0$).*

(b) *The magnitude by which the fraction of switching workers differs from $1/3$ is affected by the productivity change induced by switching (k'), the output price (p), and the relative probabilities that switching improves productivity (Δ). However, this magnitude declines with the switching cost differentiation parameter (σ).*

(c) *In the absence of any productivity change induced by switching ($k' = 0$), the fraction of switching workers is $1/3$. Likewise, if the probability that switching is productive equals the probability that switching unproductive ($\Delta = 0$), the fraction $s_i = 1/3$ of all workers switch employers.*

(d) *Switching occurs even under circumstances when switching is more likely to be unproductive than productive ($\Delta < 0$).*

The particular role of the fraction $1/3$ is a consequence of the assumed uniform distribution of switching costs. The same fraction $1/3$ of switching consumers is an equilibrium outcome in standard switching cost models focusing on imperfect competition in product markets (see, for example, Chen (1997)). However, Result 2 adds to the insights from the literature in industrial economics by explicitly showing how the fraction of switching workers is influenced by factors particularly relevant for labor mobility: k' , Δ , and σ .

Result 2(d) is remarkable because it implies that wage competition for talent acquisition induces labor mobility also under circumstances where switching reduces workers' productivity. Under these circumstances competition induces firms to engage in poaching although poaching is harmful from the perspective of efficiency. That is, in this case aggregate industry output is higher without poaching than with poaching. Poaching nevertheless occurs because firms find it profitable to increase sales even if such increase necessitates paying higher wages to switching, less productive workers. This finding resembles the "damaged goods" mechanism for price discrimination explored in Deneckere and McAfee (1996), where a product or service with higher

production costs is sold at a lower price to consumers with lower willingness to pay.⁷ In our model of talent competition, firms can achieve wage discrimination by paying higher wages to switching workers, irrespectively of whether the switching is productive or unproductive. In both applications, discrimination, be that price discrimination or wage discrimination, does not support first-best allocations.

In our model, poaching and the associated job switching introduce uncertainty regarding the productivity of labor. Oligopoly models exploring the effects of increased uncertainty on equilibrium profits can therefore be applied in order to evaluate the effects of poaching on equilibrium profits in our model.⁸ Also, Lazear (1995) has developed a model with the feature that the external recruitment of workers introduces uncertainty regarding the productivity of the firm. However, in Lazear's model the external recruitment is explained by the associated option value. Our model incorporates no option values. Instead, in our model the increased uncertainty generated by external recruitment changes the strategic interaction between firms.

In order to explore how labor mobility affects aggregate industry output, let $Q = q_A + q_B$ denote aggregate industry output. If workers do not switch employers, aggregate output is $Q = 2nk$, which is total labor force multiplied by worker-specific productivity of each identical worker (k). However, when firms target wage offers to the rival's labor force, some switch employers in equilibrium as characterized above. Therefore, with some workers switching, equilibrium aggregate industry output is then given by

$$\begin{aligned}
 Q = q_A + q_B &= 2nk + \underbrace{\delta^H n(s_A + s_B)k'}_{\text{output gain from switching}} - \underbrace{\delta^L n(s_A + s_B)k'}_{\text{output loss from switching}} \\
 &= 2nk + \frac{2nk'\Delta(k'p\Delta + \sigma)}{3\sigma}, \quad (8)
 \end{aligned}$$

where s_A and s_B are substituted from (7). The sum of the output gains and losses associated with switching in (8) will become very important in our welfare analysis, because the output changes

⁷For example, Fed-Ex may find second-day delivery service to be more costly due to storage. However, the introduction of "slower" delivery opens up the market to consumers with lower willingness to pay while consumers with high willingness to pay may continue to pay a premium of overnight delivery. Internet delay of stock price quotes or delayed information in general are also relevant examples of damaged goods.

⁸Models of price competition with uncertainty include Spulber (1995), Janssen and Rasmusen (2002), and Lagerlöf (2014).

as well as the aggregate switching costs determine the change in total welfare resulting from the labor mobility among firms in the given industry. Equation (8) shows that in equilibrium labor mobility will induce an increase in aggregate industry output if and only if the probability of productive switching exceeds that of unproductive switching.

4. Industry profit, worker surplus, and total welfare in a poaching equilibrium

4.1 Analysis of profit

In this subsection we compute the industry profits associated with equilibrium wages. Substituting the equilibrium wages (6) and market shares (7) into (5), and summing up over the two firms yields the equilibrium aggregate industry profit level

$$\Pi = \pi_A + \pi_B = \frac{2n(2k'^2p^2\Delta^2 - 2k'p\Delta\sigma + 5\sigma^2)}{9\sigma}. \quad (9)$$

Differentiating (9) with respect to σ , k' , Δ , and p , respectively, yields the following result.

Result 3. (a) *Equilibrium industry profit increases with the switching cost effect (σ).*

(b) *Let $\bar{\sigma} \stackrel{\text{def}}{=} 2k'p\Delta$ be a threshold value of the switching cost parameter. Industry profit increases with the relative probability that switching improves productivity (Δ) if and only if $\sigma \leq \bar{\sigma}$.*

(c) *Let $\Delta > 0$. Then, industry profit increases with the productivity change induced by switching (k') and the output price (p) if and only if $\sigma \leq \bar{\sigma}$.*

Result 3(a) is consistent with our finding, formalized in Result 1, that the switching cost effect relaxes wage competition between the firms. Results 3(b) and 3(c) capture the feature that the parameters k' , Δ , and p affect the equilibrium wages in a direction opposite to the switching cost effect (σ), as shown by (6). The threshold $\bar{\sigma}$ characterized in Results 3(b) and 3(c) balances these two opposite effects.

4.2 Analysis of worker surplus

We next examine worker surplus, denoted by WS , associated with the poaching equilibrium. In order to fully understand the effects of labor mobility and job switching on worker surplus, we break WS into two components: Total wage incomes to the workers I and aggregate switching costs SC borne by all workers who switch employers. Formally, aggregate worker surplus is defined as $WS = I - SC$.

Because labor is the only input to production, total wages must be equal to the total factor costs borne by both employers. Thus, $I = c_A + c_B$. Substituting (6) and (7) into (3) yields

$$I = \frac{2n(9kp\sigma + k'^2p^2\Delta^2 + 5k'p\Delta\sigma - 5\sigma^2)}{9\sigma}. \quad (10)$$

It can be directly verified that aggregate income (I) increases with the productivity of non-switching and switching workers (k and k') as well as the output price (p) and the relative probability of productive switches (Δ). However, the total income of workers declines with the switching cost effect (σ), because this parameter relaxes wage competition between the two employers.

As illustrated by Figure 1, only consumers with relatively low switching costs switch employers. In order to characterize aggregate switching costs we need to sum up the heterogeneous individual costs of switching (s) for those workers who are attracted by the poaching wages. Formally, aggregate switching costs are computed by

$$SC = n \int_0^{s_A} \sigma s \, ds + n \int_0^{s_B} \sigma s \, ds = \frac{n(k'p\Delta + \sigma)^2}{9\sigma}, \quad (11)$$

where s_A and s_B are substituted from (7).

Straightforward comparative statics analysis reveals that the aggregate switching costs (SC) increase as a function of the relative probability of productive switches (Δ) and the switching cost effect (σ), whereas the effects of the productivity of switching workers (k') and the output price (p) depend on the sign of the relative probability of productive switches (Δ).

By subtracting (11) from (10) we find aggregate worker surplus to be

$$WS = \frac{n(18kp\sigma + k'^2p^2\Delta^2 + 8k'p\Delta\sigma - 11\sigma^2)}{9\sigma}. \quad (12)$$

Differentiating (12) with respect to k , k' , p , Δ , and σ yields the following result.

Result 4. *Worker surplus increases with the productivity of non-switching and switching workers (k and k'), the output price (p), and the relative probability of productive switches (Δ). However, it decreases with the switching cost effect (σ).*

In particular, Result 4 formalizes the view that increased dispersion with respect to the switching costs of workers hurts worker welfare, because it softens wage competition.

Figure 2 illustrates Result 4 by plotting aggregate worker income from wages (I) derived in equation (10), aggregate worker switching cost (SC) derived in equation (11), and aggregate worker surplus $WS = I - SC$.

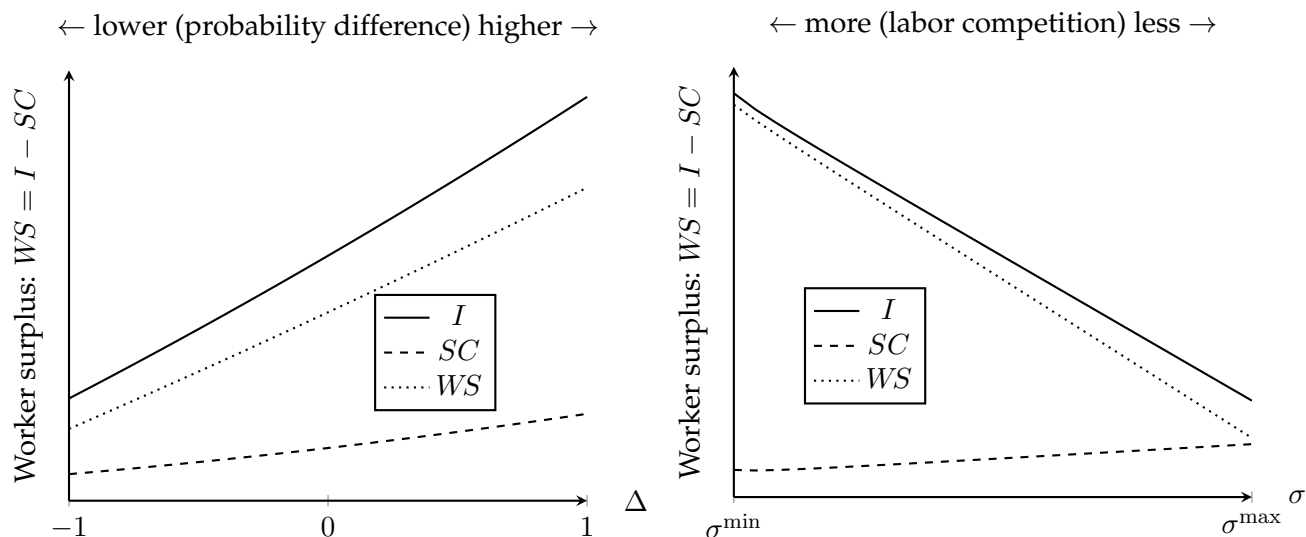


Figure 2: Aggregate worker income (solid), aggregate worker switching cost (dashed), worker surplus (dotted). *Left panel:* As functions of the probability difference (Δ). *Right panel:* As functions of decreasing degree of competition intensity (σ).

4.3 Analysis of total welfare

Total welfare is defined as the sum of aggregate worker surplus and aggregate industry profit, so that $W = WS + \Pi$. Because aggregate income from wages constitutes a transfer from firms to workers, an equivalent definition of total welfare is total sales revenue less than aggregate switching cost, so that $W = pQ - SC$.

Formally, adding (12) and (9) yields

$$W = \frac{n(18kp\sigma + 5k'^2p^2\Delta^2 + 4k'p\Delta\sigma - \sigma^2)}{9\sigma} \quad (13)$$

Differentiating (13) with respect to k , k' , p , Δ , and σ yields the following result.

Result 5. *Total welfare increases as a function of the productivity of non-switching and switching workers (k and k'), the output price (p), and the relative probability of productive switches (Δ). However, it decreases with the switching cost effect (σ).*

In light of Results 3 and 4, there is a conflict of interest between firms and workers as far as the effect of the switching costs σ is concerned. Result 5 demonstrates that the negative effect of relaxed competition on workers is stronger than the associated positive effect on industry profits. Thus, total welfare decreases as a function of the switching cost effect σ .

Figure 3 illustrates Result 5 by plotting aggregate industry profit (Π) derived in equation (9), aggregate worker surplus (WS) derived in equation (12), and total welfare (W) given in (13). Note

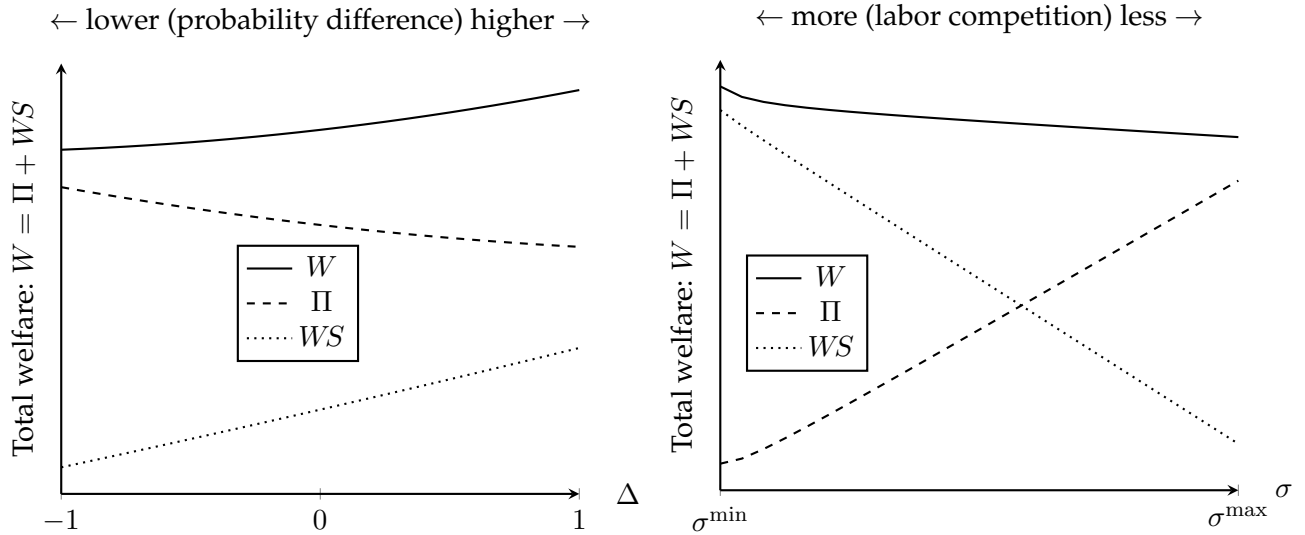


Figure 3: Total welfare (solid), aggregate industry profit (dashed), worker surplus (dotted). *Left panel:* As functions of the degree of the probability difference (Δ). *Right panel:* As functions of decreasing degree of competition intensity (σ).

that the slope of the Π function on the left panel could be negative or position, as described in Result 3.

5. Anti-poaching agreements: Effects on profits and welfare

In this section we explore the effects on profits and worker surplus of anti-poaching agreements, whereby firms agree not to engage in “cold calling” each other’s employees. The Californian high-tech court case presented in the Introduction serves as a good motivation for undertaking such an analysis.

An anti-poaching agreement is introduced in order to eliminate a significant form of competition to attract a certain category of talented human capital. More precisely, poaching is ruled out when firms sign an anti-poaching agreement, which forces firms to compete with uniform wages, that is, wages which do not differentiate between whether a worker is employed by the firm itself or by its rival. As for any type of agreement, an anti-poaching agreement cannot be sustained as a non-cooperative equilibrium. Instead, it serves as a mechanism to achieve implicit or explicit collusion.

We introduce the following formal definition of an anti-poaching agreement.

DEFINITION 2. Competing firms (employers) form an anti-poaching agreement if they agree not to apply poaching wages in order to attract workers from the rivals. Formally, firms are restricted to setting uniform wages, denoted by u_A and u_B .

It should be highlighted that an anti-poaching agreement is not a mechanism for the coordination of wage setting. Further, it should be emphasized that workers always have the option to switch employers if they find it beneficial to do so, independently of whether firms have an anti-poaching agreement or not. An anti-poaching agreement is nothing more and nothing less than a mutual restriction on the firms’ wage structure which prevents firms from setting different wages for switching workers.

The next subsection characterizes the equilibrium wages in the presence of an anti-poaching agreement. It also explores the effects of such an anti-poaching agreement on industry profits and welfare by conducting comparisons with the outcome associated with the equilibrium allowing for poaching. We will conduct these comparisons for the more natural case where switching

improves productivity.⁹ Thus, for the remainder of our analysis we impose the following assumption, which is expressed by applying the terminology introduced in Definition 1(c).

ASSUMPTION 3. *Switching is more likely to be productive* ($\Delta = \delta^H - \delta^L \geq 0$).

5.1 Anti-poaching agreements: Wages, profits and welfare

As characterized in Definition 2, in the presence of an anti-poaching agreement, firms A and B compete by setting uniform wages, denoted u_A and u_B , respectively. These wages apply uniformly to all existing employees as well as to potentially new switching employees. In light of the model with poaching we now impose the restriction that $u_i = w_i = v_i$.

Clearly, workers have no incentives to switch employers if both firms pay the same uniform wage ($u_A = u_B$). Therefore, with no loss of generality, we explore an equilibrium where firm A pays a higher (or equal) wage than firm B . Formally, we assume that $u_A \geq u_B$ and note that we do not, ex ante, rule out equal wages. Then, $s_A = 0$ because no A -worker would switch to firm B that pays a lower wage. Hence, equations (2) and (3) imply that the fraction of B workers who switch to firm A and the resulting costs (total wage bills) to firms A and B , respectively, are given by

$$s_B = \frac{u_A - u_B}{\sigma}, \quad c_A = n \left(1 + \frac{u_A - u_B}{\sigma} \right) u_A \quad \text{and} \quad c_B = n \left(1 - \frac{u_A - u_B}{\sigma} \right) u_B. \quad (14)$$

Substituting (4) and (14) into (5), and then maximizing each profit function π_i with respect to the uniform wage u_i ($i = A, B$) yields the unique Nash equilibrium wages and the resulting fractions of switching workers

$$u_A^{AP} = \frac{3kp + 2k'p\Delta - 3\sigma}{3}, \quad u_B^{AP} = \frac{3kp + k'p\Delta - 3\sigma}{3}, \quad s_A^{AP} = 0 \quad \text{and} \quad s_B^{AP} = \frac{k'p\Delta}{3\sigma}. \quad (15)$$

In (15) the superscript “ AP ” stands for the equilibrium wage under the anti-poaching agreement.

Note that Assumption 2 implies that $0 < s_B^{AP} < 1$.

⁹Result 2(d) showed that in a poaching equilibrium, switching takes place also under circumstances when it is more likely that switching is unproductive ($\Delta < 0$). This result highlights how wage competition can decrease social welfare because expected productivity declines and on top of that the economy bears switching costs. From a total welfare perspective, the case with unproductive switching seems less interesting than productive switching, because unproductive switching can never be socially optimal. Therefore, the remainder of the paper will focus on the case with productive switching. It should nevertheless be emphasized that we could very well carry out equivalent comparisons of profits and welfare for the case with unproductive switching.

Comparing (15) with (6) and (7) reveals that $u_A^{AP} - w_A = (k'p\Delta - \sigma)/3$ which could be positive or negative for the range of admissible values of σ under Assumption 2. Further effects of an anti-poaching agreement on equilibrium wages are characterized by the differences $u_A^{AP} - v_A = -2\sigma/3 < 0$, $u_B^{AP} - w_B = -\sigma/3 < 0$, and $u_B^{AP} - v_B = -(k'p\Delta + 2\sigma)/3 < 0$.

In light of a comparison between (15) and (7) we can infer that an anti-poaching agreement reduces labor mobility significantly: it not only eliminates switching from A to B ($s_A^{AP} = 0$), but it also reduces mobility in the other direction as $s_B^{AP} = \frac{k'p\Delta}{3\sigma} = s_B - \frac{1}{3}$.

We can summarize the findings regarding the equilibrium wages and labor mobility under an anti-poaching agreement according to the following result.

Result 6. *An anti-poaching agreement*

- (a) *increases the wage paid to loyal workers of the high-wage firm ($u_A^{AP} > w_A$) if the switching cost parameter is sufficiently small ($\sigma < k'p\Delta$), whereas it reduces this wage ($u_A^{AP} < w_A$) otherwise ($\sigma > k'p\Delta$).*
- (b) *reduces the wages paid to all other types of workers ($u_A^{AP} < v_A$, $u_B^{AP} < w_B$, and $u_B^{AP} < v_B$).*
- (c) *reduces labor mobility not only by eliminating switching from the high-wage firm as $s_A^{AP} = 0$, but also by reducing switching in the other direction as $s_B^{AP} = \frac{k'p\Delta}{3\sigma} = s_B - \frac{1}{3}$.*

Result 6 verifies the intuitive view that an anti-poaching agreement would reduce the wages for several categories of workers. However, it also shows the surprising result that an anti-poaching agreement may increase the wage paid to some category of workers, more precisely the high-wage firm A 's loyal employees, when the switching cost parameter is sufficiently low. But, if $\sigma > k'p\Delta$ the wage paid to this category of workers, i.e. those loyal to A , is already so high in the poaching equilibrium that firm A would not profit from raising the uniform wage under the anti-poaching agreement above this level.

Because of the possibility that some workers may gain from an anti-poaching agreement, we cannot immediately conclude that such an agreement would automatically hurt the workers. Likewise, it is not at all clear whether such an anti-poaching agreement softens wage competition so as to stimulate industry profits. Next we will investigate these issues in detail, starting by exploring the effects of an anti-poaching agreement on industry profits.

Substituting the uniform equilibrium wages (15) into (14) and (4), and then into the profit functions (5) yields the firms' equilibrium profit levels and aggregate industry profit under an anti-poaching agreement

$$\pi_A^{AP} = \frac{n(k'^2 p^2 \Delta^2 - 3k' p \Delta \sigma + 9\sigma^2)}{9\sigma}, \quad \pi_B^{AP} = \frac{n(k' p \Delta - 3\sigma)^2}{9\sigma},$$

and $\Pi^{AP} = \pi_A^{AP} + \pi_B^{AP} = \frac{n(2k'^2 p^2 \Delta^2 - 9k' p \Delta \sigma + 18\sigma^2)}{9\sigma}. \quad (16)$

Comparing equilibrium profits under the anti-poaching agreement (16) with profits under the poaching equilibrium (9), Appendix B proves the following result.

- Result 7.** (a) *Under the anti-poaching agreement, the firm that pays a higher wage and attracts some workers to switch from the rival firm earns a higher profit than the competing firm. Formally, $\pi_A^{AP} > \pi_B^{AP}$.*
- (b) *The anti-poaching agreement increases the profit of the high-wage firm relative to the poaching equilibrium if and only if workers face sufficiently high switching costs. Formally, $\pi_A^{AP} \geq \pi_A$ if and only if $\sigma \geq \sigma_A^{AP}$ where $\sigma_A^{AP} \stackrel{\text{def}}{=} (1 + \sqrt{17}) k' p \Delta / 8$.*
- (c) *The anti-poaching agreement increases the profit of the low-wage firm relative to the poaching equilibrium if and only if workers face sufficiently high switching costs. Formally, $\pi_B^{AP} \geq \pi_B$ if and only if $\sigma \geq \sigma_B^{AP}$ where $\sigma_B^{AP} \stackrel{\text{def}}{=} (1 + \sqrt{2}) k' p \Delta / 2$.*
- (d) *The anti-poaching agreement increases aggregate industry profit relative to the poaching equilibrium if and only if workers face sufficiently high switching costs. Formally, $\Pi^{AP} > \Pi$ if and only if $\sigma \geq \sigma_{\Pi}^{AP}$ where $\sigma_{\Pi}^{AP} \stackrel{\text{def}}{=} (5 + \sqrt{89}) k' p \Delta / 16$.*

According to Result 7(a) the distribution of roles between the firms determines the equilibrium profits. It reveals that the high-wage firm attracts workers to such an extent that the associated production expansion outweighs the disadvantage of having to pay higher wages.

As emphasized in our comments on Result 1, a higher switching cost parameter relaxes wage competition, and therefore stimulates profits in the poaching equilibrium. Inspection of the equilibrium wages (15) reveals that a higher switching cost parameter also softens wage competition in the presence of an anti-poaching agreement. In fact, from a careful comparison between (15)

and (6) we can conclude that the competition-softening effect of the switching cost parameter is stronger under an anti-poaching agreement. It is consistent with this property that Results 7(b), 7(c), and 7(d) separately characterize switching cost thresholds above which the anti-poaching agreement leads to higher profits than the poaching equilibrium.

The switching cost thresholds characterized in Results 7(b), 7(c), and 7(d) can be ordered by $\sigma_A^{AP} < \sigma_{II}^{AP} < \sigma_B^{AP}$. This ordering is illustrated in Table 1 in subsection 5.2. Furthermore, it appeals to intuition that the threshold regarding industry profits σ_{II}^{AP} lies between the thresholds for firms A and B .

Clearly, the formation of an anti-poaching agreement would be blocked if at least one firm finds it profitable to deviate from such an agreement. In light of the ordering of the switching costs thresholds we can draw the following conclusion.

Result 8. *An anti-poaching agreement requires that the switching cost parameter exceeds the threshold relevant for each of the participating firms. This requirement is satisfied if $\sigma \geq \sigma_B^{AP}$.*

We next explore the effects of an anti-poaching agreement on total worker surplus as well as on total welfare. Aggregate worker surplus was defined as the difference between total wage income and aggregate switching costs. Formally, with an anti-poaching agreement $WS^{AP} = I^{AP} - SC^{AP}$, where $I^{AP} = C^{AP} = c_A^{AP} + c_B^{AP}$ is equal to the total wage bill paid by all firms. Substituting the equilibrium wages (15) into (14) yields total worker income

$$I^{AP} = \frac{n(18kp\sigma + k'^2p^2\Delta^2 + 9k'p\Delta\sigma - 18\sigma^2)}{9\sigma}. \quad (17)$$

To compute aggregate switching costs, note that $s_A^{AP} = 0$ because firm A pays a higher wage than firm B . Substituting the equilibrium wages (15) into (14) yields aggregate switching cost and the resulting aggregate worker surplus:

$$SC^{AP} = \int_0^{s_B^{AP}} \sigma s ds = \frac{k'^2np^2\Delta^2}{18\sigma} \quad \text{and}$$

$$WS^{AP} = I^{AP} - SC^{AP} = \frac{n(36kp\sigma + k'^2p^2\Delta^2 + 18k'p\Delta\sigma - 36\sigma^2)}{18\sigma}. \quad (18)$$

It remains for us to compare aggregate worker surplus under the anti-poaching agreement (18) with worker surplus associated with the poaching equilibrium (12). In this respect, Appendix B proves the following result.

Result 9. *Aggregate worker surplus is lower under the anti-poaching agreement compared with the poaching equilibrium. Formally, $WS^{AP} < WS$.*

Based on the combination of Result 7 and Result 9 we can conclude that anti-poaching agreement unambiguously reduces total welfare if the switching cost parameter is sufficiently low. However, for a sufficiently high switching cost parameter an anti-poaching agreement introduces an interesting distributional conflict between the workers and the firms. Our comparison of the total welfare effects of an anti-poaching agreement addresses precisely this tradeoff.

With an anti-poaching agreement, total welfare can be computed as

$$W^{AP} = WS^{AP} + \Pi^{AP} = \frac{np(36k\sigma + 5k'^2p\Delta^2)}{18\sigma}. \quad (19)$$

Comparing (19) with (13), Appendix B proves our final result.

Result 10. *Let $\sigma_W^{AP} \stackrel{\text{def}}{=} k'p\Delta(2 + \sqrt{26}/2)$. The anti-poaching agreement increases total welfare compared to the equilibrium with poaching if and only if $\sigma \geq \sigma_W^{AP}$.*

Combining Result 7 and Result 9 reveals that there is no conflict of interest between firms and workers when $\sigma < \sigma_{\Pi}^{AP}$, because for $\sigma < \sigma_{\Pi}^{AP}$ workers as well as firms are worse off with an anti-poaching agreement. But for $\sigma > \sigma_{\Pi}^{AP}$, an anti-poaching agreement enhances industry profits, but harms the workers. Result 10 essentially implies that the gains to firms exactly outweighs the harm to workers when $\sigma = \sigma_W^{AP}$. The threshold $\sigma_W^{AP} \approx 4.55k'p\Delta$ is significantly higher than the threshold $\sigma_{\Pi}^{AP} \approx 0,9k'p\Delta$, defined in Result 7. This makes sense, because the threshold relevant for total welfare has to compensate for the fact that an anti-poaching agreement always reduces total worker surplus. Furthermore, the gains from an anti-poaching agreement to firms are stronger than the associated losses to workers when $\sigma > \sigma_W^{AP}$.

5.2 Anti-poaching agreements: A discussion

The wage equilibrium under an anti-poaching agreement has the property that competition between identical firms leads to asymmetric wages.¹⁰ The mechanism behind this feature is crucially linked to the feature that workers can switch in only one direction when firm apply different uniform wages. The firm applying a higher wage therefore attracts more workers, which facilitates expansion of production. As the high-wage firm has a higher equilibrium profit than the low-wage firm we can conclude that the production expansion outweighs the cost increase associated with the higher cost per worker.

In an anti-poaching agreement with uniform wages the asymmetric equilibrium is a mechanism for firms to benefit from market power created by switching costs. Thus, the history-based price discrimination at the root of the poaching equilibrium is not the only mechanism for firms to benefit from switching costs. However, under an anti-poaching agreement the firms can benefit from only one-sided switching, i.e. switching from the low-wage firm to the high-wage firm.

Our analysis has clarified that the switching cost parameter σ plays a crucial role for the evaluation of an anti-poaching agreement. In fact, comparisons between the poaching equilibrium and the anti-poaching agreement depend crucially on the switching cost parameter σ . The general structure is that there is a threshold for the switching cost parameter σ such that the anti-poaching agreement comes out favorably for switching cost parameters above this threshold. However, the level of the switching cost threshold depends on whether we focus on the high-wage firm, the low-wage firm, industry profits or welfare.

Table 1 provides an overview of the results from the switching cost perspective by listing all the threshold values of σ from high to low. Note that the lower bound is σ^{\min} is defined in Assumption 2. The upper bound σ^{\max} is not displayed because, depending on the productivity parameter k , it may range from above σ_{Π}^{AP} to any higher level for sufficiently large values of k .

Table 1 shows that the threshold above which the anti-poaching agreement stimulates prof-

¹⁰The literature has presented a number of examples of this remarkable feature. For example, in the duopoly model of Reinganum (1981) the adoption timings for a new technology are dispersed even though the firms are identical. Similarly, our paper does not, *ex ante*, rule out symmetric wages (in which case workers do not switch in any direction). However, in equilibrium, the labor market sustains an asymmetric configuration with one high-wage firm, whereas the other firm optimally chooses to pay a lower wage and operate on a lower scale.

	σ	Value	Approx.	Effect	Reference
High	σ_W^{AP}	$(2 + \sqrt{26}/2)k'p\Delta$	$4.55 k'p\Delta$	Enhance ($W^{AP} > W$) Reduce ($W^{AP} < W$)	Result 10
	\uparrow	σ_B^{AP}	$(1 + \sqrt{2})k'p\Delta/2$	$1.21 k'p\Delta$	Enhance ($\pi_B^{AP} > \pi_B$) Reduce ($\pi_B^{AP} < \pi_B$)
\uparrow	σ_{Π}^{AP}	$(5 + \sqrt{89})k'p\Delta/16$	$0.90 k'p\Delta$	Enhance ($\Pi^{AP} > \Pi$) Reduce ($\Pi^{AP} < \Pi$)	Result 7(d)
\uparrow	σ_A^{AP}	$(1 + \sqrt{17})k'p\Delta/8$	$0.64 k'p\Delta$	Enhance ($\pi_A^{AP} > \pi_A$) Reduce ($\pi_A^{AP} < \pi_A$)	Result 7(b)
Low	σ^{\min}	$k'p\Delta/2$	$0.50 k'p\Delta$	Lower bound	Assumption 2

Table 1: Summary of threshold values of the switching cost parameter and related effects.

its for the high-wage firm, σ_A^{AP} , is below that applying to the low-wage firm, σ_B^{AP} . Further, the threshold regarding industry profits σ_{Π}^{AP} belongs to the interval defined by the thresholds for the high-wage and low-wage firms. These thresholds, and their ordering, are important because the formation of an anti-poaching agreement would be blocked if at least one firm finds it profitable to deviate from such an agreement. Table 1 also illustrates that the threshold (σ_W^{AP}) required for an anti-poaching agreement to benefit total welfare is significantly higher than the threshold for such an agreement to be profitable for the firms. This makes sense, because the threshold relevant for total welfare has to compensate for the fact that an anti-poaching agreement always reduces total worker surplus.

6. Conclusion

This study has analyzed a duopoly model of wage competition such that firms can design poaching offers consisting of higher wages paid to workers who switch from a competing firm. Within such a framework we have evaluated the effects of an anti-poaching agreement, which eliminates poaching as a recruitment method. We established that firms benefit from such an anti-poaching agreement if the switching cost effect is sufficiently strong. Table 1 summarizes the switching cost thresholds for an anti-poaching agreement to promote firm-specific or industrywide profits.

Our analysis established that aggregate worker surplus always declines as a consequence of

an anti-poaching agreement, even though it is possible that some category of workers may benefit from the agreement. Furthermore, an anti-poaching agreement always reduces labor mobility, i.e. the proportion of switching workers. Table 2 highlights these results. Further, the gains to firms from an anti-poaching agreement may be stronger than the associated losses to workers, but this requires that the switching costs exceed a threshold that is significantly higher than the threshold for the agreement to be profitable, as shown in Table 1.

Endogenous variable	Effects of anti-poaching agreements
Fraction of switching workers (s_i)	Reduced
Wages paid to loyal workers (w_i)	Ambiguous
Wages paid to switching workers (v_i)	Reduced
Aggregate worker surplus (WS)	Reduced
Aggregate industry profit (Π)	Enhanced ($\sigma > \sigma_{\Pi}^{AP}$) Reduced ($\sigma < \sigma_{\Pi}^{AP}$)
Total welfare (W)	Enhanced ($\sigma > \sigma_W^{AP}$) Reduced ($\sigma < \sigma_W^{AP}$)

Table 2: The effects of anti-poaching agreements.

Our analysis could be extended in a number of directions. The current study was restricted to an evaluation of the effects of anti-poaching agreements in the market for experienced high-skilled employees. Apart from differentiation with respect to switching costs, the model focused on a homogeneous labor force with actual switching as the only source of uncertainty regarding the productivity development. Of course, any serious attempts to derive any implications of our model for equilibrium unemployment would require extensions of the model to incorporate a labor force which is heterogeneous with respect to both productivity and employment history (or absence thereof).

Our analysis has highlighted strategic competition for human capital among firms as an integral part of overall competition, and in doing so it has downplayed the effects of market power in the product market. Our model could be extended to investigate the interaction between strategic competition in both labor and product markets in order to explore how product market consider-

ations might modify the wage policies of firms.¹¹ Anti-poaching agreements may have different effects on industry profits and welfare when strategic product market considerations are taken into account. Furthermore, such an analysis would also be suitable for measuring the effects on consumers and workers separately. Finally, our model could also be extended to incorporate multiple periods where at the initial recruitment stage firms and workers anticipate poaching offers from competing firms.

Appendix A Separating the expected magnitude from the dispersion of the switching costs

This appendix briefly demonstrates how our general results could be generated also in a model that separates the expected magnitude from the dispersion of the switching costs. Formally, we modify the switching cost distribution to a uniform distribution over the interval $[\mu - \lambda, \mu + \lambda]$ instead of $[0, 1]$. Figure 1 is now replaced by Figure 4 which illustrates a uniform distribution with mean μ and variance $\text{var}(s) = \int_{\mu-\lambda}^{\mu+\lambda} (s - \mu)^2 ds = 2\lambda^3/3$ where $\mu > \lambda > 0$. Thus, the parameter λ captures the dispersion of the switching costs.

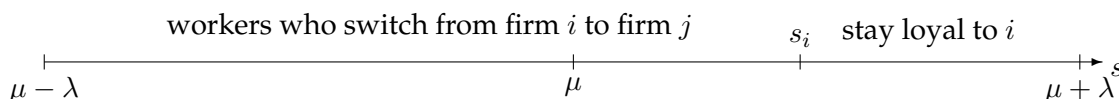


Figure 4: Mean-preserving spread switching cost distribution. *Note:* The equilibrium value of s_i could be lower than μ .

An advantage of using only σ as an indicator of the magnitude of switching costs is that it does not affect the total buyer population which was assumed to equal $2n$. As shown on Figure 4, without modifying this distribution, increasing the variance by increasing λ will increase the total buyer population, unless we neutralize this effect by assuming that total buyer population is $2n = 2N/(2\lambda)$. Under this modification, a change in λ would not affect the total number of buyers which is now $2N$ regardless of the value of λ .

Similar to Assumption 2, in order focus on interior equilibria only, we restrict the mean and

¹¹Blanchard and Giavazzi (2003), Spector (2004), and Koskela and Stenbacka (2012) are examples of studies which have combined elements of imperfections in product and labor markets in order to explore the effects on equilibrium unemployment of firms with market power in the product market.

the dispersion of the switching costs to satisfy $k'p\Delta - 3\lambda < \mu < 3kp + k'p\Delta - 3\lambda$. Setting $\sigma = 1$, equation (2) becomes $s_i = v_j - w_i$, for $i, j = A, B$ and $i \neq j$. The firms' cost (wage bill) functions (3) become

$$c_i(w_i, w_j, v_i, v_j) = \frac{N}{2\lambda} (\mu + \lambda - s_i) w_i + \frac{N}{2\lambda} [s_j - (\mu - \lambda)] v_i. \quad (\text{A.1})$$

Similarly, firms' sales quantities (4) are modified to

$$q_i(w_i, w_j, v_i, v_j) = \frac{N}{2\lambda} (\mu + \lambda - s_i) k + \frac{N}{2\lambda} [s_j - (\mu - \lambda)] [k + k'\Delta]. \quad (\text{A.2})$$

Next, substituting all the above into firm i 's profit function (5), and maximizing with respect to w_i and v_i , the equilibrium wages (6) become

$$w_A = w_B = \frac{3kp + k'p\Delta - 3\lambda - \mu}{3} \quad \text{and} \quad v_A = v_B = \frac{3kp + 2k'p\Delta - 3\lambda + \mu}{3}. \quad (\text{A.3})$$

Therefore, $v_i - w_i = (k'p\Delta + 2\mu)/3 > 0$ which resembles the difference in wages given in (6), except that σ (switching cost magnitude parameter) is replaced by 2μ (twice the mean switching cost).

Using the equilibrium wages (A.3), we demonstrate the similarities and differences between the two models with the following replication of Result 1.

Result A.1. (a) *Loyalty wages (poaching wages) are strictly decreasing (increasing) as functions of the mean switching cost μ . In addition, all wages are strictly decreasing as functions of the switching cost dispersion λ .*

(b) *There is a wage premium ($v_i > w_i$, $i = A, B$) for switching workers and this premium is strictly increasing in the mean switching cost μ , but it is unaffected by the dispersion λ . In addition, the wage premium is strictly increasing in the probability of a productive switch relative to the probability of an unproductive switch Δ .*

(c) *Identical to Result 1(c) in all respects.*

Appendix B Proofs

Proof of Result 7. Equation (16) implies that $\pi_A^{AP} - \pi_B^{AP} = k'np\Delta/3 > 0$.

Comparing (16) with (9) implies that $\pi_A^{AP} - \pi_A = n(-k'^2p^2\Delta^2 - k'p\Delta\sigma + 4\sigma^2)/(9\sigma) \geq 0$ if and

only if $\sigma \geq \sigma_A^{AP}$, where $\sigma_A^{AP} \stackrel{\text{def}}{=} (1 + \sqrt{17}) k' p \Delta / 8$.

Next, $\pi_B^{AP} - \pi_B = -n (k'^2 p^2 \Delta^2 + 4k' p \Delta \sigma - 4\sigma^2) / (9\sigma) \geq 0$ if and only if $\sigma \geq \sigma_B^{AP}$, where $\sigma_B^{AP} \stackrel{\text{def}}{=} (1 + \sqrt{2}) k' p \Delta / 2$.

Next we focus on aggregate industry profit. Subtracting (9) from (16) yields

$$\Pi^{AP} - \Pi = -n (2k'^2 p^2 \Delta^2 + 5k' p \Delta \sigma - 8\sigma^2) / (9\sigma).$$

This difference is non-negative if and only if $\sigma \geq \sigma_{\Pi}^{AP}$, where $\sigma_{\Pi}^{AP} \stackrel{\text{def}}{=} (5 + \sqrt{89}) k' p \Delta / 16$.

Proof of Result 9. Subtracting (12) from (16) implies that

$$WS^{AP} - WS = -\frac{n (k'^2 p^2 \Delta^2 - 2k' p \Delta \sigma + 14\sigma^2)}{18\sigma} < 0$$

if $\sigma(7\sigma - k' p \Delta) > -k'^2 p^2 \Delta^2 / 2$. This inequality holds because the right hand side is negative, whereas the left hand side is positive by Assumption 2.

Proof of Result 10. Subtracting (13) from (19) yields

$$W^{AP} - W = -\frac{n (5k'^2 p^2 \Delta^2 + 8k' p \Delta \sigma - 2\sigma^2)}{18\sigma} > 0$$

if and only if $5k'^2 p^2 \Delta^2 + 8k' p \Delta \sigma - 2\sigma^2 < 0$, and hence if and only if $\sigma \geq \sigma_{\Pi}^{AP}$, where $\sigma_{\Pi}^{AP} \stackrel{\text{def}}{=} (5 + \sqrt{89}) k' p \Delta / 16$.

References

- Bhaskar, Venkataraman, Alan Manning, and Ted To. 2002. "Oligopsony and Monopsonistic Competition in Labor Markets." *Journal of Economic Perspectives* 16 (2):155–174.
- Bhaskar, Venkataraman and Ted To. 2003. "Oligopsony and the Distribution of Wages." *European Economic Review* 47 (2):371–399.
- Blanchard, Olivier and Francesco Giavazzi. 2003. "Macroeconomic Effects of Regulation and Deregulation in Goods and Labor Markets." *Quarterly Journal of Economics* 118 (3):879–907.
- Booth, Alison. 2014. "Wage Determination and Imperfect Competition." *Labour Economics* 30:53–58.
- Boudreau, John. 2014. "Uber-Style Talent Poaching Happens in All Industries." *Harvard Business Review commentary* September.

- Burguet, Roberto, Ramon Caminal, and Carmen Matutes. 2002. "Golden Cages for Showy Birds: Optimal Switching Costs in Labor Contracts." *European Economic Review* 46 (7):1153–1185.
- Cappelli, Peter. 2000. "A Market-Driven Approach to Retaining Talent." *Harvard business review* 78 (1):103–11.
- Chen, Yongmin. 1997. "Paying Customers to Switch." *Journal of Economics and Management Strategy* 6 (4):877–897.
- Ciapanna, Emanuela. 2011. "Directed Matching with Endogenous Markov Probability: Clients or Competitors?" *RAND Journal of Economics* 42 (1):92–120.
- Deneckere, Raymond and Preston McAfee. 1996. "Damaged Goods." *Journal of Economics and Management Strategy* 5 (2):149–174.
- Esteves, Rosa. 2009. "A Survey on the Economics of Behaviour-Based Price Discrimination." Tech. rep., NIPE-Universidade do Minho.
- . 2010. "Pricing with Customer Recognition." *International Journal of Industrial Organization* 28 (6):669–681.
- Fox, Jeremy. 2010. "Estimating the Employer Switching Costs and Wage Responses of Forward-Looking Engineers." *Journal of Labor Economics* 28 (2):357–412.
- Fudenberg, Drew and Jean Tirole. 2000. "Customer Poaching and Brand Switching." *RAND Journal of Economics* 31 (4):634–657.
- Fudenberg, Drew and Miguel Villas-Boas. 2007. "Behavior-Based Price Discrimination and Customer Recognition." In *Handbook of Economics and Information Systems*, edited by T. Hendershott. Elsevier, 377–433.
- Gehrig, Thomas., Oz Shy, and Rune Stenbacka. 2011. "History-based Price Discrimination and Entry in Markets with Switching Costs: A Welfare Analysis." *European Economic Review* 55 (5):732–739.
- Janssen, Maarten and Eric Rasmusen. 2002. "Bertrand Competition under Uncertainty." *Journal of Industrial Economics* 50 (1):11–21.
- Koskela, Erkki and Rune Stenbacka. 2012. "The Relationship between Product Market Competition and Unemployment with Profit Sharing." *Labour Economics* 19 (3):291–297.
- Lagerlöf, Johan. 2014. "Does Cost Uncertainty in the Bertrand Model Soften Competition?" *University of Copenhagen Department of Economics Discussion Paper* (14-08).

- Lazear, Edward. 1995. "Hiring Risky Workers." National Bureau of Economic Research, Working Paper No. 5334.
- Manning, Alan. 2003. *Monopsony in motion: Imperfect competition in labor markets*. Princeton University Press.
- . 2011. "Imperfect Competition in the Labor Market." *Handbook of Labor Economics* 4:973–1041.
- Naidu, Suresh. 2010. "Recruitment Restrictions and Labor Markets: Evidence from the Postbellum US South." *Journal of Labor Economics* 28 (2):413–445.
- Reinganum, Jennifer. 1981. "Market Structure and the Diffusion of New Technology." *Bell Journal of Economics* 12 (2):618–624.
- Sliwka, Dirk and Patrick Kampkötter. 2014. "Wage Premia for Newly Hired Employees." *Labour Economics* 31:45–60.
- Spector, David. 2004. "Competition and the Capital–Labor Conflict." *European Economic Review* 48 (1):25–38.
- Spulber, Daniel. 1995. "Bertrand Competition when Rivals' Costs are Unknown." *Journal of Industrial Economics* 43 (1):1–11.