Employer market power in Silicon Valley

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April 2019†

***PRELIMINARY & INCOMPLETE ***

Abstract

The falling labor share of income in the US has renewed interest in employer market power. I examine an important case of such power: no-poach agreements through which technology companies agreed not to compete for each other's workers. Exploiting the plausibly exogenous timing of a Department of Justice investigation, I estimate the effects of these agreements using double- and triple-difference designs. Data from Glassdoor.com permit the inclusion of rich employer- and job-level controls. Estimates indicate each agreement cost affected workers 2.6 to 4.0 percent of annual salary. Stock bonuses and worker mobility were also negatively affected. (JEL J42, J30, L40)

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†First draft July 2018

The workmen desire to get as much, the masters to give as little as possible. The former are disposed to combine in order to raise, the latter in order to lower the wages of labor. ...We rarely hear...of the combinations of masters, though frequently of those of workmen. But whoever imagines...that masters rarely combine, is as ignorant of the world as of the subject. ...To violate this combination is every where a most unpopular action, and a sort of reproach to a master among his neighbours and equals. ...Masters too sometimes enter into particular combinations to sink the wages of labour even below this rate. These are always conducted with the utmost silence and secrecy...and when the workmen yield...without resistance...they are never heard of by other people.
–Adam Smith, *The Wealth of Nations* (1776)

I would be very pleased if your recruiting department would stop doing this.
–Steve Jobs (Apple), in an email to Eric Schmidt (Google; 2005)

Steve, as a followup we investigated the recruiter's actions and she violated our policies. Apologies again on this... Should this ever happen again please let me know immediately and we will handle. ...On this specific case, the sourcer who contacted this Apple employee should not have and will be terminated within the hour.
–Schmidt reply to Jobs

:)
–Jobs reply to Schmidt

1 Introduction

From 1970 to 2014 the labor share of US GDP fell from 66 to 60 percent (University of Groningen and UC Davis 2018) and other countries have seen similar declines (Karabarbounis and Neiman 2013). Several competing explanations have attracted researcher interest. One strand of work emphasizes neoclassical factors, including trade and technological change (Autor et al. 2017a; Autor et al. 2017b; Grossman et al. 2017). A second emphasizes institutional factors, including declining unionization (Blanchard and Giavazzi 2003) and employer market power (US CEA 2016; Krueger and Posner 2018).[1] This paper examines an important example of such power: the 2005-2009 no-poach agreements among Silicon Valley technology firms.

Because employer market power typically arises endogenously, it is difficult to separate from other determinants of labor earnings. Moreover in the United States, explicit collusion to depress labor compensation is illegal under the Sherman Act, and exercising market power is illegal under the Clayton Act (US Department of Justice 2010b; Marinescu and Hovenkamp 2018). This gives firms engaged in such behavior powerful incentives to hide it from both government officials and researchers. The recent "no-poach" agreements among technology companies provide a rare opportunity to identify causal effects of employer market power.

The following large firms were party to at least one no-poach agreement: Adobe, Apple, eBay, Google, Intel, Intuit, Lucasfilm and Pixar. Concluded at the highest levels of management, including boards and CEOs, the agreements prohibited participating firms from recruiting or hiring each other's employees. Managers informed recruiters which potential hires were off limits and some recruiting departments maintained written lists. Implementation was straightforward. A potential new employee cannot avoid disclosing her recent and current employers to a firm at which she seeks a job. Even if she were to do so, platforms like LinkedIn make it all but impossible to withhold such information. Enforcement was similarly easy. In cases where a firm violated an agreement, its counterparty often contacted a senior manager at the violating firm, who would then put a stop to the violation (US Department of Justice 2010b; US Department of Justice 2012). This exercise of market power was remarkably simple and cheap, relying on well-defined commitments from a small number of individuals. It required no elaborate salary schedules. The empirical ease with which these firms coordinated stands in some contrast to the difficulty of sustaining coordination in many textbook theoretical models of firm behavior.

A US Department of Justice investigation began to unravel the no-poach agreements in

[1] Such market power is frequently termed monopsony (Robinson 1933) or oligopsony (Marinescu and Hovenkamp 2018).

early 2009. National media revealed the antitrust investigation on June 3, 2009 and DOJ filed its complaint in US v. Adobe Systems on Sept. 24, 2010 (Helft 2009; US Department of Justice 2010b). This was followed by a civil class action in 2011.

Using difference-in-differences designs, I estimate the effect of these no-poach agreements on salaries. The timing of entry into the agreements is potentially a function of unobserved economic factors that also influence labor earnings. My identification relies instead on the plausibly exogenous timing of the DOJ investigation, which forced defendant firms to end the agreements and led to salary increases. I find each full-year no-poach agreement reduced salaries by 2.6 to 4.0 percent. My data are a novel set of compensation surveys from the website Glassdoor. They include both employer names and detailed job titles in addition to salary and other compensation.

These results are important because the information technology sector is a large and growing part of the US economy. From 1997 to 2017, value added in this sector rose from $373.8 billion to $961.5 billion (real 2009 dollars; US Bureau of Economic Analysis 2018). My estimates may assume more general significance because of broad trends in the US economy. No-poach agreements were facilitated by interlocking corporate boards and high market concentration, which reduced coordination costs (US Department of Justice 2012). From 1997 to 2012, the revenue share of the top 50 firms increased in the majority of US industries (US CEA 2016). Recent work has found that workers in a majority of US occupations face labor markets that are "highly concentrated" under DOJ guidelines (Azar et al. 2018). Growing use of arbitration and non-compete clauses may also be increasing employer market power (US CEA 2016).

This paper contributes to the empirical literature on employer market power.[2] Using online job vacancy data, Azar et al. (2018) document concentration in US labor markets and estimate associations between concentration and wages. Using Census data, Benmelech, Bergman, and Kim (2018) find a negative relationship between local labor market concentration and wages that has grown stronger over time. My approach is most similar to Naidu, Nyarko, and Wang (2016), who use a policy reform relaxing constraints on worker mobility in the United Arab Emirates to study the effect of monopsony on earnings. In a similar vein, Staiger, Spetz, and Phibbs (2010) use a policy-mandated wage change at a subset of VA hospitals to examine wage responses at other hospitals in the same labor markets. This paper also adds to the literature on no-poach agreements. In important recent work, Krueger and Ashenfelter (2017) study the prevalence of no-poach agreements in the franchise sector. More broadly, my results contribute to the economic literature on white-collar crime (Kahan

[2] For surveys see Manning (2003) and Manning (2011).

and Posner 2005; Levitt 2006; Slemrod 2007).[3]

The rest of the paper proceeds as follows. Section 2 presents a theoretical model. Section 3 describes my data and Section 4 presents estimating equations. Section 5 discusses empirical results and Section 6 concludes.

2 Theory

I extend the model of Shy and Stenbacka (2019) along two dimensions. First, I consider the three-firm case. Second, in keeping with my empirical setting, I define no-poach agreements as quantity restrictions rather than uniform wage restrictions. Consider three firms, a, b, and c, indexed by i and facing output prices p_i. Each firm initially employs n workers, and competes for workers by offering a loyalty wage w_i and a poaching wage v_i. Within each firm workers have switching costs $s \sim U[0,1]$. These switching costs scale by a factor σ that varies by firm pair. A worker's productivity is ϕ at the originating firm and ϕ' (potentially different) at the destination firm.

A worker initially employed at firm i maximizes the following utility function.

$$u_i(s) = \begin{cases} w_i & if\ stay \\ v_j - \sigma_{ij}s & if\ leave\ for\ j \\ v_k - \sigma_{ik}s & if\ leave\ for\ k \end{cases}$$

Let l_{ij} denote the supply of firm i labor that moves to firm j, allowing for the case $i = j$ ("stayers"). The firm's optimization problem can then be written compactly.

$$\max_{w_i,v_i} p_i \left[n\phi l_{ii} + n\phi' (l_{ji} + l_{ki}) \right] - \left[nw_i l_{ii} + nv_i (l_{ji} + l_{ki}) \right]$$

First-order conditions are as follows.

$$\begin{aligned} (p_i\phi - w_i)\frac{\partial l_{ii}}{\partial w_i} - l_{ii} = 0 \\ \left(p_i\phi' - v_i\right)\left(\frac{\partial l_{ji}}{\partial v_i} + \frac{\partial l_{ki}}{\partial v_i}\right) - (l_{ji} + l_{ki}) = 0 \end{aligned} \tag{1}$$

Empirically, unrestrained markets for technology workers typically feature flows among all firms. Given the theoretical structure above, the only potential equilibrium featuring switching across all three firm pairs is one in which $v_a > v_b > v_c$ and $\sigma_{ab} = \sigma_{ba} > \sigma_{ac} =$

[3] While the DOJ did not undertake a criminal prosecution in response to the no-poach agreements I study, it had the authority to do so under the Sherman Act.

$\sigma_{ca} > \sigma_{bc} = \sigma_{cb}$, as illustrated in Figure 1. Within each firm, wage offers and switching costs divide workers into three types. For example, consider firm a. Workers with values of s on $\left(0, \frac{v_c - v_b}{\sigma_{ac} - \sigma_{ab}}\right)$ switch to firm b. Workers with values of s on $\left(\frac{v_c - v_b}{\sigma_{ac} - \sigma_{ab}}, \frac{v_c - w_a}{\sigma_{ac}}\right)$ switch to firm c. Workers with values of s on $\left(\frac{v_c - w_a}{\sigma_{ac}}, 1\right)$ stay at firm a. Provided $p_a \gg p_b \gg p_c$ and differences in switching costs are small relative to levels of switching costs, an equilibrium exists with $v_a^* > v_b^* > v_c^* > w_a^* > w_b^* > w_c^*$. Closed-form solutions (w_i^*, v_i^*) are in Appendix E.

Given this initial equilibrium, the only potentially incentive-compatible no-poach agreement is between firms b and c. (A deal between firm a and one of the lower-wage firms would not reduce poaching from the lower-wage firm.) I set the corresponding supply functions equal to zero ($l_{bc} = l_{cb} = 0$) and solve for new equilibrium wages (w_i^{np}, v_i^{np}). The DOJ complaint and the class action both allege that the no-poach agreements reduced labor earning at colluding firms, so I am interested in parameter values that yield this prediction. If switching is strongly productivity-reducing ($\phi' \ll \phi$) or switching costs $\sigma_{ba} + \sigma_{ac}$ are large relative to productivity gains, then both loyalty wages w_i^{np} and poaching wages v_i^{np} fall at the colluding firms b and c (relative to the equilibrium without a no-poach agreement).[4] Under these conditions, the no-poach agreement also reduces both loyalty wages w_a^{np} and poaching wages v_a^{np} at firm a. Details are in Appendices E and F.

3 Data

3.1 Description

My data come from Glassdoor, an online aggregator of wage and salary self-reports. Reports cover employer, work location, raw job title, salary, and years of experience. The chief strengths of these data, relative to public data sets like the Current Population Survey, are the inclusion of employer names and detailed job titles. Glassdoor uses machine-learning models to classify users' raw job title input at three increasingly granular levels: general occupation, specific occupation, and job title. As described by the company, the machine-learning model groups user-provided raw job titles by looking at job search and clicking behavior on their website. Importantly, salary information is not an input into the model. The top ten categories under each classification are in Table A2. I use reports from the following industries: "Computer Hardware & Software", "Internet", and "Motion Picture Production & Distribution." My data include age, education, and gender for a subset of

[4] If switching is productivity-increasing ($\phi' > \phi$) or switching costs $\sigma_{ba} + \sigma_{ac}$ are small, the model predicts increased loyalty wages at firms b and c. The effect on average wages at b and c is then potentially zero or even positive.

users.

The salary variable is not censored at high values. For users that report monthly or hourly earnings (10 percent of my sample), I impute an annual salary by assuming a 40-hour work week and 50 work weeks per year. I convert all nominal salaries to 2009 U.S. dollars using the chained personal consumption expenditures deflator from the Bureau of Economic Analysis.

Self-reported data naturally raise the question of measurement error. Karabarbounis and Pinto (2018) investigate by comparing Glassdoor data to the QCEW and the PSID. Industry-level correlations for mean salary are .87 and .9, respectively. The authors conclude, "...the wage distribution (conditional on industry or region) in Glassdoor represents the respective distributions in other datasets, such as QCEW and PSID fairly well." More generally, previous research suggests survey respondents report annual pre-tax earnings with good precision. Using the Displaced Worker Supplement to the Current Population Survey (CPS), Oyer (2004) finds mean reporting error of +5.1% and median error of +1.3%. Both mean and median error are smaller for respondents reporting annual earnings, as 90 percent of respondents in my data do. Similarly, Bound and Krueger (1991) compare CPS reports to Social Security earnings records and find a signal-to-noise ratio of .82 for men, .92 for women. Abowd and Stinson (2013) relax the assumption that administrative data are accurate and survey data are measured with error. They estimate similar reliability statistics for the Survey of Income and Program Participation and Social Security earnings data. Using the same two data sets, Kim and Tamborini (2014) find reporting error is smaller for workers with undergraduate and graduate degrees, who comprise 93 percent of my sample (Appendix Table A1).

While some reports are unincentivized, others are incentivized by a "give-to-get" model: complete access to the website's aggregate salary and job satisfaction data requires a survey response that passes quality checks. Users may submit multiple reports for the same or different jobs. Naturally the resulting sample is non-random, and I discuss sample selection in Section 3.2 below. I use all complete reports from full-time regular employees, ages 16 to 70, from 2007 to 2017.[5] Descriptive statistics are in Appendix Table A1.

3.2 Sample selection

The plaintiffs' expert report from the civil class action (Leamer 2012) contains some data that are useful in evaluating selection into my Glassdoor sample. Leamer (2012) Fig. 5 gives firms, job titles, years, and nominal compensation for the named plaintiffs. While

[5]Temporary, part-time and contract workers are excluded.

these observations are not randomly selected, that does not necessarily imply that they are not representative. Indeed all but one of the observations for the named plaintiffs is close to the corresponding fitted value from Leamer's econometric model, estimated using the full data set. Barring the one exception, they are representative despite their non-random selection. One named plaintiff earned $118,226 in salary and $3,445 in other compensation as a Computer Scientist at Adobe in 2008. Matching on firm, job title, and year, the corresponding Glassdoor means are $122,238 and $11,509. A second named plaintiff earned an average of $109,363 in salary and $30,641 in other compensation as a Software Engineer at Intel 2008-2011. The corresponding Glassdoor means are $106,548 and $14,844. A third named plaintiff held multiple positions at Intuit. In 2008 he earned $91,300 in salary and $83,877 in other compensation as a Software Engineer. (This observation is far from the corresponding fitted value of roughly $110,000 from the Leamer model, perhaps because of the large non-salary compensation.) The corresponding Glassdoor means are $91,212 and $9,021. In 2009 he earned $94,000 in salary and $38,553 in other compensation as a Software Engineer II. The corresponding Glassdoor means are $95,662 and $9,310. The absolute mean salary difference between the administrative and Glassdoor data is $693, and the mean absolute difference is $2,144. These observations suggest that the Glassdoor data are reasonably representative of salaries at colluding firms. The Glassdoor measures of non-salary compensation are noisier, at minimum, and potentially less representative.[6] Leamer's Exhibit 2 permits a few comparisons of report frequencies by job for Pixar Animation. The top five jobs by count of worker-years are "Technical Director," "Animator," "Software Engineer," "Artist–Story," and "Artist–Sketch." For Glassdoor the top five job titles by worker-years are "Technical Director," "Production Coordinator," "Senior Software Engineer," "Software Engineer," and "Animator." While these lists do not match perfectly, they are reasonably similar.

While the above comparisons are suggestive, they are limited in scope. Leamer's Figure 4 permits comparison of mean total (nominal) compensation per person-year at Adobe and Intuit during the collusive period. Two cautions are in order. First, for Adobe the comparison is imperfect, as the Leamer figure includes compensation data from pre-2007 periods not covered by Glassdoor data. Second, Glassdoor coverage of non-salary compensation is much more limited than coverage of salary. Because non-salary compensation is highly right-skewed (Leamer 2012, Figure 8), this could lead to large differences in mean total compensation. Per Leamer Figure 4, mean total compensation during the collusive period was $123,385 for Adobe, $169,576 for Intuit. The corresponding figures in my sample are $157,316 for Adobe,

[6] For non-salary compensation, the absolute mean difference between administrative and Glassdoor data is $27,958 and the mean absolute difference is $31,990

$140,890 for Intuit. Because these means are in nominal dollars and the Glassdoor data do not include pre-2007 observations, the difference in temporal coverage may explain why the Adobe mean is substantially higher in Glassdoor data. For Intuit the temporal coverage is identical in Leamer's Figure 4 and my Glassdoor sample, and the means differ by 17%.

The Occupational Employment Statistics from the Bureau of Labor Statistics permit a broader set of comparisons at the occupation-year level, including both treatment and control firms. Figure 2 presents a scatter plot of occupation-years, where occupations are defined by year-2000 SOC codes. Vertical coordinates are nominal mean salaries from BLS OES data. Horizontal coordinates are nominal mean salaries from Glassdoor data. At values below $100,000 the data cluster tightly around the 45-degree line, indicating a close correspondence between OES and Glassdoor data. At higher values most observations lie below the line, indicating the Glassdoor mean is greater than the OES mean. This is partly due to censoring in the OES data, with thresholds from $145,600 to $208,000 depending on year. While the Glassdoor sample is not randomly drawn, Figure 2 suggests it is nonetheless reasonably representative.

4 Empirical strategy

I begin from the following difference-in-differences equation.

$$\ln\left(Salary_{egsjilt}\right) = \alpha_{eg} + \beta_{gt} + \gamma_l + \delta Num.Agreements_{et} + \varepsilon_{egsjilt} \quad (2)$$

Indices are: e~employer, g~general occupation, s~specific occupation, j~job title, i~user, l~location (MSA), and t~year. The parameters α_{eg} control for cross-sectional differences across employer-general-occupation groups. In subsequent specifications I move to employer-specific-occupation (α_{es}) and employer-job-title (α_{ej}) groups. The parameters β_{gt} control for arbitrary general-occupation-year trends. In subsequent specifications I move to specific-occupation-year (β_{st}) and job-title-year (β_{jt}) trends. The parameters γ_l capture regional salary differences. The treatment variable $Num.Agreements_{et}$ is a weighted count of no-poach agreements in force. For example, if a firm had 1 agreement in force for 5 months and 2 for 7 months, $Num.Agreements_{et} = \left(\frac{5}{12}\right)1 + \left(\frac{7}{12}\right)2$.[7] It follows that δ is the effect of having one additional no-poach agreement in force for a full year. Standard errors are clustered in two dimensions, general occupation and employer. This allows for arbitrary covariances in the error term within occupation or employer, both cross-sectionally and over time.

The event study in Figure 3 provides a preliminary view of the treatment effect and

[7] Details for each treated firm are in Appendix A.

allows for evaluation of identifying assumptions. This figure is constructed from a variant of Equation 2. Controls are job-title-employer, job-title-year, and MSA fixed effects. Treatment is a collusion dummy interacted with year indicators and the 2017 treatment-control difference is normalized to zero. My data begin in 2007, at which time many of the no-poach agreements had already entered into force. The effect of these agreements is visible in the left-hand region of Figure 3, where treatment-group salaries are below control-group salaries by 5 percent. The estimate for 2007 is not statistically significant at the five percent level, but those for 2008 and 2009 are. The vertical line just after 2009 marks the end of the treatment period. DOJ documents indicate that the no-poach agreements ended in 2009, but that at least some continued after the investigation was publicly revealed in June (US Department of Justice 2012). Therefore I assume that all agreements in force at the beginning of 2009 continued through the end of 2009. Treatment-group salaries begin to converge to control-group salaries after this point, but estimates remain substantially negative in 2010 and 2011. Full convergence occurs in 2012. My identification strategy relies not on the potentially endogenous introduction of no-poach agreements, but rather on the plausibly exogenous DOJ investigation that ended them.

Figure 3 also allows indirect evaluation of the parallel trends assumption required for a difference-in-differences design to identify the causal effect of the no-poach agreements. In the 2007-2009 period covered by the agreements, treatment and control salaries move in parallel. In the post-treatment period 2012-2017 there is more variance in point estimates, but none are statistically significant at the five percent level.[8] There is no evidence of different trends in the two groups. Broadly the event study results imply that the magnitudes of my estimates based on Equation 2 are likely biased downward. My specification ignores the 2010-2011 transition, during which salaries at treatment-group firms may have been reduced by lingering effects of the no-poach agreements. While this is undesirable, the alternative is worse: defining treatment based on endogenous transition behavior could introduce endogeneity. The firms that were party to no-poach agreements are large and could conceivably have reduced salaries at non-participating firms. If such was the case, then these general-equilibrium effects also bias my estimates downward in magnitude.

To study worker mobility I define a discrete variable C taking the following values: $C = 1$ indicates staying at the current employer, $C = 2$ indicates leaving for a treated employer, and $C = 3$ indicates leaving for a control employer. I then estimate multinomial logit models,

[8] Approximately 13% of observations come from treatment-group firms, which is one reason for the higher variance in that time series.

beginning from the following equation.

$$\ln\left[\frac{pr_{eit}\left(C=c\right)}{pr_{eit}\left(C=1\right)}\right]=\alpha Treated_e+\beta Collusion_t+\delta Treated_e*Collusion_t+\nu_{eit} \qquad (3)$$

In this equation $Treated_e$ is an indicator for originating in a treated firm and $Collusion_t$ is an indicator for a transition occurring during the collusive period 2007-2009. In subsequent specifications I add year dummies, a dummy for each treated employer, and metropolitan area dummies.

5 Empirical results

5.1 Primary empirical results

Table 1 presents estimated effects of one additional no-poach agreement. Column one corresponds exactly to Equation 2. The estimated effect is -1.5 percent, statistically significant at the ten percent level. Column two uses specific occupation and the estimate is modestly larger: -1.9 percent, statistically significant at the five percent level. Column three uses controls based on job title, the most specific classification scheme, and the estimate is larger still: -2.6 percent, statistically significant at the one percent level. This is my preferred specification, because it employs rich controls for both cross-sectional and time-series differences across job titles while maintaining a large, plausibly representative sample. Column four adds user fixed effects, so identifying variation comes only from users who submit multiple reports.[9] The resulting estimate is -4.0 percent, statistically significant at the one percent level. The increased magnitude springs from the change in sample, not the inclusion of user fixed effects. Table A3 reports the same four specifications as Table 1, limited everywhere to the sample under user fixed effects, and estimates are all in the -4 to -5 percent range. These estimated reductions are consistent with the theoretical prediction that no-poach agreements reduce salaries at participating firms (see Section 2). The model also predicts reduced salaries at control-group firms. If such was the case, then my empirical estimates are biased downward in magnitude.

The magnitude of these effects is striking because these employees are well educated and highly paid. Thirty-one percent have an advanced degree and the mean salary in the larger sample is $85,555 (2009 US$). From intuition one might expect these characteristics to make them less vulnerable than other groups to employer market power. My estimates are in the range of the firm- and year-specific effects on total compensation estimated by the plaintiffs'

[9]Note that such users may constitute a selected subsample.

expert report from the class action: from -1.6 to -20.1 percent, with most from -1.6 to -10 percent (Leamer 2012).[10] The defendants' expert report is, to the best of my knowledge, not part of the public court record. However in certifying the plaintiff class Judge Lucy Koh quoted its conclusions: "'Defendants argue that, when Dr. Murphy disaggregated the Conduct Regression, he received dramatically different results. See id. at 12-13; Murphy Rep. ¶ 117 (finding that Lucasfilm and Pixar "show[ed] no 'undercompensation' but instead 'overcompensation' . . . throughout the period," Google, Adobe, and Intel showed overcompensation in some years, and Apple showed "much smaller" undercompensation)"' (Koh 2013). My estimates are inconsistent with the quoted results.

Previous research on employer market power has estimated effects of similar magnitude. Azar et al. (2018) find that a 10 percent increase in concentration (HHI) is associated with a .3 to 1.3 percent decrease in wages. Benmelech, Bergman, and Kim (2018) find that a one standard deviation increase in HHI is associated with a 1 to 2 percent decrease in wages, and that the relationship is stronger in more recent data. Naidu, Nyarko, and Wang (2016) find that when migrant workers in the United Arab Emirates are allowed to change employers at the end of their initial contract, their earnings increase by 10 percent.

The following back-of-the-envelope calculation estimates aggregate damages based on salary alone. The plaintiffs' expert report estimates 109,048 members of the class and $52 billion in affected earnings (Leamer 2012). In my data the average treated worker was affected by roughly two no-poach agreements. Based on column three of Table 1, the marginal effect is approximately $2 * -.026 = -.052$ percent. Earnings in the absence of the agreements would then have been $\frac{\$52bn}{1-.052} = \$54.85bn$ and employee losses were $\$2.85bn$, or approximately $5,200 per employee-year.[11] Even ignoring non-salary compensation, my damage estimate is substantially greater than the $435 million the defendants paid to settle the case (Elder 2015; *High-Tech Employee Antitrust Settlement* 2018).[12] This gap raises the question of whether the settlement will meaningfully deter future exercise of employer market power.[13]

Theory predicts that damages represent a transfer from labor to owners of other factors

[10] The experts in this litigation had access to administrative compensation data from defendant firms, but not from other firms. The research design employed in (Leamer 2012) is a single difference, comparing agreement periods to pre- and post-agreement periods.

[11] These calculations can instead be performed in levels, using regression results from Table A4. For the larger all-employee class, damages are then (109,048 employees)(-$2760/agreement-yr)(2 agreements)(5 years), approximately $3 billion in 2009 dollars. Alternatively one can assume that only technical and creative salaries were affected (59,550 employees). From the triple-difference regressions of Table A6, the marginal effect of the agreements is approximately $2 * -.0309 \approx .062$. Earnings in the absence of the agreements would have been $\frac{\$33bn}{1-.062} = \$35.2bn$ and employee losses were $\$2.2bn$.

[12] Apple, Google, Intel and Adobe settled together for $415 million in 2015. The other defendants settled for $20 million.

[13] This remains true even if one alls for uncertainty in my estimate and non-settlement losses.

(Shy and Stenbacka 2019). At macroeconomic scale, the declining labor share has been associated not with an increased capital share, but rather increased profit (Barkai 2017), though this need not be true in this particular setting. An estimate of the attendant deadweight loss is beyond the scope of this paper. Given the high mean salary among affected workers, it could be argued that the welfare consequences of earnings lost to the no-poach agreements are relatively small. For workers in the San Francisco Bay Area this argument is unconvincing because high housing costs greatly reduce the real purchasing power of six-figure nominal salaries. In June 2018 the US Department of Housing and Urban Development revised its eligibility threshold for low-income housing assistance to $117,400 for Marin, San Mateo, and San Francisco counties (Sciacca 2018).

Table 2 examines non-salary compensation, including cash bonuses, stock bonuses, and profit sharing. Note that Glassdoor does not require responses for these variables, and the sample is a potentially selected subset of the one from Table 1. I observe non-zero supplemental compensation for 66 percent of reports, while according to Leamer (2012) 93 percent of employee-years included supplemental compensation. The following results should therefore be interpreted with caution. For each compensation type I estimate a linear probability model using a dummy for positive compensation and a model with log compensation as the dependent variable. The probability of a positive stock bonus declines by 5 percentage points per no-poach agreement. Conditional on a positive stock bonus, the amount declines by 21 percent (23.9 log points). Both estimates are statistically significant at the one percent level. Estimates for cash bonuses and profit sharing are close to zero in the linear probability models. In the log models they are substantially negative at -6 and -13.5 percent, respectively, but not statistically significant.

The data allow me to observe job transitions for users who submit multiple salary reports. For descriptive purposes, I first divide the sample into treatment (2007-2009) and post-treatment (2012-2017) periods and report flows as shares in Appendix Table A5. To examine worker mobility more rigorously, I estimate a multinomial logit model over three choices: 1) stay at the current employer; 2) leave for a treated (colluding) employer; or 3) leave for a control (non-colluding) employer. Table 3 reports average marginal effects from an interaction of two dummies: the first for originating from a treated employer and the second for a transition occurring in the treated period. Estimates are stable across specifications. Under the richest control set (column four), the probability of staying increases by 6.8 percentage points and the probability of leaving for a treated employer falls by 6.4 percentage points. The latter estimate is statistically significant at the ten percent level. The probability of leaving for a control employer is approximately unchanged. While these estimates are imprecise, they are consistent with the no-poach agreements limiting worker mobility.

5.2 Empirical robustness

To test for selection into treatment on observables, Panel A of Table 4 presents estimates for the subsample in which I observe demographic variables. Controls are as above, with the addition of a female dummy, age, age squared, and a set of educational attainment dummies in all columns. Estimates in columns one through three are strongly similar to their counterparts in Table 1. The estimate under individual fixed effects is smaller at -2.3 percent, but remains statistically significant at the one percent level. Together these estimates suggest that selection into treatment on observables is not driving my primary results.

In specifications with user fixed effects, selection into treatment on time-invariant unobservables is not a potential source of bias, but may matter for interpretation of the estimates. Selection on time-invariant unobservables remains a potential threat to identification in other specifications. As a first check of this concern, I estimate effects on the subsample of "give to get" reports. Previous research has found that "give to get" mitigates selection of employees with highly positive or negative views of their employers (Marinescu et al. 2018). Panel B of Table 4 shows results, which are large in magnitude at -5 to -10 percent, but not statistically significant. This is evidence that selection may bias my primary estimates toward zero. As a second check, I am working on implementing the framework of Oster (2017) in this setting.

To test robustness to specification changes, I estimate regressions using an alternative exposure variable, a simple dummy for whether a firm has one or more no-poach agreements in force. As before, I employ a duration-weighted average for years in which a firm was in both states. Estimates in Panel C of Table 4 range from -1.6 to -7.5 percent. In columns three and four they are statistically significant at the five and one percent levels, respectively. These are not directly comparable to my primary results because the treatment definition differs, however the similar pattern of signs and statistical significance demonstrates that my results are robust to a different set of reasonable modeling choices.

I also consider alternative definitions of the treated group. Qualitative evidence from the civil suit suggests the no-poach agreements may have been enforced only for technical employees (Leamer 2012). This suggests a triple-difference specification, using non-technical employees at colluding firms to help estimate counterfactual salaries. Appendix Table A6 presents estimates from such a specification, which range from -2.9 to -3.4 percent in columns one through three; the estimate under user fixed effects becomes more negative but extremely imprecise. Intuition suggests another group of employees at colluding firms who may not have been in the treatment group: human resources (HR) employees, who had detailed knowledge of the no-poach agreements. Appendix Table A7 presents variants of my primary double-difference specification in which the number of agreements interacts with a HR indicator.

Estimated coefficients on this interaction are statistically significant and positive. This is evidence that HR employees were less affected than others by the no-poach agreements. Indeed the estimated marginal effect on HR employees is not statistically distinguishable from zero in any column. There are multiple explanations consistent with this empirical pattern. Colluding firms could have kept HR salaries high to discourage whistle-blowing, for example, or HR employees could have increased search effort.

The use of annual salaries in my primary regressions restricts my ability to carefully study dynamics. To test the importance of this limitation, Appendix Figure A1 provides event-study estimates using report quarter (rather than year of salary) as the time variable. This requires additional sample restrictions.[14] As in Figure 3, the parallel trends assumption appears plausible. Estimate magnitudes under collusion are similar at roughly negative five percent. Following the revelation of the DOJ investigation in 2009, full convergence is achieved more rapidly, in 2011 rather than 2012. In the corresponding pooled regression, the marginal effect of a full-year agreement is -3.4 percent. Note this is not directly comparable to the estimates in Table 1 due to the difference in sample.

Movement of workers across treatment and control firms raises the potential for bias from spillovers (violation of the SUTVA assumption). Intuitively, observed wage changes could come from changes in the composition of a firm's workforce, rather than changes in pay conditional on a given workforce. To evaluate this concern, I exclude users observed at both a treatment and a control firm over the full timespan of the Glassdoor data. This eliminates approximately 2400 observations. I then re-estimate the models of Table 1 on this reduced sample. Results are reported in Appendix Table A8. Coefficient estimates and standard errors are strongly similar to my primary results in columns 1 through 3. With user fixed effects the estimate is -.0735, larger than the corresponding -.0398 from Table 1. Such a change is perhaps unsurprising, as eliminating switchers reduces sample size by 22 percent and may substantially change the sample of workers providing identifying variation. This is an imperfect test for the influence of spillovers, because I do not observe multiple salary reports for all users. Nonetheless the lack of any meaningful change in columns 1 through 3 of Appendix Table A8, and the increased magnitude in column 4, suggest that worker movement is not producing first-order upward bias in my primary estimates.

[14] To create this figure, the primary estimation sample was subset to observations meeting the following criteria: 1) report year equal to salary year; 2) report month from July 2008 through December 2017. The first criterion limits the possible mis-measurement in the horizontal coordinate. The second criterion excludes the first two quarters of Glassdoor reports, in which treated sample sizes are small.

6 Conclusion

Economists have long been interested in employer market power (Robinson 1933), but such monopsony has attracted renewed interest of late. Using novel compensation data from Glassdoor, this paper estimates the effects of no-poach agreements among Silicon Valley technology companies. Difference-in-differences regressions return negative, statistically significant estimates for both base salaries and stock bonuses. They suggest the increasing market concentration in many US industries could lead to increasing use of employer market power, with negative impacts on workers and overall social welfare. My analysis lends additional weight to calls for greater policy scrutiny of employer market power and its sources, including mergers, mobility constraints, information asymmetries, and non-compete clauses (US CEA 2016; Krueger and Posner 2018; Marinescu 2018).

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7 Figures

Figure 1: Three-firm equilibrium, no agreement

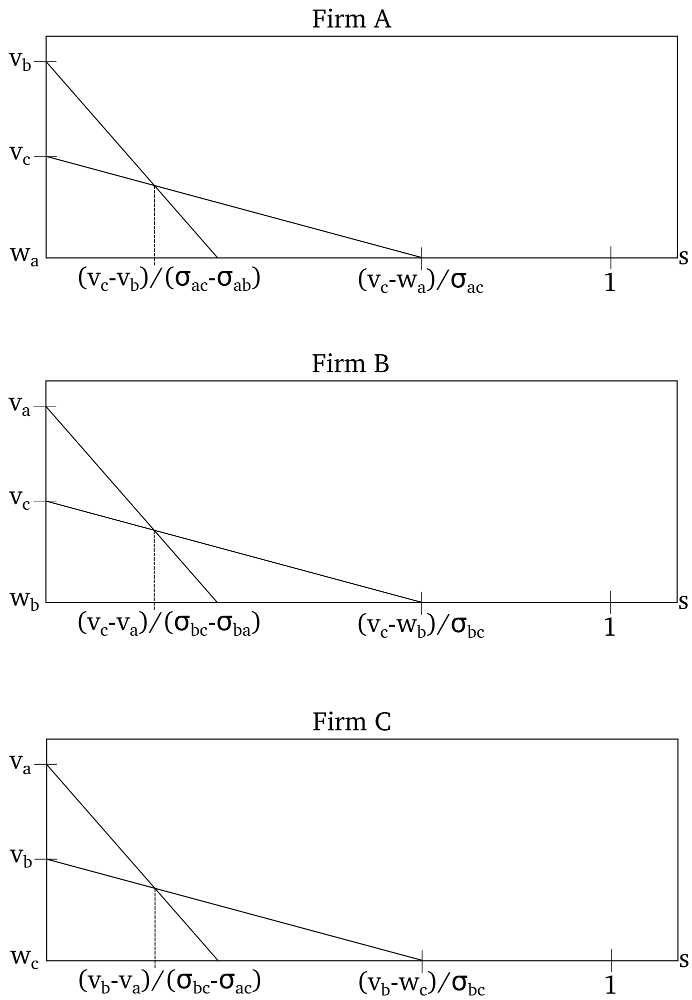
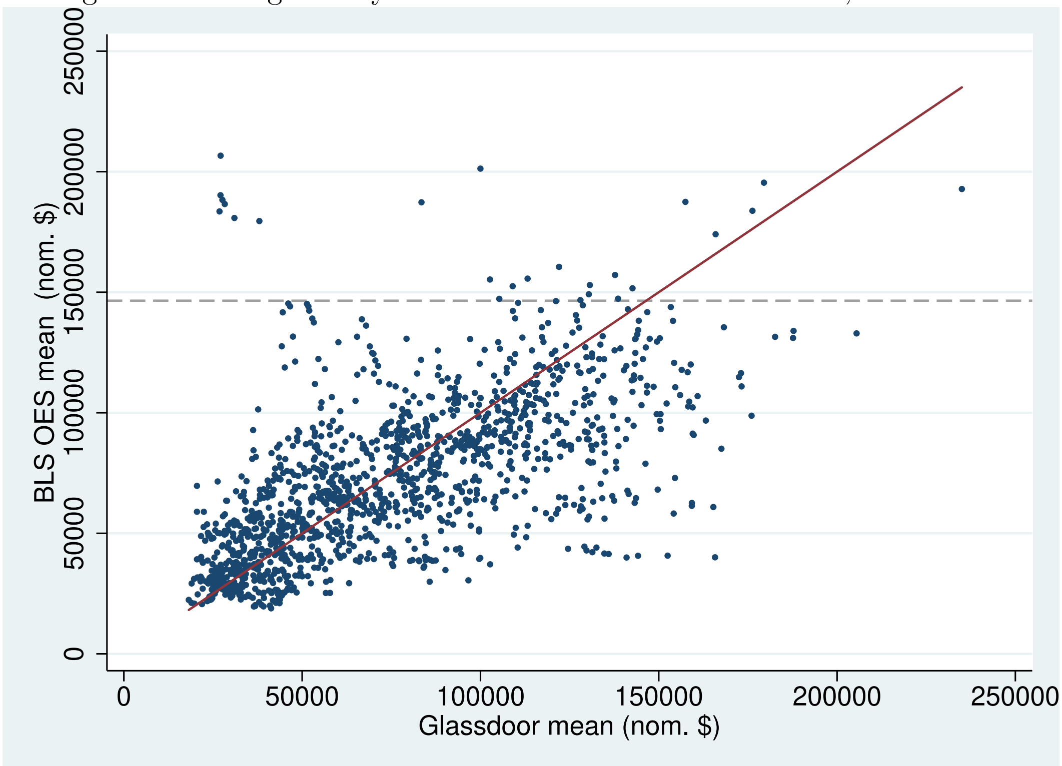


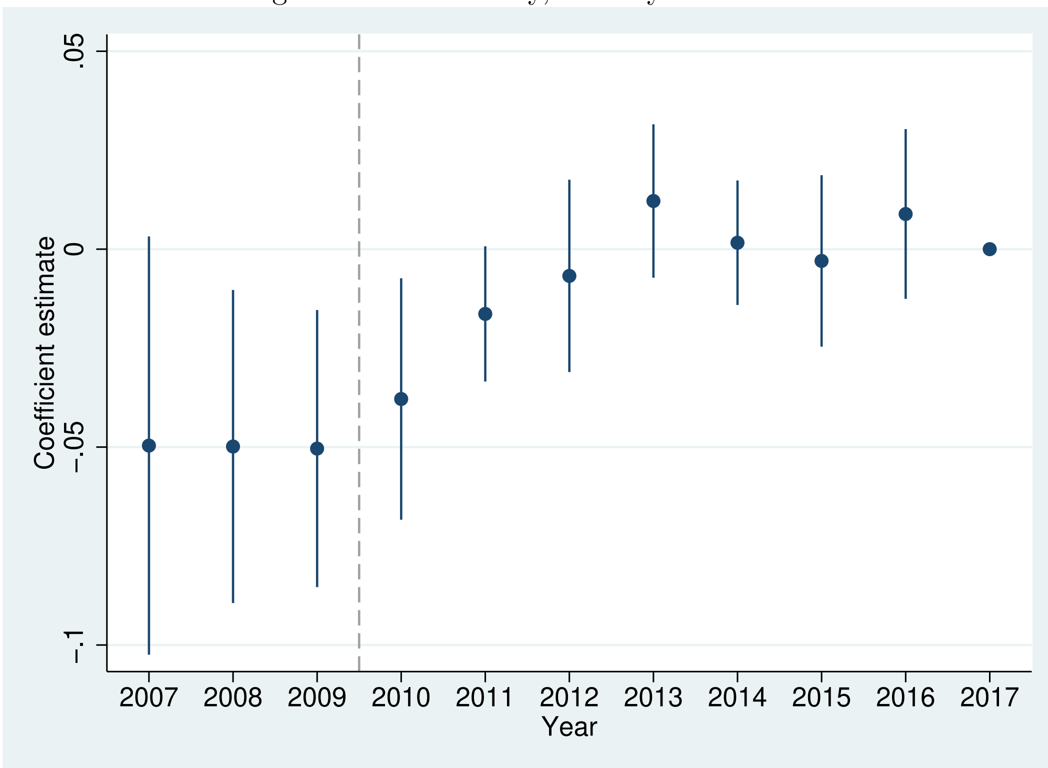
Figure depicts an equilibrium in which poaching occurs in both directions across all three firm pairs. There is no no-poach agreement. Poaching wages are v_i, loyalty wages are w_i, and $s \sim U(0,1)$ is worker switching cost. The figure assumes $v_a > v_b > v_c$ and symmetric switching costs that vary by firm pair, with $\sigma_{ab} > \sigma_{ac} > \sigma_{bc}$. Within each firm, wage offers and switching costs divide workers into three types. For example, consider firm A. Workers with values of s on $\left(0, \frac{v_c - v_b}{\sigma_{ac} - \sigma_{ab}}\right)$ switch to firm B. Workers with values of s on $\left(\frac{v_c - v_b}{\sigma_{ac} - \sigma_{ab}}, \frac{v_c - w_a}{\sigma_{ac}}\right)$ switch to firm C. Workers with values of s on $\left(\frac{v_c - w_a}{\sigma_{ac}}, 1\right)$ stay at firm A.

Figure 2: Average salary in Glassdoor and BLS OES data, 2007-2017



Each observation is an occupation-year, where occupations are defined by year-2000 SOC codes. Vertical coordinates are nominal mean salaries from BLS OES data. Horizontal coordinates are nominal mean salaries from Glassdoor data. The red line has slope equal to one ($y = x$). OES data are censored at high values, with thresholds from \$145,600 to \$208,000 depending on year. The horizontal dashed gray line represents the minimum censoring threshold in OES data.

Figure 3: Event study, dummy treatment



Coefficient estimates are from a regression of log real annual salary (2009 US dollars) on job-title-employer, job-title-year, and MSA fixed effects. Treatment is a collusion dummy interacted with year indicators and the 2017 treatment-control difference is normalized to zero. Whiskers represent 95 percent confidence intervals. National media revealed the antitrust investigation on June 3, 2009 and DOJ filed its complaint in US v. Adobe Systems on Sept. 24, 2010. The magnitude of the estimates 2007-2009 is roughly twice that of the estimate in Table 1, column three, because the average number of agreements at a treated firm is approximately two.

8 Tables

Table 1: Effect of no-poach agreements on salary

	ln(Salary)	ln(Salary)	ln(Salary)	ln(Salary)
Num. agreements	-0.0146*	-0.0190**	-0.0262***	-0.0398***
	(0.00790)	(0.00931)	(0.00861)	(0.00315)
General occupation FE	Yes	No	No	No
Specific occupation FE	No	Yes	No	No
Job title FE	No	No	Yes	Yes
User FE	No	No	No	Yes
Observations	198682	198682	198682	5091

Estimates in column 1 correspond to Equation 2. Column 2 employs specific-occupation-employer and specific-occupation-year FE. Column 3 employs job-title-employer and job-title-year FE. Column 4 employs user, job-title-employer, and job-title-year FE. Dependent variable is log real annual salary (2009 US$). Standard errors are two-way clustered on general occupation and employer in all columns.

Table 2: Effect of no-poach agreements on other compensation

	Cash bonus - LPM	ln(Cash bonus)
Num. agreements	0.00614	-0.0579
	(0.00921)	(0.0560)
Observations	198682	71705
	Stock bonus - LPM	ln(Stock bonus)
Num. agreements	-0.0511***	-0.239***
	(0.00502)	(0.0266)
Observations	198682	36927
	Profit sharing - LPM	ln(Profit sharing)
Num. agreements	0.00484	-0.135
	(0.00721)	(0.156)
Observations	198682	3906

Estimates from an adaptation of Equation 2 with job-title-employer and job-title-year FE. Dependent variable is either an indicator for positive compensation of a given type or log real compensation of a given type (2009 US$). Standard errors are two-way clustered on general occupation and employer in all columns.

Table 3: Effect of no-poach agreements on worker mobility

pr(Stay)	0.0654	0.0759	0.0878	0.0624
	(0.0706)	(0.0671)	(0.0677)	(0.0650)
pr(Leave for treated employer)	-0.0613	-0.0603	-0.0633	-0.0635*
	(0.0408)	(0.0407)	(0.0408)	(0.0383)
pr(Leave for control employer)	-0.00409	-0.0156	-0.0245	0.00110
	(0.0714)	(0.0684)	(0.0689)	(0.0663)
Observations	14492	14492	14492	14492

The dependent variable takes on three values: 1=stay at the current employer; 2=leave for treated employer; 3=leave for control employer. Estimates are average marginal effects of treatment, which is an interaction of two dummies: the first for originating from a treated employer and the second for a transition occurring in the treated period 2007-2009. Column 1 corresponds exactly to Equation 3. Column 2 adds year dummies. Column 3 adds a dummy for each treated employer. Column 4 adds metropolitan area dummies.

Table 4: Effect of no-poach agreements on salary, robustness checks

Panel A: Demographic controls				
	ln(Salary)	ln(Salary)	ln(Salary)	ln(Salary)
Num. agreements	-0.0125	-0.0185	-0.0274***	-0.0231***
	(0.0101)	(0.0122)	(0.00759)	(0.00641)
Observations	57766	57766	57766	1335
Panel B: Give to get only				
Num. agreements	-0.0878	-0.103	-0.0479	
	(0.0585)	(0.0702)	(0.0508)	
Observations	27427	27427	27427	
Panel C: Alternative treatment definition				
Agreement in force	-0.0158	-0.0244	-0.0464**	-0.0754***
	(0.0160)	(0.0208)	(0.0206)	(0.0208)
Observations	198682	198682	198682	5091
General occupation FE	Yes	No	No	No
Specific occupation FE	No	Yes	No	No
Job title FE	No	No	Yes	Yes
User FE	No	No	No	Yes

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

All panels: Estimates in column 1 correspond to Equation 2, with the addition of a female dummy, age, age squared, and a set of educational attainment dummies. Column 2 employs specific-occupation-employer and specific-occupation-year FE. Column 3 employs job-title-employer and job-title-year FE. Column 4 employs user, job-title-employer, and job-title-year FE. Dependent variable is log real annual salary (2009 US$). Standard errors are two-way clustered on general occupation and employer in all columns.
Panel A: Samples are smaller than in Table 1 because most reports do not contain user demographics.
Panel B: "Give to get" reports are offered by users in exchange for access to aggregate salary reports. The sample in this panel is a subset of the one employed in Table 2. A specification with user FE cannot be estimated because, by design, each user can contribute only one "give to get" salary report.
Panel C: Estimates in column 1 correspond to Equation 2, but with a different exposure variable: a dummy for having one or more no-poach agreements in force.

Appendix A Details of no-poach agreements

According to the complaint in the civil class action, "Defendants' conspiracy consisted of an interconnected web of express 14 agreements, each with the active involvement and participation of a company under the control of Steven P. Jobs ("Steve Jobs") and/or a company that shared at least one member of Apple's board 16 of directors" (Saveri 2011). All agreements prohibited parties from "cold calling" (recruiting) each other's employees. Many required that if an employee of one party applied to another, the prospective new employer would inform the current one. Many also prohibited the prospective new employer from hiring such an applicant without permission of the current employer. In the event of an offer, bidding wars were generally prohibited (US Department of Justice 2010b; Saveri 2011; US Department of Justice 2012). Agreements were not limited by geography or employee role (Leamer 2012), but there is some evidence that they were enforced more rigorously in cases of highly educated, highly paid employees (Leamer 2012; Koh 2013).

- Apple-Google. The agreement began no later than 2006 (US Department of Justice 2010b). The class action alleged that this agreement began in February 2005 (Leamer 2012). As my data begin in 2007, the difference is irrelevant to my analysis.

- Apple-Adobe. The agreement began no later than May 2005 (US Department of Justice 2010b).

- Apple-Pixar. The agreement began no later than April 2007 (US Department of Justice 2010a).

- eBay-Intuit. The agreement began no later than August 2006 and lasted until at least June 2009 (US Department of Justice 2012).

- Google-Intel. The agreement began no later than September 2007 (US Department of Justice 2010b). The class action alleged that this agreement began in March 2005 (Leamer 2012). As the class action plaintiffs had financial incentives to allege longer agreements, I conservatively adopt the DOJ start date of September 2007.

- Google-Intuit. The agreement began no later than June 2007 (US Department of Justice 2010a).

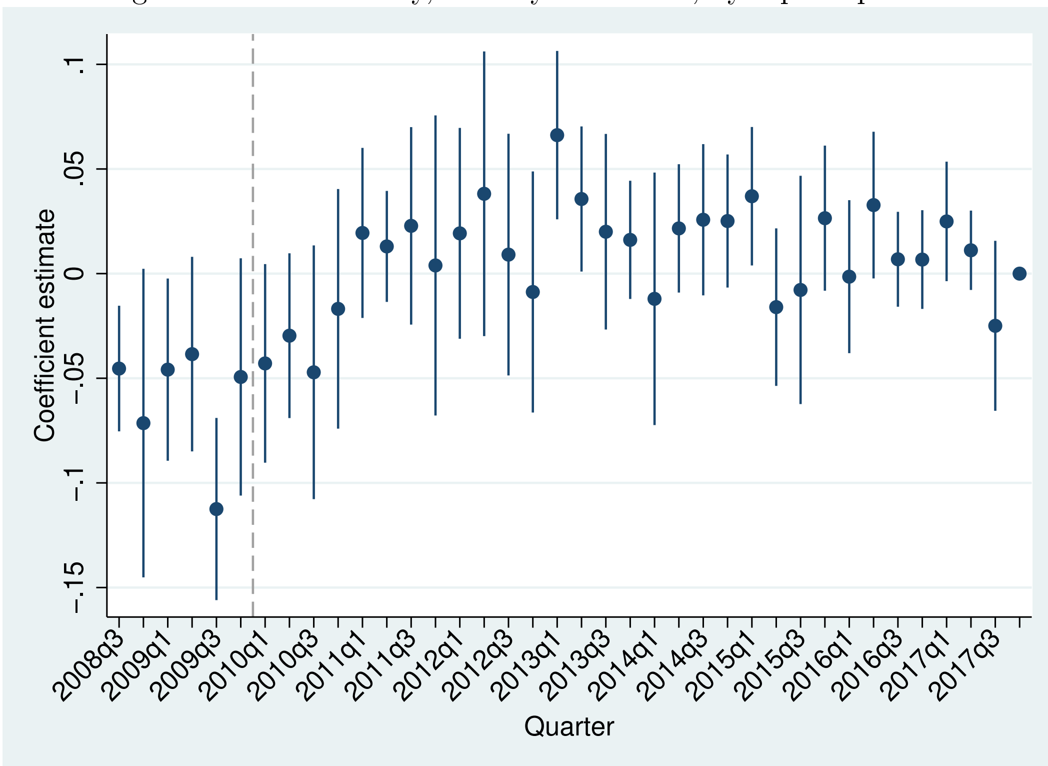
- Lucasfilm-Pixar. The agreement began no later than January 2005 (US Department of Justice 2010c). The class action alleged that this agreement began before the year 2000 (Leamer 2012). As my data begin in 2007, the difference is irrelevant to my analysis.

Appendix B Litigation timeline

- March 2009. DOJ sends civil investigative demands to technology firms.
- June 3, 2009. DOJ antitrust investigation becomes public (Helft 2009).
- Sept. 24, 2010. Complaint filed in US v. Adobe (US Department of Justice 2010b).
- Dec. 21, 2010. Complaint filed in US v. Lucasfilm (US Department of Justice 2010c).
- March 18, 2011. Final judgment in US v. Adobe.
- May 4, 2011. Civil class action *In re: High-Tech Employee Antitrust Litigation* filed.
- Nov. 6, 2012. Complaint filed in US v. eBay (US Department of Justice 2012).
- September 2, 2015. Remaining defendants Apple, Google, Intel and Adobe settle class action.

Appendix C Additional figures

Figure A1: Event study, dummy treatment, by report quarter



To create this figure, the primary estimation sample was subset to observations meeting the following criteria: 1) report year equal to salary year; 2) report month from July 2008 through December 2017. The first criterion limits the possible mis-measurement in the horizontal coordinate. The second criterion excludes the first two quarters of Glassdoor reports, in which treated sample sizes are small. Together these criteria reduce the length of the pre-treatment period, but facilitate investigation of salary changes within year. Coefficient estimates are from a regression of log real annual salary (2009 US dollars) on job-title-employer, job-title-year-week, and MSA fixed effects. Treatment is a collusion dummy interacted with year-quarter indicators and the 2017q4 treatment-control difference is normalized to zero. Whiskers represent 95 percent confidence intervals. National media revealed the antitrust investigation on June 3, 2009 and DOJ filed its complaint in US v. Adobe Systems on Sept. 24, 2010. The magnitude of the estimates 2007-2009 is roughly twice that of the estimate in Table 1, column three, because the average number of agreements at a treated firm is approximately two.

Appendix D Additional tables

Table A1: Descriptive statistics

	mean	sd	min	max
Base pay	85555.87	41504.32	12870.93	863106.81
Cash bonus	19990.55	269382.60	0.00	32167392.00
Stock bonus	16062.15	336794.66	0.00	41817608.00
Profit sharing	52149.13	23777921.67	0.00	1.10e+10
Female	0.27	0.44	0.00	1.00
Age	33.11	8.52	16.00	70.00
High school	0.05	0.22	0.00	1.00
Some college	0.02	0.13	0.00	1.00
College	0.62	0.49	0.00	1.00
Graduate degree	0.31	0.46	0.00	1.00

All forms of compensation in 2009 US$.

Table A2: Top 10 occupations, by classification scheme

General occupation	Specific occupation	Job title
software engineer	software engineer	software engineer
branch manager	manager	senior software engineer
engineer	software development engineer	account executive
account executive	account executive	account manager
product manager	program manager	project manager
program manager	product manager	director
sales representative	account manager	software development engineer
project manager	project manager	product manager
marketing manager	engineer	software developer
corporate account manager	software developer	program manager

Table A3: Effect of no-poach agreements on salary, user FE sample

	ln(Salary)	ln(Salary)	ln(Salary)	ln(Salary)
Num. agreements	-0.0453	-0.0493	-0.0461***	-0.0398***
	(.)	(.)	(0.00568)	(0.00315)
General occ. controls	Yes	No	No	No
Specific occ. controls	No	Yes	No	No
Job title controls	No	No	Yes	Yes
User FE	No	No	No	Yes
Observations	5091	5091	5091	5091

In all columns the sample is restricted to reports from users who submit multiple reports. Estimates in column 1 correspond to Equation 2. Column 2 employs specific-occupation-employer and specific-occupation-year FE. Column 3 employs job-title-employer and job-title-year FE. Column 4 employs user, job-title-employer, and job-title-year FE and is identical to column 4 of Table 1. Dependent variable is log real annual salary (2009 US$). Standard errors are two-way clustered on general occupation and employer in all columns.

Table A4: Effect of no-poach agreements on salary, levels

	Annual salary	Annual salary	Annual salary	Annual salary
Num. agreements	-1540.4*	-2008.0*	-2759.8***	-4413.4
	(906.6)	(1123.8)	(999.2)	(.)
General occupation FE	Yes	No	No	No
Specific occupation FE	No	Yes	No	No
Job title FE	No	No	Yes	Yes
User FE	No	No	No	Yes
Observations	198682	198682	198682	5091

Estimates in column 1 correspond to Equation 2. Column 2 employs specific-occupation-employer and specific-occupation-year FE. Column 3 employs job-title-employer and job-title-year FE. Column 4 employs user, job-title-employer, and job-title-year FE. Dependent variable is real annual salary (2009 US$), rather than log real annual salary. Standard errors are two-way clustered on general occupation and employer in all columns.

Table A5: Worker flows

2007-2009

		To: Stay	To: Leave	
			Control	Treated
From	Control	72%	23%	5%
	Treated	83%	16%	1%

2012-2017

		To: Stay	To: Leave	
			Control	Treated
From	Control	51%	44%	4%
	Treated	59%	36%	4%

Flows are calculated from users who submitted multiple reports within the 2007-2009 or 2012-2017 period. Rows sum to 100%.

The fraction of stayers falls at both treated and control firms from the treatment to the post-treatment period, but the fall is greater (both absolutely and proportionally) at treated firms. This is consistent with the no-poach agreements limiting worker mobility. The share leaving treated firms for other treated firms rises from 1% to 4%. Among those leaving treated firms, the share going to other treated firms rises from $1/17 = 5.9\%$ to $4/40 = 10\%$. This is the expected pattern if the no-poach agreements differentially suppressed transitions to other treated firms. Among those leaving control firms, the share going to treated firms falls from $5/28 = 18\%$ to $4/48 = 8\%$. This is consistent with treated firms redirecting recruiting effort from control firms to treated firms in the post-agreement period.

Table A6: Effect of no-poach agreements, triple-difference specification

	ln(Salary)	ln(Salary)	ln(Salary)	ln(Salary)
Num. agreements*technical class	-0.0286***	-0.0343***	-0.0309***	-0.320**
	(0.0104)	(0.0109)	(0.00748)	(0.127)
General occupation FE	Yes	No	No	No
Specific occupation FE	No	Yes	No	No
Job title FE	No	No	Yes	Yes
User FE	No	No	No	Yes
Observations	198585	198585	198585	5058

This table is similar to Table 1, but regressions add a third dimension of difference: technical vs. non-technical employees. Estimates in column 1 correspond to Equation 2, with the addition of interactions with a technical class dummy for all variables. Column 2 employs specific-occupation-employer and specific-occupation-year FE and interactions with technical class. Column 3 employs job-title-employer and job-title-year FE and interactions with technical class. Column 4 employs user, job-title-employer, and job-title-year FE and interactions with technical class. Dependent variable is log real annual salary (2009 US$). Standard errors are two-way clustered on general occupation and employer in all columns. Sample sizes are smaller than the corresponding figures in 1 because the triple-difference regression leads to more singletons.

Table A7: Effect of no-poach agreements, interacted with HR indicator

	ln(Salary)	ln(Salary)	ln(Salary)
Num. agreements	-0.0150*	-0.0192**	-0.0264***
	(0.00781)	(0.00933)	(0.00866)
HR=1*Num. agreements	0.0561***	0.0393*	0.0378**
	(0.0151)	(0.0211)	(0.0173)
General occupation FE	Yes	No	No
Specific occupation FE	No	Yes	No
Job title FE	No	No	Yes
Observations	198682	198682	198682

Estimates in column 1 correspond to Equation 2, with the addition of an interaction between the number of agreements and a HR indicator. Column 2 employs specific-occupation-employer and specific-occupation-year FE. Column 3 employs job-title-employer and job-title-year FE. Dependent variable is log real annual salary (2009 US$). Standard errors are two-way clustered on general occupation and employer in all columns.

Table A8: Effect of no-poach agreements on salary, no treatment-control switchers

	ln(Salary)	ln(Salary)	ln(Salary)	ln(Salary)
Num. agreements	-0.0132*	-0.0175*	-0.0257***	-0.0735***
	(0.00751)	(0.00926)	(0.00880)	(0.00188)
General occupation FE	Yes	No	No	No
Specific occupation FE	No	Yes	No	No
Job title FE	No	No	Yes	Yes
User FE	No	No	No	Yes
Observations	196245	196245	196245	3961

Sample excludes users observed at both a treatment and a control firm ("switchers") over the full timespan of the data. Estimates in column 1 correspond to Equation 2. Column 2 employs specific-occupation-employer and specific-occupation-year FE. Column 3 employs job-title-employer and job-title-year FE. Column 4 employs user, job-title-employer, and job-title-year FE. Dependent variable is log real annual salary (2009 US$). Standard errors are two-way clustered on general occupation and employer in all columns.

Appendix E Poaching equilibrium

E.1 Firm A

Firm A's labor shares are as follows.

$$l_{aa} = 1 - \left(\frac{v_c - w_a}{\sigma_{ac}}\right)$$
$$l_{ba} = \frac{v_a - v_c}{\sigma_{ba} - \sigma_{bc}} = \frac{v_a - v_c}{2\delta}$$
$$l_{ca} = \frac{v_a - v_b}{\sigma_{ac} - \sigma_{bc}} = \frac{v_a - v_b}{\delta}$$

Relevant derivatives are as follows.

$$\frac{\partial l_{aa}}{\partial w_a} = \frac{1}{\sigma_{ac}}$$
$$\frac{l_{ba}}{\partial v_a} = \frac{1}{2\delta}$$
$$\frac{l_{ca}}{\partial v_a} = \frac{1}{\delta}$$

These can then be plugged into the general FOCs given in Equations 1.

$$(p_a\phi - w_a)\frac{1}{\sigma_{ac}} - \left(1 - \left(\frac{v_c - w_a}{\sigma_{ac}}\right)\right) = 0$$
$$\left(p_a\phi' - v_a\right)\left(\frac{1}{2\delta} + \frac{1}{\delta}\right) - \left(\frac{v_a - v_c}{2\delta} + \frac{v_a - v_b}{\delta}\right) = 0$$

The first FOC can be solved for w_a.

$$(p_a\phi - w_a)\frac{1}{\sigma_{ac}} - \left(1 - \left(\frac{v_c - w_a}{\sigma_{ac}}\right)\right) = 0$$
$$\frac{p_a\phi - w_a + v_c - w_a}{\sigma_{ac}} = 1$$
$$p_a\phi - 2w_a + v_c = \sigma_{ac}$$
$$2w_a = p_a\phi + v_c - \sigma_{ac}$$
$$w_a = \frac{1}{2}p_a\phi + \frac{1}{2}v_c - \frac{1}{2}\sigma_{ac} \tag{4}$$

The second FOC can be solved for v_a.

$$
\begin{aligned}
\left(p_a\phi^{'} - v_a\right)\left(\frac{1}{2\delta} + \frac{1}{\delta}\right) - \left(\frac{v_a - v_c}{2\delta} + \frac{v_a - v_b}{\delta}\right) &= 0 \\
\left(\frac{p_a\phi^{'} - v_a}{2\delta} + \frac{p_a\phi^{'} - v_a}{\delta}\right) - \left(\frac{v_a - v_c}{2\delta} + \frac{v_a - v_b}{\delta}\right) &= 0 \\
\frac{p_a\phi^{'} - v_a - (v_a - v_c)}{2\delta} + \frac{p_a\phi^{'} - v_a - (v_a - v_b)}{\delta} &= 0 \\
\frac{p_a\phi^{'} - 2v_a + v_c}{2\delta} + \frac{p_a\phi^{'} - 2v_a + v_b}{\delta} &= 0 \\
p_a\phi^{'} - 2v_a + v_c + 2\left(p_a\phi^{'} - 2v_a + v_b\right) &= 0 \\
p_a\phi^{'} - 2v_a + v_c + 2p_a\phi^{'} - 4v_a + 2v_b &= 0 \\
3p_a\phi^{'} - 6v_a + v_c + 2v_b &= 0
\end{aligned}
$$

$$
\begin{aligned}
6v_a &= 3p_a\phi^{'} + v_c + 2v_b \\
v_a &= \frac{1}{2}p_a\phi^{'} + \frac{1}{6}v_c + \frac{1}{3}v_b \qquad (5)
\end{aligned}
$$

E.2 Firm B

Firm B's labor shares are as follows.

$$
\begin{aligned}
l_{bb} &= 1 - \left(\frac{v_c - w_b}{\sigma_{bc}}\right) \\
l_{ab} &= \frac{v_b - v_c}{\sigma_{ab} - \sigma_{ac}} = \frac{v_b - v_c}{\delta} \\
l_{cb} &= \left(\frac{v_b - w_c}{\sigma_{bc}}\right) - \left(\frac{v_a - v_b}{\sigma_{ac} - \sigma_{bc}}\right) = \left(\frac{v_b - w_c}{\sigma_{bc}}\right) - \left(\frac{v_a - v_b}{\delta}\right)
\end{aligned}
$$

Relevant derivatives are as follows.

$$
\begin{aligned}
\frac{\partial l_{bb}}{\partial w_b} &= \frac{1}{\sigma_{bc}} \\
\frac{l_{ab}}{\partial v_b} &= \frac{1}{\delta} \\
\frac{l_{cb}}{\partial v_b} &= \frac{1}{\sigma_{bc}} + \frac{1}{\delta}
\end{aligned}
$$

These can then be plugged into the general FOCs given in Equations 1.

$$\begin{aligned} (p_b\phi - w_b)\frac{1}{\sigma_{bc}} - \left(1 - \left(\frac{v_c - w_b}{\sigma_{bc}}\right)\right) &= 0 \\ \left(p_b\phi^{'} - v_b\right)\left(\frac{1}{\delta} + \frac{1}{\sigma_{bc}} + \frac{1}{\delta}\right) - \left[\frac{v_b - v_c}{\delta} + \left(\frac{v_b - w_c}{\sigma_{bc}}\right) - \left(\frac{v_a - v_b}{\delta}\right)\right] &= 0 \end{aligned}$$

The first FOC can be solved for w_b.

$$\begin{aligned} (p_b\phi - w_b)\frac{1}{\sigma_{bc}} - \left(1 - \left(\frac{v_c - w_b}{\sigma_{bc}}\right)\right) &= 0 \\ \frac{p_b\phi - w_b + v_c - w_b}{\sigma_{bc}} &= 1 \\ p_b\phi - 2w_b + v_c &= \sigma_{bc} \\ 2w_b &= p_b\phi + v_c - \sigma_{bc} \\ w_b &= \frac{1}{2}p_b\phi + \frac{1}{2}v_c - \frac{1}{2}\sigma_{bc} \end{aligned} \tag{6}$$

The second FOC can be solved for v_b.

$$\begin{aligned} \left(p_b\phi^{'} - v_b\right)\left(\frac{1}{\delta} + \frac{1}{\sigma_{bc}} + \frac{1}{\delta}\right) - \left[\frac{v_b - v_c}{\delta} + \left(\frac{v_b - w_c}{\sigma_{bc}}\right) - \left(\frac{v_a - v_b}{\delta}\right)\right] &= 0 \\ \left(p_b\phi^{'} - v_b\right)\left(\frac{2}{\delta} + \frac{1}{\sigma_{bc}}\right) - \left(\frac{v_b - v_c - v_a + v_b}{\delta} + \frac{v_b - w_c}{\sigma_{bc}}\right) &= 0 \\ \left(\frac{2p_b\phi^{'} - 2v_b}{\delta} + \frac{p_b\phi^{'} - v_b}{\sigma_{bc}}\right) - \left(\frac{2v_b - v_c - v_a}{\delta} + \frac{v_b - w_c}{\sigma_{bc}}\right) &= 0 \\ \frac{2p_b\phi^{'} - 2v_b - 2v_b + v_c + v_a}{\delta} + \frac{p_b\phi^{'} - v_b - v_b + w_c}{\sigma_{bc}} &= 0 \\ \frac{2p_b\phi^{'} - 4v_b + v_c + v_a}{\delta} + \frac{p_b\phi^{'} - 2v_b + w_c}{\sigma_{bc}} &= 0 \\ 2p_b\phi^{'} - 4v_b + v_c + v_a + \left(\frac{\delta}{\sigma_{bc}}\right)\left(p_b\phi^{'} - 2v_b + w_c\right) &= 0 \\ 2p_b\phi^{'} - 4v_b + v_c + v_a + \frac{\delta}{\sigma_{bc}}p_b\phi^{'} - 2\frac{\delta}{\sigma_{bc}}v_b + \frac{\delta}{\sigma_{bc}}w_c &= 0 \\ \left(2 + \frac{\delta}{\sigma_{bc}}\right)p_b\phi^{'} - \left(4 + \frac{2\delta}{\sigma_{bc}}\right)v_b + v_c + v_a + \frac{\delta}{\sigma_{bc}}w_c &= 0 \end{aligned}$$

$$\left(4+\frac{2\delta}{\sigma_{bc}}\right)v_b = \left(2+\frac{\delta}{\sigma_{bc}}\right)p_b\phi^{'} + v_c + v_a + \frac{\delta}{\sigma_{bc}}w_c$$
$$v_b = \left(\frac{1}{4+\frac{2\delta}{\sigma_{bc}}}\right)\left[\left(2+\frac{\delta}{\sigma_{bc}}\right)p_b\phi^{'} + v_c + v_a + \frac{\delta}{\sigma_{bc}}w_c\right]$$
$$v_b = \frac{1}{2}\left(\frac{1}{2+\frac{\delta}{\sigma_{bc}}}\right)\left[\left(2+\frac{\delta}{\sigma_{bc}}\right)p_b\phi^{'} + v_c + v_a + \frac{\delta}{\sigma_{bc}}w_c\right]$$
$$v_b = \frac{1}{2}\left[p_b\phi^{'} + \left(\frac{1}{2+\frac{\delta}{\sigma_{bc}}}\right)v_c + \left(\frac{1}{2+\frac{\delta}{\sigma_{bc}}}\right)v_a + \left(\frac{1}{2+\frac{\delta}{\sigma_{bc}}}\right)\frac{\delta}{\sigma_{bc}}w_c\right]$$

Let $\beta_1 \equiv \left(\frac{1}{2+\frac{\delta}{\sigma_{bc}}}\right)$.

$$v_b = \frac{1}{2}\left[p_b\phi^{'} + \beta_1 v_c + \beta_1 v_a + \beta_1\frac{\delta}{\sigma_{bc}}w_c\right]$$
$$v_b = \frac{1}{2}p_b\phi^{'} + \frac{1}{2}\beta_1 v_c + \frac{1}{2}\beta_1 v_a + \frac{1}{2}\beta_1\frac{\delta}{\sigma_{bc}}w_c \tag{7}$$

E.3 Firm C

Firm C's labor shares are as follows.

$$l_{cc} = 1 - \left(\frac{v_b - w_c}{\sigma_{bc}}\right)$$
$$l_{ac} = \left(\frac{v_c - w_a}{\sigma_{ac}}\right) - \left(\frac{v_b - v_c}{\sigma_{ab} - \sigma_{ac}}\right) = \left(\frac{v_c - w_a}{\sigma_{ac}}\right) - \left(\frac{v_b - v_c}{\delta}\right)$$
$$l_{bc} = \left(\frac{v_c - w_b}{\sigma_{bc}}\right) - \left(\frac{v_a - v_c}{\sigma_{ba} - \sigma_{bc}}\right) = \left(\frac{v_c - w_b}{\sigma_{bc}}\right) - \left(\frac{v_a - v_c}{2\delta}\right)$$

Relevant derivatives are as follows.

$$\frac{\partial l_{cc}}{\partial w_c} = \frac{1}{\sigma_{bc}}$$
$$\frac{l_{ac}}{\partial v_c} = \frac{1}{\sigma_{ac}} + \frac{1}{\delta}$$
$$\frac{l_{bc}}{\partial v_c} = \frac{1}{\sigma_{bc}} + \frac{1}{2\delta}$$

These can then be plugged into the general FOCs given in Equations 1.

$$
\begin{aligned}
(p_c\phi - w_c)\frac{1}{\sigma_{bc}} - \left(1 - \left(\frac{v_b - w_c}{\sigma_{bc}}\right)\right) &= 0 \\
\left(p_c\phi' - v_c\right)\left(\frac{1}{\sigma_{ac}} + \frac{1}{\delta} + \frac{1}{\sigma_{bc}} + \frac{1}{2\delta}\right) - \left[\left(\frac{v_c - w_a}{\sigma_{ac}}\right) - \left(\frac{v_b - v_c}{\delta}\right) + \left(\frac{v_c - w_b}{\sigma_{bc}}\right) - \left(\frac{v_a - v_c}{2\delta}\right)\right] &= 0
\end{aligned}
$$

The first FOC can be solved for w_c.

$$
\begin{aligned}
(p_c\phi - w_c)\frac{1}{\sigma_{bc}} - \left(-\left(\frac{v_b - w_c}{\sigma_{bc}}\right)\right) &= 0 \\
\frac{p_c\phi - w_c + v_b - w_c}{\sigma_{bc}} &= 1 \\
p_c\phi - 2w_c + v_b &= \sigma_{bc} \\
2w_c &= p_c\phi + v_b - \sigma_{bc} \\
w_c &= \frac{1}{2}p_c\phi + \frac{1}{2}v_b - \frac{1}{2}\sigma_{bc} \qquad (8)
\end{aligned}
$$

The second FOC can be solved for v_c.

$$\left(p_c\phi^{'} - v_c\right)\left(\frac{1}{\sigma_{ac}} + \frac{1}{\delta} + \frac{1}{\sigma_{bc}} + \frac{1}{2\delta}\right) - \left[\left(\frac{v_c - w_a}{\sigma_{ac}}\right) - \left(\frac{v_b - v_c}{\delta}\right) + \left(\frac{v_c - w_b}{\sigma_{bc}}\right) - \left(\frac{v_a - v_c}{2\delta}\right)\right]$$

$$\left(p_c\phi^{'} - v_c\right)\left(\frac{1}{\sigma_{ac}} + \frac{2}{2\delta} + \frac{1}{\sigma_{bc}} + \frac{1}{2\delta}\right) - \left[\left(\frac{v_c - w_a}{\sigma_{ac}}\right) - \left(\frac{2v_b - 2v_c}{2\delta}\right) + \left(\frac{v_c - w_b}{\sigma_{bc}}\right) - \left(\frac{v_a - v_c}{2\delta}\right)\right]$$

$$\left(p_c\phi^{'} - v_c\right)\left(\frac{1}{\sigma_{ac}} + \frac{1}{\sigma_{bc}} + \frac{3}{2\delta}\right) - \left[\left(\frac{v_c - w_a}{\sigma_{ac}}\right) + \left(\frac{v_c - w_b}{\sigma_{bc}}\right) - \left(\frac{v_a + 2v_b - 3v_c}{2\delta}\right)\right]$$

$$\left(p_c\phi^{'} - v_c\right)\left(\frac{\sigma_{bc}}{\sigma_{ac}\sigma_{bc}} + \frac{\sigma_{ac}}{\sigma_{ac}\sigma_{bc}} + \frac{3}{2\delta}\right) - \left[\left(\frac{\sigma_{bc}v_c - \sigma_{bc}w_a}{\sigma_{ac}\sigma_{bc}}\right) + \left(\frac{\sigma_{ac}v_c - \sigma_{ac}w_b}{\sigma_{ac}\sigma_{bc}}\right) - \left(\frac{v_a + 2v_b - 3v_c}{2\delta}\right)\right]$$

$$\left(p_c\phi^{'} - v_c\right)\left(\frac{\sigma_{bc} + \sigma_{ac}}{\sigma_{ac}\sigma_{bc}} + \frac{3}{2\delta}\right) - \left[\left(\frac{\sigma_{bc}v_c - \sigma_{bc}w_a + \sigma_{ac}v_c - \sigma_{ac}w_b}{\sigma_{ac}\sigma_{bc}}\right) - \left(\frac{v_a + 2v_b - 3v_c}{2\delta}\right)\right]$$

$$\left[\frac{\left(\sigma_{bc} + \sigma_{ac}\right)\left(p_c\phi^{'} - v_c\right)}{\sigma_{ac}\sigma_{bc}} + \frac{3\left(p_c\phi^{'} - v_c\right)}{2\delta}\right] - \left[\left(\frac{\sigma_{bc}v_c - \sigma_{bc}w_a + \sigma_{ac}v_c - \sigma_{ac}w_b}{\sigma_{ac}\sigma_{bc}}\right) - \left(\frac{v_a + 2v_b - 3v_c}{2\delta}\right)\right]$$

$$\left[\frac{\left(\sigma_{bc} + \sigma_{ac}\right)p_c\phi^{'} - \left(\sigma_{bc} + \sigma_{ac}\right)v_c - \left(\sigma_{bc}v_c - \sigma_{bc}w_a + \sigma_{ac}v_c - \sigma_{ac}w_b\right)}{\sigma_{ac}\sigma_{bc}} + \frac{3p_c\phi^{'} - 3v_c + \left(v_a + 2v_b - 3v_c\right)}{2\delta}\right]$$

$$\left[\frac{\left(\sigma_{bc} + \sigma_{ac}\right)p_c\phi^{'} - \left(\sigma_{bc} + \sigma_{ac}\right)v_c - \sigma_{bc}v_c + \sigma_{bc}w_a - \sigma_{ac}v_c + \sigma_{ac}w_b}{\sigma_{ac}\sigma_{bc}} + \frac{3p_c\phi^{'} - 3v_c + v_a + 2v_b - 3v_c}{2\delta}\right]$$

$$\left[\frac{\left(\sigma_{bc} + \sigma_{ac}\right)p_c\phi^{'} - \left(\sigma_{bc} + \sigma_{ac} + \sigma_{bc} + \sigma_{ac}\right)v_c + \sigma_{bc}w_a + \sigma_{ac}w_b}{\sigma_{ac}\sigma_{bc}} + \frac{3p_c\phi^{'} - 6v_c + v_a + 2v_b}{2\delta}\right]$$

$$\left(\frac{2\delta}{\sigma_{ac}\sigma_{bc}}\right)\left[\left(\sigma_{bc} + \sigma_{ac}\right)p_c\phi^{'} - \left(2\sigma_{bc} + 2\sigma_{ac}\right)v_c + \sigma_{bc}w_a + \sigma_{ac}w_b\right] + \left(3p_c\phi^{'} - 6v_c + v_a + 2v_b\right)$$

$$\left[\left(\frac{2\delta}{\sigma_{ac}\sigma_{bc}}\right)\left(\sigma_{bc} + \sigma_{ac}\right)p_c\phi^{'} - \left(\frac{2\delta}{\sigma_{ac}\sigma_{bc}}\right)\left(2\sigma_{bc} + 2\sigma_{ac}\right)v_c + \left(\frac{2\delta}{\sigma_{ac}\sigma_{bc}}\right)\sigma_{bc}w_a + \left(\frac{2\delta}{\sigma_{ac}\sigma_{bc}}\right)\sigma_{ac}w_b\right] + \left(3p_c\phi^{'} - 6v_c + v_a + 2v_b\right)$$

$$\left(\frac{2\delta\left(\sigma_{bc} + \sigma_{ac}\right)}{\sigma_{ac}\sigma_{bc}}\right)p_c\phi^{'} - \left(\frac{4\delta\left(\sigma_{bc} + \sigma_{ac}\right)}{\sigma_{ac}\sigma_{bc}}\right)v_c + \left(\frac{2\delta\sigma_{bc}}{\sigma_{ac}\sigma_{bc}}\right)w_a + \left(\frac{2\delta\sigma_{ac}}{\sigma_{ac}\sigma_{bc}}\right)w_b + 3p_c\phi^{'} - 6v_c + v_a + 2v_b$$

$$\left(3 + \frac{2\delta\left(\sigma_{bc} + \sigma_{ac}\right)}{\sigma_{ac}\sigma_{bc}}\right)p_c\phi^{'} - \left(6 + \frac{4\delta\left(\sigma_{bc} + \sigma_{ac}\right)}{\sigma_{ac}\sigma_{bc}}\right)v_c + \left(\frac{2\delta}{\sigma_{ac}}\right)w_a + \left(\frac{2\delta}{\sigma_{bc}}\right)w_b + v_a + 2v_b$$

$$\left(6 + \frac{4\delta\left(\sigma_{bc} + \sigma_{ac}\right)}{\sigma_{ac}\sigma_{bc}}\right)v_c = \left(3 + \frac{2\delta\left(\sigma_{bc} + \sigma_{ac}\right)}{\sigma_{ac}\sigma_{bc}}\right)p_c\phi^{'} + \left(\frac{2\delta}{\sigma_{ac}}\right)w_a + \left(\frac{2\delta}{\sigma_{bc}}\right)w_b + v_a + 2v_b$$

$$v_c = \frac{\left(3+\frac{2\delta(\sigma_{bc}+\sigma_{ac})}{\sigma_{ac}\sigma_{bc}}\right)}{\left(6+\frac{4\delta(\sigma_{bc}+\sigma_{ac})}{\sigma_{ac}\sigma_{bc}}\right)} p_c\phi^{'} + \frac{\left(\frac{2\delta}{\sigma_{ac}}\right)}{\left(6+\frac{4\delta(\sigma_{bc}+\sigma_{ac})}{\sigma_{ac}\sigma_{bc}}\right)} w_a + \frac{\left(\frac{2\delta}{\sigma_{bc}}\right)}{\left(6+\frac{4\delta(\sigma_{bc}+\sigma_{ac})}{\sigma_{ac}\sigma_{bc}}\right)} w_b + \frac{1}{\left(6+\frac{4\delta(\sigma_{bc}+\sigma_{ac})}{\sigma_{ac}\sigma_{bc}}\right)} v_a + \frac{2}{\left(6+\frac{4\delta(\sigma_{bc}+\sigma_{ac})}{\sigma_{ac}\sigma_{bc}}\right)} v_b$$

$$v_c = \frac{\left(3+\frac{2\delta(\sigma_{bc}+\sigma_{ac})}{\sigma_{ac}\sigma_{bc}}\right)}{2\left(3+\frac{2\delta(\sigma_{bc}+\sigma_{ac})}{\sigma_{ac}\sigma_{bc}}\right)} p_c\phi^{'} + \frac{2\left(\frac{\delta}{\sigma_{ac}}\right)}{2\left(3+\frac{2\delta(\sigma_{bc}+\sigma_{ac})}{\sigma_{ac}\sigma_{bc}}\right)} w_a + \frac{2\left(\frac{\delta}{\sigma_{bc}}\right)}{2\left(3+\frac{2\delta(\sigma_{bc}+\sigma_{ac})}{\sigma_{ac}\sigma_{bc}}\right)} w_b + \frac{1}{2\left(3+\frac{2\delta(\sigma_{bc}+\sigma_{ac})}{\sigma_{ac}\sigma_{bc}}\right)} v_a + \frac{2}{2\left(3+\frac{2\delta(\sigma_{bc}+\sigma_{ac})}{\sigma_{ac}\sigma_{bc}}\right)}$$

$$v_c = \frac{1}{2} p_c\phi^{'} + \frac{\left(\frac{\delta}{\sigma_{ac}}\right)}{\left(3+\frac{2\delta(\sigma_{bc}+\sigma_{ac})}{\sigma_{ac}\sigma_{bc}}\right)} w_a + \frac{\left(\frac{\delta}{\sigma_{bc}}\right)}{\left(3+\frac{2\delta(\sigma_{bc}+\sigma_{ac})}{\sigma_{ac}\sigma_{bc}}\right)} w_b + \frac{1}{2\left(3+\frac{2\delta(\sigma_{bc}+\sigma_{ac})}{\sigma_{ac}\sigma_{bc}}\right)} v_a + \frac{1}{\left(3+\frac{2\delta(\sigma_{bc}+\sigma_{ac})}{\sigma_{ac}\sigma_{bc}}\right)} v_b$$

$$v_c = \frac{1}{2} p_c\phi^{'} + \frac{\left(\frac{\delta}{\sigma_{ac}}\right)}{\left(\frac{3\sigma_{ac}\sigma_{bc}}{\sigma_{ac}\sigma_{bc}}+\frac{2\delta(\sigma_{bc}+\sigma_{ac})}{\sigma_{ac}\sigma_{bc}}\right)} w_a + \frac{\left(\frac{\delta}{\sigma_{bc}}\right)}{\left(\frac{3\sigma_{ac}\sigma_{bc}}{\sigma_{ac}\sigma_{bc}}+\frac{2\delta(\sigma_{bc}+\sigma_{ac})}{\sigma_{ac}\sigma_{bc}}\right)} w_b + \frac{1}{2\left(\frac{3\sigma_{ac}\sigma_{bc}}{\sigma_{ac}\sigma_{bc}}+\frac{2\delta(\sigma_{bc}+\sigma_{ac})}{\sigma_{ac}\sigma_{bc}}\right)} v_a + \frac{1}{\left(\frac{3\sigma_{ac}\sigma_{bc}}{\sigma_{ac}\sigma_{bc}}+\frac{2\delta(\sigma_{bc}+\sigma_{ac})}{\sigma_{ac}\sigma_{bc}}\right)}$$

$$v_c = \frac{1}{2} p_c\phi^{'} + \frac{\left(\frac{\delta}{\sigma_{ac}}\right)}{\left(\frac{3\sigma_{ac}\sigma_{bc}+2\delta\sigma_{bc}+2\delta\sigma_{ac}}{\sigma_{ac}\sigma_{bc}}\right)} w_a + \frac{\left(\frac{\delta}{\sigma_{bc}}\right)}{\left(\frac{3\sigma_{ac}\sigma_{bc}+2\delta\sigma_{bc}+2\delta\sigma_{ac}}{\sigma_{ac}\sigma_{bc}}\right)} w_b + \frac{1}{2\left(\frac{3\sigma_{ac}\sigma_{bc}+2\delta\sigma_{bc}+2\delta\sigma_{ac}}{\sigma_{ac}\sigma_{bc}}\right)} v_a + \frac{1}{\left(\frac{3\sigma_{ac}\sigma_{bc}+2\delta\sigma_{bc}+2\delta\sigma_{ac}}{\sigma_{ac}\sigma_{bc}}\right)} v_b$$

$$v_c = \frac{1}{2} p_c\phi^{'} + \left(\frac{\delta}{\sigma_{ac}}\right)\left(\frac{\sigma_{ac}\sigma_{bc}}{3\sigma_{ac}\sigma_{bc}+2\delta\sigma_{bc}+2\delta\sigma_{ac}}\right) w_a + \left(\frac{\delta}{\sigma_{bc}}\right)\left(\frac{\sigma_{ac}\sigma_{bc}}{3\sigma_{ac}\sigma_{bc}+2\delta\sigma_{bc}+2\delta\sigma_{ac}}\right) w_b + \frac{1}{2}\left(\frac{\sigma_{ac}\sigma_{bc}}{3\sigma_{ac}\sigma_{bc}+2\delta\sigma_{bc}+2\delta\sigma_{ac}}\right) v_a + \left(\frac{\sigma_{ac}\sigma_{bc}}{3\sigma_{ac}\sigma_{bc}+2\delta\sigma_{bc}+2\delta\sigma_{ac}}\right) v_b$$

Let $\beta_2 \equiv \left(\frac{\sigma_{ac}\sigma_{bc}}{3\sigma_{ac}\sigma_{bc}+2\delta\sigma_{bc}+2\delta\sigma_{ac}}\right)$.

$$v_c = \frac{1}{2} p_c\phi^{'} + \frac{\delta}{\sigma_{ac}}\beta_2 w_a + \frac{\delta}{\sigma_{bc}}\beta_2 w_b + \frac{1}{2}\beta_2 v_a + \beta_2 v_b \tag{9}$$

E.4 Solving for wages

Equations 4 through 9 comprise a system in six variables $\{w_a, v_a, w_b, v_b, w_c, v_c\}$.

$$\begin{aligned}
w_a &= \frac{1}{2} p_a\phi + \frac{1}{2} v_c - \frac{1}{2}\sigma_{ac} \\
v_a &= \frac{1}{2} p_a\phi^{'} + \frac{1}{6} v_c + \frac{1}{3} v_b \\
w_b &= \frac{1}{2} p_b\phi + \frac{1}{2} v_c - \frac{1}{2}\sigma_{bc} \\
v_b &= \frac{1}{2} p_b\phi^{'} + \frac{1}{2}\beta_1 v_c + \frac{1}{2}\beta_1 v_a + \frac{1}{2}\beta_1 \frac{\delta}{\sigma_{bc}} w_c \\
w_c &= \frac{1}{2} p_c\phi + \frac{1}{2} v_b - \frac{1}{2}\sigma_{bc} \\
v_c &= \frac{1}{2} p_c\phi^{'} + \frac{\delta}{\sigma_{ac}}\beta_2 w_a + \frac{\delta}{\sigma_{bc}}\beta_2 w_b + \frac{1}{2}\beta_2 v_a + \beta_2 v_b
\end{aligned}$$

To begin, substitute the equations for w_i into those for v_i to obtain a 3x3 system.

$$\begin{aligned}
v_a =& \frac{1}{2}p_a\phi^{'} + \frac{1}{6}v_c + \frac{1}{3}v_b \\
v_b =& \frac{1}{2}p_b\phi^{'} + \frac{1}{2}\beta_1 v_c + \frac{1}{2}\beta_1 v_a + \frac{1}{2}\beta_1\frac{\delta}{\sigma_{bc}}\left(\frac{1}{2}p_c\phi + \frac{1}{2}v_b - \frac{1}{2}\sigma_{bc}\right) \\
v_c =& \frac{1}{2}p_c\phi^{'} + \frac{\delta}{\sigma_{ac}}\beta_2\left(\frac{1}{2}p_a\phi + \frac{1}{2}v_c - \frac{1}{2}\sigma_{ac}\right) + \frac{\delta}{\sigma_{bc}}\beta_2\left(\frac{1}{2}p_b\phi + \frac{1}{2}v_c - \frac{1}{2}\sigma_{bc}\right) + \frac{1}{2}\beta_2 v_a + \beta_2 v_b
\end{aligned}$$

This can be simplified.

$$\begin{aligned}
v_a =& \frac{1}{2}p_a\phi^{'} + \frac{1}{6}v_c + \frac{1}{3}v_b \\
v_b =& \frac{1}{2}p_b\phi^{'} + \frac{1}{2}\beta_1 v_c + \frac{1}{2}\beta_1 v_a + \left(\frac{1}{4}\beta_1\frac{\delta}{\sigma_{bc}}p_c\phi + \frac{1}{4}\beta_1\frac{\delta}{\sigma_{bc}}v_b - \frac{1}{4}\beta_1\frac{\delta}{\sigma_{bc}}\sigma_{bc}\right) \\
v_c =& \frac{1}{2}p_c\phi^{'} + \left(\frac{1}{2}\frac{\delta}{\sigma_{ac}}\beta_2 p_a\phi + \frac{1}{2}\frac{\delta}{\sigma_{ac}}\beta_2 v_c - \frac{1}{2}\frac{\delta}{\sigma_{ac}}\beta_2\sigma_{ac}\right) + \left(\frac{1}{2}\frac{\delta}{\sigma_{bc}}\beta_2 p_b\phi + \frac{1}{2}\frac{\delta}{\sigma_{bc}}\beta_2 v_c - \frac{1}{2}\frac{\delta}{\sigma_{bc}}\beta_2\sigma_{bc}\right) + \frac{1}{2}\beta_2 v_a +
\end{aligned}$$

This can be simplified.

$$\begin{aligned}
v_a =& \frac{1}{2}p_a\phi^{'} + \frac{1}{6}v_c + \frac{1}{3}v_b \\
v_b =& \frac{1}{2}p_b\phi^{'} + \frac{1}{2}\beta_1 v_c + \frac{1}{2}\beta_1 v_a + \left(\frac{1}{4}\beta_1\frac{\delta}{\sigma_{bc}}p_c\phi + \frac{1}{4}\beta_1\frac{\delta}{\sigma_{bc}}v_b - \frac{1}{4}\beta_1\delta\right) \\
v_c =& \frac{1}{2}p_c\phi^{'} + \left(\frac{1}{2}\frac{\delta}{\sigma_{ac}}\beta_2 p_a\phi + \frac{1}{2}\frac{\delta}{\sigma_{ac}}\beta_2 v_c - \frac{1}{2}\delta\beta_2\right) + \left(\frac{1}{2}\frac{\delta}{\sigma_{bc}}\beta_2 p_b\phi + \frac{1}{2}\frac{\delta}{\sigma_{bc}}\beta_2 v_c - \frac{1}{2}\delta\beta_2\right) + \frac{1}{2}\beta_2 v_a + \beta_2 v_b
\end{aligned}$$

This can be simplified.

$$\begin{aligned}
v_a =& \frac{1}{2}p_a\phi^{'} + \frac{1}{3}v_b + \frac{1}{6}v_c \\
v_b =& \left(\frac{1}{2}p_b\phi^{'} + \frac{1}{4}\beta_1\frac{\delta}{\sigma_{bc}}p_c\phi - \frac{1}{4}\beta_1\delta\right) + \frac{1}{2}\beta_1 v_a + \frac{1}{4}\beta_1\frac{\delta}{\sigma_{bc}}v_b + \frac{1}{2}\beta_1 v_c \\
v_c =& \left(\frac{1}{2}p_c\phi^{'} + \frac{1}{2}\frac{\delta}{\sigma_{ac}}\beta_2 p_a\phi + \frac{1}{2}\frac{\delta}{\sigma_{bc}}\beta_2 p_b\phi - \frac{1}{2}\delta\beta_2 - \frac{1}{2}\delta\beta_2\right) + \frac{1}{2}\beta_2 v_a + \beta_2 v_b + \frac{1}{2}\frac{\delta}{\sigma_{ac}}\beta_2 v_c + \frac{1}{2}\frac{\delta}{\sigma_{bc}}\beta_2 v_c
\end{aligned}$$

This can be simplified.

$$\begin{aligned}
v_a =& \frac{1}{2}p_a\phi^{'} + \frac{1}{3}v_b + \frac{1}{6}v_c \\
v_b =& \left(\frac{1}{2}p_b\phi^{'} + \frac{1}{4}\beta_1\frac{\delta}{\sigma_{bc}}p_c\phi - \frac{1}{4}\beta_1\delta\right) + \frac{1}{2}\beta_1 v_a + \frac{1}{4}\beta_1\frac{\delta}{\sigma_{bc}}v_b + \frac{1}{2}\beta_1 v_c \\
v_c =& \left(\frac{1}{2}p_c\phi^{'} + \frac{1}{2}\frac{\delta}{\sigma_{ac}}\beta_2 p_a\phi + \frac{1}{2}\frac{\delta}{\sigma_{bc}}\beta_2 p_b\phi - \delta\beta_2\right) + \frac{1}{2}\beta_2 v_a + \beta_2 v_b + \frac{1}{2}\beta_2\left(\frac{\delta}{\sigma_{ac}} + \frac{\delta}{\sigma_{bc}}\right)v_c
\end{aligned}$$

Substituting the first equation into the second and third yields a 2x2 system.

$$v_b = \left(\frac{1}{2}p_b\phi^{'} + \frac{1}{4}\beta_1\frac{\delta}{\sigma_{bc}}p_c\phi - \frac{1}{4}\beta_1\delta\right) + \frac{1}{2}\beta_1\left(\frac{1}{2}p_a\phi^{'} + \frac{1}{3}v_b + \frac{1}{6}v_c\right) + \frac{1}{4}\beta_1\frac{\delta}{\sigma_{bc}}v_b + \frac{1}{2}\beta_1 v_c$$
$$v_c = \left(\frac{1}{2}p_c\phi^{'} + \frac{1}{2}\frac{\delta}{\sigma_{ac}}\beta_2 p_a\phi + \frac{1}{2}\frac{\delta}{\sigma_{bc}}\beta_2 p_b\phi - \delta\beta_2\right) + \frac{1}{2}\beta_2\left(\frac{1}{2}p_a\phi^{'} + \frac{1}{3}v_b + \frac{1}{6}v_c\right) + \beta_2 v_b + \frac{1}{2}\beta_2\left(\frac{\delta}{\sigma_{ac}} + \frac{\delta}{\sigma_{bc}}\right)v_c$$

This can be simplified.

$$v_b = \left(\frac{1}{2}p_b\phi^{'} + \frac{1}{4}\beta_1\frac{\delta}{\sigma_{bc}}p_c\phi - \frac{1}{4}\beta_1\delta\right) + \frac{1}{4}\beta_1 p_a\phi^{'} + \frac{1}{6}\beta_1 v_b + \frac{1}{12}\beta_1 v_c + \frac{1}{4}\beta_1\frac{\delta}{\sigma_{bc}}v_b + \frac{1}{2}\beta_1 v_c$$
$$v_c = \left(\frac{1}{2}p_c\phi^{'} + \frac{1}{2}\frac{\delta}{\sigma_{ac}}\beta_2 p_a\phi + \frac{1}{2}\frac{\delta}{\sigma_{bc}}\beta_2 p_b\phi - \delta\beta_2\right) + \frac{1}{4}\beta_2 p_a\phi^{'} + \frac{1}{6}\beta_2 v_b + \frac{1}{12}\beta_2 v_c + \beta_2 v_b + \frac{1}{2}\beta_2\left(\frac{\delta}{\sigma_{ac}} + \frac{\delta}{\sigma_{bc}}\right)v_c$$

This can be simplified.

$$v_b = \left(\frac{1}{4}\beta_1 p_a\phi^{'} + \frac{1}{2}p_b\phi^{'} + \frac{1}{4}\beta_1\frac{\delta}{\sigma_{bc}}p_c\phi - \frac{1}{4}\beta_1\delta\right) + \frac{1}{6}\beta_1 v_b + \frac{1}{4}\beta_1\frac{\delta}{\sigma_{bc}}v_b + \frac{1}{2}\beta_1 v_c + \frac{1}{12}\beta_1 v_c$$
$$v_c = \left(\frac{1}{4}\beta_2 p_a\phi^{'} + \frac{1}{2}\frac{\delta}{\sigma_{ac}}\beta_2 p_a\phi + \frac{1}{2}\frac{\delta}{\sigma_{bc}}\beta_2 p_b\phi + \frac{1}{2}p_c\phi^{'} - \delta\beta_2\right) + \frac{1}{6}\beta_2 v_b + \beta_2 v_b + \frac{1}{2}\beta_2\left(\frac{\delta}{\sigma_{ac}} + \frac{\delta}{\sigma_{bc}}\right)v_c + \frac{1}{12}\beta_2 v_c$$

This can be simplified.

$$v_b = \left(\frac{1}{4}\beta_1 p_a\phi^{'} + \frac{1}{2}p_b\phi^{'} + \frac{1}{4}\beta_1\frac{\delta}{\sigma_{bc}}p_c\phi - \frac{1}{4}\beta_1\delta\right) + \left(\frac{1}{6} + \frac{1}{4}\frac{\delta}{\sigma_{bc}}\right)\beta_1 v_b + \left(\frac{1}{2} + \frac{1}{12}\right)\beta_1 v_c$$
$$v_c = \left(\frac{1}{4}\beta_2 p_a\phi^{'} + \frac{1}{2}\frac{\delta}{\sigma_{ac}}\beta_2 p_a\phi + \frac{1}{2}\frac{\delta}{\sigma_{bc}}\beta_2 p_b\phi + \frac{1}{2}p_c\phi^{'} - \delta\beta_2\right) + \left(\frac{1}{6} + 1\right)\beta_2 v_b + \frac{1}{2}\beta_2\left(\frac{\delta}{\sigma_{ac}} + \frac{\delta}{\sigma_{bc}} + \frac{1}{6}\right)v_c$$

This can be simplified.

$$v_b = \left(\frac{1}{4}\beta_1 p_a\phi^{'} + \frac{1}{2}p_b\phi^{'} + \frac{1}{4}\beta_1\frac{\delta}{\sigma_{bc}}p_c\phi - \frac{1}{4}\beta_1\delta\right) + \frac{1}{2}\left(\frac{1}{3} + \frac{1}{2}\frac{\delta}{\sigma_{bc}}\right)\beta_1 v_b + \frac{7}{12}\beta_1 v_c$$
$$v_c = \left(\frac{1}{4}\beta_2 p_a\phi^{'} + \frac{1}{2}\frac{\delta}{\sigma_{ac}}\beta_2 p_a\phi + \frac{1}{2}\frac{\delta}{\sigma_{bc}}\beta_2 p_b\phi + \frac{1}{2}p_c\phi^{'} - \delta\beta_2\right) + \frac{7}{6}\beta_2 v_b + \frac{1}{2}\beta_2\left(\frac{\delta}{\sigma_{ac}} + \frac{\delta}{\sigma_{bc}} + \frac{1}{6}\right)v_c$$

This can be simplified.

$$v_b - \frac{1}{2}\left(\frac{1}{3} + \frac{1}{2}\frac{\delta}{\sigma_{bc}}\right)\beta_1 v_b = \left(\frac{1}{4}\beta_1 p_a\phi^{'} + \frac{1}{2}p_b\phi^{'} + \frac{1}{4}\beta_1\frac{\delta}{\sigma_{bc}}p_c\phi - \frac{1}{4}\beta_1\delta\right) + \frac{7}{12}\beta_1 v_c$$
$$v_c = \left(\frac{1}{4}\beta_2 p_a\phi^{'} + \frac{1}{2}\frac{\delta}{\sigma_{ac}}\beta_2 p_a\phi + \frac{1}{2}\frac{\delta}{\sigma_{bc}}\beta_2 p_b\phi + \frac{1}{2}p_c\phi^{'} - \delta\beta_2\right) + \frac{7}{6}\beta_2 v_b + \frac{1}{2}\beta_2\left(\frac{\delta}{\sigma_{ac}} + \frac{\delta}{\sigma_{b}}\right.$$

This can be simplified.

$$v_b\left[1-\frac{1}{2}\left(\frac{1}{3}+\frac{1}{2}\frac{\delta}{\sigma_{bc}}\right)\beta_1\right]=\left(\frac{1}{4}\beta_1 p_a\phi^{'}+\frac{1}{2}p_b\phi^{'}+\frac{1}{4}\beta_1\frac{\delta}{\sigma_{bc}}p_c\phi-\frac{1}{4}\beta_1\delta\right)+\frac{7}{12}\beta_1 v_c$$

$$v_c=\left(\frac{1}{4}\beta_2 p_a\phi^{'}+\frac{1}{2}\frac{\delta}{\sigma_{ac}}\beta_2 p_a\phi+\frac{1}{2}\frac{\delta}{\sigma_{bc}}\beta_2 p_b\phi+\frac{1}{2}p_c\phi^{'}-\delta\beta_2\right)+\frac{7}{6}\beta_2 v_b+\frac{1}{2}\beta_2\left(\frac{\delta}{\sigma_{ac}}+\right.$$

This can be simplified.

$$v_b\left(1-\frac{1}{6}\beta_1-\frac{1}{4}\frac{\delta}{\sigma_{bc}}\beta_1\right)=\left(\frac{1}{4}\beta_1 p_a\phi^{'}+\frac{1}{2}p_b\phi^{'}+\frac{1}{4}\beta_1\frac{\delta}{\sigma_{bc}}p_c\phi-\frac{1}{4}\beta_1\delta\right)+\frac{7}{12}\beta_1 v_c$$

$$v_c=\left(\frac{1}{4}\beta_2 p_a\phi^{'}+\frac{1}{2}\frac{\delta}{\sigma_{ac}}\beta_2 p_a\phi+\frac{1}{2}\frac{\delta}{\sigma_{bc}}\beta_2 p_b\phi+\frac{1}{2}p_c\phi^{'}-\delta\beta_2\right)+\frac{7}{6}\beta_2 v_b+\frac{1}{2}\beta_2\left(\frac{\delta}{\sigma_{ac}}+\frac{\delta}{\sigma_{bc}}\right.$$

This can be simplified.

$$v_b=\frac{\left(\frac{1}{4}\beta_1 p_a\phi^{'}+\frac{1}{2}p_b\phi^{'}+\frac{1}{4}\beta_1\frac{\delta}{\sigma_{bc}}p_c\phi-\frac{1}{4}\beta_1\delta\right)}{\left(1-\frac{1}{6}\beta_1-\frac{1}{4}\frac{\delta}{\sigma_{bc}}\beta_1\right)}+\frac{\frac{7}{12}\beta_1}{\left(1-\frac{1}{6}\beta_1-\frac{1}{4}\frac{\delta}{\sigma_{bc}}\beta_1\right)}v_c$$

$$v_c=\left(\frac{1}{4}\beta_2 p_a\phi^{'}+\frac{1}{2}\frac{\delta}{\sigma_{ac}}\beta_2 p_a\phi+\frac{1}{2}\frac{\delta}{\sigma_{bc}}\beta_2 p_b\phi+\frac{1}{2}p_c\phi^{'}-\delta\beta_2\right)+\frac{7}{6}\beta_2 v_b+\frac{1}{2}\beta_2\left(\frac{\delta}{\sigma_{ac}}+\frac{\delta}{\sigma_{bc}}+\frac{1}{6}\right)v_c$$

Finally one can substitute for v_b and solve for v_c in terms of parameters.

$$\begin{aligned}v_c=&\left(\frac{1}{4}\beta_2 p_a\phi^{'}+\frac{1}{2}\frac{\delta}{\sigma_{ac}}\beta_2 p_a\phi+\frac{1}{2}\frac{\delta}{\sigma_{bc}}\beta_2 p_b\phi+\frac{1}{2}p_c\phi^{'}-\delta\beta_2\right)\\&+\frac{7}{6}\beta_2\left[\frac{\left(\frac{1}{4}\beta_1 p_a\phi^{'}+\frac{1}{2}p_b\phi^{'}+\frac{1}{4}\beta_1\frac{\delta}{\sigma_{bc}}p_c\phi-\frac{1}{4}\beta_1\delta\right)}{\left(1-\frac{1}{6}\beta_1-\frac{1}{4}\frac{\delta}{\sigma_{bc}}\beta_1\right)}+\frac{\frac{7}{12}\beta_1}{\left(1-\frac{1}{6}\beta_1-\frac{1}{4}\frac{\delta}{\sigma_{bc}}\beta_1\right)}v_c\right]\\&+\frac{1}{2}\beta_2\left(\frac{\delta}{\sigma_{ac}}+\frac{\delta}{\sigma_{bc}}+\frac{1}{6}\right)v_c\end{aligned}$$

This can be simplified.

$$\begin{aligned}v_c=&\left(\frac{1}{4}\beta_2 p_a\phi^{'}+\frac{1}{2}\frac{\delta}{\sigma_{ac}}\beta_2 p_a\phi+\frac{1}{2}\frac{\delta}{\sigma_{bc}}\beta_2 p_b\phi+\frac{1}{2}p_c\phi^{'}-\delta\beta_2\right)\\&+\frac{7}{6}\beta_2\left[\frac{\left(\frac{1}{4}\beta_1 p_a\phi^{'}+\frac{1}{2}p_b\phi^{'}+\frac{1}{4}\beta_1\frac{\delta}{\sigma_{bc}}p_c\phi-\frac{1}{4}\beta_1\delta\right)}{\left(1-\frac{1}{6}\beta_1-\frac{1}{4}\frac{\delta}{\sigma_{bc}}\beta_1\right)}\right]\\&+\frac{7}{6}\beta_2\frac{\frac{7}{12}\beta_1}{\left(1-\frac{1}{6}\beta_1-\frac{1}{4}\frac{\delta}{\sigma_{bc}}\beta_1\right)}v_c+\frac{1}{2}\beta_2\left(\frac{\delta}{\sigma_{ac}}+\frac{\delta}{\sigma_{bc}}+\frac{1}{6}\right)v_c\end{aligned}$$

This can be simplified.

$$v_c = \left(\frac{1}{4}\beta_2 p_a \phi^{'} + \frac{1}{2}\frac{\delta}{\sigma_{ac}}\beta_2 p_a \phi + \frac{1}{2}\frac{\delta}{\sigma_{bc}}\beta_2 p_b \phi + \frac{1}{2} p_c \phi^{'} - \delta\beta_2\right) + \frac{7}{6}\beta_2 \left[\frac{\left(\frac{1}{4}\beta_1 p_a \phi^{'} + \frac{1}{2} p_b \phi^{'} + \frac{1}{4}\beta_1 \frac{\delta}{\sigma_{bc}} p_c \phi - \frac{1}{4}\beta_1 \delta\right)}{\left(1 - \frac{1}{6}\beta_1 - \frac{1}{4}\frac{\delta}{\sigma_{bc}}\beta_1\right)}\right] + \frac{1}{2}\beta_2 \left[\frac{7}{3}\frac{\frac{7}{12}\beta_1}{\left(1 - \frac{1}{6}\beta_1 - \frac{1}{4}\frac{\delta}{\sigma_{bc}}\beta_1\right)} + \left(\frac{\delta}{\sigma_{ac}} + \frac{\delta}{\sigma_{bc}} + \frac{1}{6}\right)\right] v_c$$

This can be simplified.

$$v_c - \frac{1}{2}\beta_2 \left[\frac{7}{3}\frac{\frac{7}{12}\beta_1}{\left(1 - \frac{1}{6}\beta_1 - \frac{1}{4}\frac{\delta}{\sigma_{bc}}\beta_1\right)} + \frac{\delta}{\sigma_{ac}} + \frac{\delta}{\sigma_{bc}} + \frac{1}{6}\right] v_c = \left(\frac{1}{4}\beta_2 p_a \phi^{'} + \frac{1}{2}\frac{\delta}{\sigma_{ac}}\beta_2 p_a \phi + \frac{1}{2}\frac{\delta}{\sigma_{bc}}\beta_2 p_b \phi + \frac{1}{2} p_c \phi^{'} - \delta\beta_2\right) + \frac{7}{6}\beta_2 \left[\frac{\left(\frac{1}{4}\beta_1 p_a \phi^{'} + \frac{1}{2} p_b \phi^{'} + \frac{1}{4}\beta_1 \frac{\delta}{\sigma_{bc}} p_c \phi - \frac{1}{4}\beta_1 \delta\right)}{\left(1 - \frac{1}{6}\beta_1 - \frac{1}{4}\frac{\delta}{\sigma_{bc}}\beta_1\right)}\right]$$

This can be simplified.

$$v_c \left(1 - \frac{1}{2}\beta_2 \left[\frac{7}{3}\frac{\frac{7}{12}\beta_1}{\left(1 - \frac{1}{6}\beta_1 - \frac{1}{4}\frac{\delta}{\sigma_{bc}}\beta_1\right)} + \frac{\delta}{\sigma_{ac}} + \frac{\delta}{\sigma_{bc}} + \frac{1}{6}\right]\right) = \left(\frac{1}{4}\beta_2 p_a \phi^{'} + \frac{1}{2}\frac{\delta}{\sigma_{ac}}\beta_2 p_a \phi + \frac{1}{2}\frac{\delta}{\sigma_{bc}}\beta_2 p_b \phi + \frac{1}{2} p_c \phi^{'} - \delta\beta_2\right) + \frac{7}{6}\beta_2 \left(\frac{\frac{1}{4}\beta_1 p_a \phi^{'} + \frac{1}{2} p_b \phi^{'} + \frac{1}{4}\beta_1 \frac{\delta}{\sigma_{bc}} p_c \phi - \frac{1}{4}\beta_1 \delta}{1 - \frac{1}{6}\beta_1 - \frac{1}{4}\frac{\delta}{\sigma_{bc}}\beta_1}\right)$$

This can be simplified.

$$v_c \left(1 - \frac{1}{2}\beta_2 \left[\frac{7}{3}\frac{7}{12}\frac{\beta_1}{\beta_1}\frac{1}{\left(\frac{1}{\beta_1} - \frac{1}{6} - \frac{1}{4}\frac{\delta}{\sigma_{bc}}\right)} + \frac{\delta}{\sigma_{ac}} + \frac{\delta}{\sigma_{bc}} + \frac{1}{6}\right]\right) = \left(\frac{1}{4}\beta_2 p_a \phi^{'} + \frac{1}{2}\frac{\delta}{\sigma_{ac}}\beta_2 p_a \phi + \frac{1}{2}\frac{\delta}{\sigma_{bc}}\beta_2 p_b \phi + \frac{1}{2} p_c \phi^{'} - \delta\beta_2\right) + \frac{7}{6}\beta_2 \left(\frac{\beta_1}{\beta_1}\frac{\frac{1}{4} p_a \phi^{'} + \frac{1}{2}\frac{1}{\beta_1} p_b \phi^{'} + \frac{1}{4}\frac{\delta}{\sigma_{bc}} p_c \phi - \frac{1}{4}\delta}{\frac{1}{\beta_1} - \frac{1}{6} - \frac{1}{4}\frac{\delta}{\sigma_{bc}}}\right)$$

This can be simplified.

$$v_c\left(1-\frac{1}{2}\beta_2\left[\frac{49}{36}\frac{1}{\left(\frac{1}{\beta_1}-\frac{1}{6}-\frac{1}{4}\frac{\delta}{\sigma_{bc}}\right)}+\frac{\delta}{\sigma_{ac}}+\frac{\delta}{\sigma_{bc}}+\frac{1}{6}\right]\right)$$
$$=\left(\frac{1}{4}\beta_2 p_a\phi^{'}+\frac{1}{2}\frac{\delta}{\sigma_{ac}}\beta_2 p_a\phi+\frac{1}{2}\frac{\delta}{\sigma_{bc}}\beta_2 p_b\phi+\frac{1}{2}p_c\phi^{'}-\delta\beta_2\right)$$
$$+\frac{7}{6}\beta_2\left(\frac{\frac{1}{4}p_a\phi^{'}+\frac{1}{2}\frac{1}{\beta_1}p_b\phi^{'}+\frac{1}{4}\frac{\delta}{\sigma_{bc}}p_c\phi-\frac{1}{4}\delta}{\frac{1}{\beta_1}-\frac{1}{6}-\frac{1}{4}\frac{\delta}{\sigma_{bc}}}\right)$$

Dividing yields a solution for v_c in terms of parameters.

$$v_c=\frac{\left(\frac{1}{4}\beta_2 p_a\phi^{'}+\frac{1}{2}\frac{\delta}{\sigma_{ac}}\beta_2 p_a\phi+\frac{1}{2}\frac{\delta}{\sigma_{bc}}\beta_2 p_b\phi+\frac{1}{2}p_c\phi^{'}-\delta\beta_2\right)}{\left(1-\frac{1}{2}\beta_2\left[\frac{49}{36}\frac{1}{\left(\frac{1}{\beta_1}-\frac{1}{6}-\frac{1}{4}\frac{\delta}{\sigma_{bc}}\right)}+\frac{\delta}{\sigma_{ac}}+\frac{\delta}{\sigma_{bc}}+\frac{1}{6}\right]\right)}$$
$$+\frac{\frac{7}{6}\beta_2\left(\frac{\frac{1}{4}p_a\phi^{'}+\frac{1}{2}\frac{1}{\beta_1}p_b\phi^{'}+\frac{1}{4}\frac{\delta}{\sigma_{bc}}p_c\phi-\frac{1}{4}\delta}{\frac{1}{\beta_1}-\frac{1}{6}-\frac{1}{4}\frac{\delta}{\sigma_{bc}}}\right)}{\left(1-\frac{1}{2}\beta_2\left[\frac{49}{36}\frac{1}{\left(\frac{1}{\beta_1}-\frac{1}{6}-\frac{1}{4}\frac{\delta}{\sigma_{bc}}\right)}+\frac{\delta}{\sigma_{ac}}+\frac{\delta}{\sigma_{bc}}+\frac{1}{6}\right]\right)}$$

This can be simplified.

$$v_c=\frac{\beta_2\left(\frac{1}{4}p_a\phi^{'}+\frac{1}{2}\frac{\delta}{\sigma_{ac}}p_a\phi+\frac{1}{2}\frac{\delta}{\sigma_{bc}}p_b\phi+\frac{1}{2}\frac{1}{\beta_2}p_c\phi^{'}-\delta\right)}{\beta_2\left(\frac{1}{\beta_2}-\frac{1}{2}\left[\frac{49}{36}\frac{1}{\left(\frac{1}{\beta_1}-\frac{1}{6}-\frac{1}{4}\frac{\delta}{\sigma_{bc}}\right)}+\frac{\delta}{\sigma_{ac}}+\frac{\delta}{\sigma_{bc}}+\frac{1}{6}\right]\right)}$$
$$+\frac{\frac{7}{6}\beta_2\left(\frac{\frac{1}{4}p_a\phi^{'}+\frac{1}{2}\frac{1}{\beta_1}p_b\phi^{'}+\frac{1}{4}\frac{\delta}{\sigma_{bc}}p_c\phi-\frac{1}{4}\delta}{\frac{1}{\beta_1}-\frac{1}{6}-\frac{1}{4}\frac{\delta}{\sigma_{bc}}}\right)}{\beta_2\left(\frac{1}{\beta_2}-\frac{1}{2}\left[\frac{49}{36}\frac{1}{\left(\frac{1}{\beta_1}-\frac{1}{6}-\frac{1}{4}\frac{\delta}{\sigma_{bc}}\right)}+\frac{\delta}{\sigma_{ac}}+\frac{\delta}{\sigma_{bc}}+\frac{1}{6}\right]\right)}$$

This can be simplified.

$$v_c^*=\frac{\frac{1}{4}p_a\phi^{'}+\frac{1}{2}\frac{\delta}{\sigma_{ac}}p_a\phi+\frac{1}{2}\frac{\delta}{\sigma_{bc}}p_b\phi+\frac{1}{2\beta_2}p_c\phi^{'}-\delta}{\frac{1}{\beta_2}-\frac{49}{72}\frac{1}{\left(\frac{1}{\beta_1}-\frac{1}{6}-\frac{\delta}{4\sigma_{bc}}\right)}-\frac{\delta}{2\sigma_{ac}}-\frac{\delta}{2\sigma_{bc}}-\frac{1}{12}}$$
$$+\frac{\frac{7}{6}\left(\frac{\frac{1}{4}p_a\phi^{'}+\frac{1}{2}\frac{1}{\beta_1}p_b\phi^{'}+\frac{1}{4}\frac{\delta}{\sigma_{bc}}p_c\phi-\frac{1}{4}\delta}{\frac{1}{\beta_1}-\frac{1}{6}-\frac{1}{4}\frac{\delta}{\sigma_{bc}}}\right)}{\frac{1}{\beta_2}-\frac{49}{72}\frac{1}{\left(\frac{1}{\beta_1}-\frac{1}{6}-\frac{\delta}{4\sigma_{bc}}\right)}-\frac{\delta}{2\sigma_{ac}}-\frac{\delta}{2\sigma_{bc}}-\frac{1}{12}} \tag{10}$$

Using previously derived expressions gives solutions for the other endogenous variables.

$$v_b^* = \frac{\frac{1}{4}p_a\phi' + \frac{1}{2\beta_1}p_b\phi' + \frac{1}{4}\frac{\delta}{\sigma_{bc}}p_c\phi - \frac{1}{4}\delta}{\frac{1}{\beta_1} - \frac{1}{6} - \frac{\delta}{4\sigma_{bc}}} + \frac{\frac{7}{12}}{\frac{1}{\beta_1} - \frac{1}{6} - \frac{\delta}{4\sigma_{bc}}}v_c^* \tag{11}$$

$$v_a^* = \frac{1}{2}p_a\phi' + \frac{1}{6}v_c^* + \frac{1}{3}v_b^* \tag{12}$$

$$w_c^* = \frac{1}{2}p_c\phi + \frac{1}{2}v_b^* - \frac{1}{2}\sigma_{bc} \tag{13}$$

$$w_b^* = \frac{1}{2}p_b\phi + \frac{1}{2}v_c^* - \frac{1}{2}\sigma_{bc} \tag{14}$$

$$w_a^* = \frac{1}{2}p_a\phi + \frac{1}{2}v_c^* - \frac{1}{2}\sigma_{ac} \tag{15}$$

I first consider poaching wages. By equations 11 and 12, $v_b^* > v_c^*$ and $v_a^* > v_b^*$ provided $p_a\phi'$ is sufficiently large. Irrespective of how switching affects productivity, one can guarantee this with sufficiently large p_a. From the above solutions, $w_i^* < v_c^*$ provided σ_{bc} and σ_{ac} are sufficiently large.

I next consider loyalty wages. The inequality $w_a^* > w_b^*$ requires the following.

$$\frac{1}{2}p_a\phi + \frac{1}{2}v_c^* - \frac{1}{2}\sigma_{ac} > \frac{1}{2}p_b\phi + \frac{1}{2}v_c^* - \frac{1}{2}\sigma_{bc}$$
$$p_a\phi - \sigma_{ac} > p_b\phi - \sigma_{bc}$$

From the beginning the model assumed $\sigma_{ac} > \sigma_{bc}$, so this condition amounts to $p_a \gg p_b$. That is, the price of firm A's output must exceed that of firm B's output sufficient to offset the greater switching costs that allow firm A to lower its loyalty wages. The inequality$w_b^* > w_c^*$ requires

$$\frac{1}{2}p_b\phi + \frac{1}{2}v_c^* - \frac{1}{2}\sigma_{bc} > \frac{1}{2}p_c\phi + \frac{1}{2}v_b^* - \frac{1}{2}\sigma_{bc}$$
$$p_b\phi + v_c^* > p_c\phi + v_b^*$$

Under the restriction(s) given above $v_b^* > v_c^*$, so this condition amounts to $p_b \gg p_c$. That is, the price of firm B's output must exceed that of firm C's output sufficient to offset B's advantage in facing the weakest marginal poaching threat (firm C; firm C faces a stronger marginal poaching threat in firm B).

Appendix F No-poach agreement between B & C

Given the initial equilibrium, only a no-poach agreement between firms B and C can possibly be incentive-compatible. (If B were to make a deal with A, it would lose the same number of workers, but all to C rather than the combination of A and C. The case of a deal between C and A is similar.) Let superscripts np denote variables under the no-poach agreement. I represent the agreement within the model as a quantity restriction: $l_{cb}^{na} = l_{bc}^{na} = 0$. This is in keeping with my empirical setting.

F.1 Firm A, no-poach agreement between B & C

Firm A's optimization problem does change because it faces different labor supply functions l_{ba}^{na} and l_{ca}^{na}. Firm A's labor shares are as follows.

$$l_{aa}^{na} = 1 - \left(\frac{v_c^{np} - w_a^{np}}{\sigma_{ac}} \right)$$
$$l_{ba}^{na} = \frac{v_a^{np} - w_b^{np}}{\sigma_{ab}}$$
$$l_{ca}^{na} = \frac{v_a^{np} - w_c^{np}}{\sigma_{ac}}$$

Relevant derivatives are as follows.

$$\frac{\partial l_{aa}^{np}}{\partial w_a} = \frac{1}{\sigma_{ac}}$$
$$\frac{l_{ba}^{np}}{\partial v_a} = \frac{1}{\sigma_{ab}}$$
$$\frac{l_{ca}^{np}}{\partial v_a} = \frac{1}{\sigma_{ac}}$$

FOCs are as follows.

$$(p_a \phi - w_a^{np}) \frac{1}{\sigma_{ac}} - \left(1 - \left(\frac{v_c^{np} - w_a^{np}}{\sigma_{ac}} \right) \right) = 0$$
$$\left(p_a \phi' - v_a^{np} \right) \left(\frac{1}{\sigma_{ab}} + \frac{1}{\sigma_{ac}} \right) - \left(\frac{v_a^{np} - w_b^{np}}{\sigma_{ab}} + \frac{v_a^{np} - w_c^{np}}{\sigma_{ac}} \right) = 0$$

The first condition can be solved for w_a^{np}.

$$
\begin{aligned}
(p_a\phi - w_a^{np})\,\frac{1}{\sigma_{ac}} - \left(1 - \left(\frac{v_c^{np} - w_a^{np}}{\sigma_{ac}}\right)\right) &= 0 \\
(p_a\phi - w_a^{np})\,\frac{1}{\sigma_{ac}} + \frac{v_c^{np} - w_a^{np}}{\sigma_{ac}} &= 1 \\
p_a\phi - 2w_a^{np} + v_c^{np} &= \sigma_{ac} \\
2w_a^{np} &= p_a\phi + v_c^{np} - \sigma_{ac} \\
w_a^{np} &= \frac{1}{2}p_a\phi + \frac{1}{2}v_c^{np} - \frac{1}{2}\sigma_{ac} \qquad (16)
\end{aligned}
$$

The second condition can be solved for v_a^{np}.

$$
\begin{aligned}
\left(p_a\phi' - v_a^{np}\right)\left(\frac{1}{\sigma_{ab}} + \frac{1}{\sigma_{ac}}\right) - \left(\frac{v_a^{np} - w_b^{np}}{\sigma_{ab}} + \frac{v_a^{np} - w_c^{np}}{\sigma_{ac}}\right) &= 0 \\
\frac{p_a\phi' - v_a^{np} - v_a^{np} + w_b^{np}}{\sigma_{ab}} + \frac{p_a\phi' - v_a^{np} - v_a^{np} + w_c^{np}}{\sigma_{ac}} &= 0 \\
p_a\phi' - 2v_a^{np} + w_b^{np} + \frac{\sigma_{ab}}{\sigma_{ac}}\left(p_a\phi' - 2v_a^{np} + w_c^{np}\right) &= 0 \\
p_a\phi' - 2v_a^{np} + w_b^{np} + \frac{\sigma_{ab}}{\sigma_{ac}}p_a\phi' - 2\frac{\sigma_{ab}}{\sigma_{ac}}v_a^{np} + \frac{\sigma_{ab}}{\sigma_{ac}}w_c^{np} &= 0
\end{aligned}
$$

$$
\begin{aligned}
2v_a^{np} + 2\frac{\sigma_{ab}}{\sigma_{ac}}v_a^{np} &= p_a\phi' + w_b^{np} + \frac{\sigma_{ab}}{\sigma_{ac}}p_a\phi' + \frac{\sigma_{ab}}{\sigma_{ac}}w_c^{np} \\
2\left(1 + \frac{\sigma_{ab}}{\sigma_{ac}}\right)v_a^{np} &= \left(1 + \frac{\sigma_{ab}}{\sigma_{ac}}\right)p_a\phi' + w_b^{np} + \frac{\sigma_{ab}}{\sigma_{ac}}w_c^{np} \\
v_a^{np} &= \frac{1}{2}p_a\phi' + \frac{1}{2\left(1 + \frac{\sigma_{ab}}{\sigma_{ac}}\right)}w_b^{np} + \frac{1}{2\left(1 + \frac{\sigma_{ab}}{\sigma_{ac}}\right)}\frac{\sigma_{ab}}{\sigma_{ac}}w_c^{np} \\
v_a^{np} &= \frac{1}{2}p_a\phi' + \frac{1}{\left(2\frac{\sigma_{ac}}{\sigma_{ac}} + 2\frac{\sigma_{ab}}{\sigma_{ac}}\right)}w_b^{np} + \frac{1}{\left(2\frac{\sigma_{ac}}{\sigma_{ac}} + 2\frac{\sigma_{ab}}{\sigma_{ac}}\right)}\frac{\sigma_{ab}}{\sigma_{ac}}w_c^{np} \\
v_a^{np} &= \frac{1}{2}p_a\phi' + \frac{1}{\frac{2\sigma_{ac}+2\sigma_{ab}}{\sigma_{ac}}}w_b^{np} + \frac{1}{\frac{2\sigma_{ac}+2\sigma_{ab}}{\sigma_{ac}}}\frac{\sigma_{ab}}{\sigma_{ac}}w_c^{np} \\
v_a^{np} &= \frac{1}{2}p_a\phi' + \frac{\sigma_{ac}}{2\sigma_{ac} + 2\sigma_{ab}}w_b^{np} + \frac{\sigma_{ac}}{2\sigma_{ac} + 2\sigma_{ab}}\frac{\sigma_{ab}}{\sigma_{ac}}w_c^{np} \\
v_a^{np} &= \frac{1}{2}p_a\phi' + \frac{\sigma_{ac}}{2\sigma_{ac} + 2\sigma_{ab}}w_b^{np} + \frac{\sigma_{ab}}{2\sigma_{ac} + 2\sigma_{ab}}w_c^{np} \qquad (17)
\end{aligned}
$$

F.2 Firm B, no-poach agreement between B & C

Firm B's labor shares are as follows.

$$
\begin{aligned}
l_{bb}^{np} &= 1 - \left(\frac{v_a^{np} - w_b^{np}}{\sigma_{ba}}\right) \\
l_{ab}^{np} &= \frac{v_b^{np} - v_c^{np}}{\sigma_{ab} - \sigma_{ac}} = \frac{v_b^{np} - v_c^{np}}{\delta} \\
l_{cb}^{np} &= 0
\end{aligned}
$$

Relevant derivatives are as follows.

$$
\begin{aligned}
\frac{\partial l_{bb}^{np}}{\partial w_b} &= \frac{1}{\sigma_{ba}} \\
\frac{l_{ab}^{np}}{\partial v_b} &= \frac{1}{\delta} \\
\frac{l_{cb}^{np}}{\partial v_b} &= 0
\end{aligned}
$$

FOCs are as follows.

$$
\begin{aligned}
\left(p_b\phi - w_b^{np}\right)\frac{1}{\sigma_{ba}} - \left(1 - \left(\frac{v_a^{np} - w_b^{np}}{\sigma_{ba}}\right)\right) &= 0 \\
\left(p_b\phi' - v_b^{np}\right)\left(\frac{1}{\delta}\right) - \left(\frac{v_b^{np} - v_c^{np}}{\delta}\right) &= 0
\end{aligned}
$$

The first condition can be solved for w_b^{np}.

$$
\begin{aligned}
\left(p_b\phi - w_b^{np}\right)\frac{1}{\sigma_{ba}} - \left(1 - \left(\frac{v_a^{np} - w_b^{np}}{\sigma_{ba}}\right)\right) &= 0 \\
\left(p_b\phi - w_b^{np}\right)\frac{1}{\sigma_{ba}} + \left(\frac{v_a^{np} - w_b^{np}}{\sigma_{ba}}\right) &= 1 \\
p_b\phi - 2w_b^{np} + v_a^{np} &= \sigma_{ba} \\
2w_b^{np} &= p_b\phi + v_a^{np} - \sigma_{ba} \\
w_b^{np} &= \frac{1}{2}p_b\phi + \frac{1}{2}v_a^{np} - \frac{1}{2}\sigma_{ba} \qquad (18)
\end{aligned}
$$

The second condition can be solved for v_b^{np}.

$$\begin{aligned}
\left(p_b\phi^{'} - v_b^{np}\right)\left(\frac{1}{\delta}\right) - \left(\frac{v_b^{np} - v_c^{np}}{\delta}\right) &= 0 \\
\left(p_b\phi^{'} - v_b^{np}\right) - v_b^{np} + v_c^{np} &= 0 \\
p_b\phi^{'} - 2v_b^{np} + v_c^{np} &= 0 \\
2v_b^{np} &= p_b\phi^{'} + v_c^{np} \\
v_b^{np} &= \frac{1}{2}p_b\phi^{'} + \frac{1}{2}v_c^{np} \qquad (19)
\end{aligned}$$

F.3 Firm C, no-poach agreement between B & C

Firm C's labor shares are as follows.

$$\begin{aligned}
l_{cc}^{np} &= 1 - \left(\frac{v_a^{np} - w_c^{np}}{\sigma_{ac}}\right) \\
l_{ac}^{np} &= \left(\frac{v_c^{np} - w_a^{np}}{\sigma_{ac}}\right) - \left(\frac{v_b^{np} - v_c^{np}}{\sigma_{ab} - \sigma_{ac}}\right) = \left(\frac{v_c^{np} - w_a^{np}}{\sigma_{ac}}\right) - \left(\frac{v_b^{np} - v_c^{np}}{\delta}\right) \\
l_{bc}^{np} &= 0
\end{aligned}$$

Relevant derivatives are as follows.

$$\begin{aligned}
\frac{\partial l_{cc}^{np}}{\partial w_c} &= \frac{1}{\sigma_{ac}} \\
\frac{l_{ac}^{np}}{\partial v_c} &= \frac{1}{\sigma_{ac}} + \frac{1}{\delta} \\
\frac{l_{bc}^{np}}{\partial v_c} &= 0
\end{aligned}$$

FOCs are as follows.

$$\begin{aligned}
\left(p_c\phi - w_c^{np}\right)\frac{1}{\sigma_{ac}} - \left(1 - \left(\frac{v_a^{np} - w_c^{np}}{\sigma_{ac}}\right)\right) &= 0 \\
\left(p_c\phi^{'} - v_c^{np}\right)\left(\frac{1}{\sigma_{ac}} + \frac{1}{\delta}\right) - \left(\left(\frac{v_c^{np} - w_a^{np}}{\sigma_{ac}}\right) - \left(\frac{v_b^{np} - v_c^{np}}{\delta}\right)\right) &= 0
\end{aligned}$$

The first condition can be solved for w_c^{np}.

$$
\begin{aligned}
\left(p_c\phi - w_c^{np}\right)\frac{1}{\sigma_{ac}} - \left(1 - \left(\frac{v_a^{np} - w_c^{np}}{\sigma_{ac}}\right)\right) &= 0 \\
\left(p_c\phi - w_c^{np}\right)\frac{1}{\sigma_{ac}} + \left(\frac{v_a^{np} - w_c^{np}}{\sigma_{ac}}\right) &= 1 \\
\left(p_c\phi - w_c^{np}\right) + v_a^{np} - w_c^{np} &= \sigma_{ac} \\
p_c\phi - 2w_c^{np} + v_a^{np} &= \sigma_{ac} \\
2w_c^{np} &= p_c\phi + v_a^{np} - \sigma_{ac} \\
w_c^{np} &= \frac{1}{2}p_c\phi + \frac{1}{2}v_a^{np} - \frac{1}{2}\sigma_{ac} \qquad (20)
\end{aligned}
$$

The second condition can be solved for v_c^{np}.

$$
\begin{aligned}
\left(p_c\phi' - v_c^{np}\right)\left(\frac{1}{\sigma_{ac}} + \frac{1}{\delta}\right) - \left(\left(\frac{v_c^{np} - w_a^{np}}{\sigma_{ac}}\right) - \left(\frac{v_b^{np} - v_c^{np}}{\delta}\right)\right) &= 0 \\
\frac{p_c\phi' - v_c^{np}}{\sigma_{ac}} + \frac{p_c\phi' - v_c^{np}}{\delta} - \frac{v_c^{np} - w_a^{np}}{\sigma_{ac}} + \frac{v_b^{np} - v_c^{np}}{\delta} &= 0 \\
\frac{p_c\phi' - 2v_c^{np} + w_a^{np}}{\sigma_{ac}} + \frac{p_c\phi' - 2v_c^{np} + v_b^{np}}{\delta} &= 0 \\
\frac{p_c\phi' - 2v_c^{np} + w_a^{np}}{\sigma_{ac}} + \frac{p_c\phi' - 2v_c^{np} + v_b^{np}}{\delta} &= 0 \\
\frac{\delta}{\sigma_{ac}}\left(p_c\phi' - 2v_c^{np} + w_a^{np}\right) + p_c\phi' - 2v_c^{np} + v_b^{np} &= 0 \\
\left(\frac{\delta}{\sigma_{ac}}p_c\phi' - 2\frac{\delta}{\sigma_{ac}}v_c^{np} + \frac{\delta}{\sigma_{ac}}w_a^{np}\right) + p_c\phi' - 2v_c^{np} + v_b^{np} &= 0
\end{aligned}
$$

$$2v_c^{np} + 2\frac{\delta}{\sigma_{ac}}v_c^{np} = p_c\phi' + \frac{\delta}{\sigma_{ac}}p_c\phi' + \frac{\delta}{\sigma_{ac}}w_a^{np} + v_b^{np}$$

$$2\left(1 + \frac{\delta}{\sigma_{ac}}\right)v_c^{np} = \left(1 + \frac{\delta}{\sigma_{ac}}\right)p_c\phi' + \frac{\delta}{\sigma_{ac}}w_a^{np} + v_b^{np}$$

$$v_c^{np} = \frac{1}{2}p_c\phi' + \frac{\frac{\delta}{\sigma_{ac}}}{2\left(1 + \frac{\delta}{\sigma_{ac}}\right)}w_a^{np} + \frac{1}{2\left(1 + \frac{\delta}{\sigma_{ac}}\right)}v_b^{np}$$

$$v_c^{np} = \frac{1}{2}p_c\phi' + \frac{\frac{\delta}{\sigma_{ac}}}{2\left(\frac{\sigma_{ac}+\delta}{\sigma_{ac}}\right)}w_a^{np} + \frac{1}{2\left(\frac{\sigma_{ac}+\delta}{\sigma_{ac}}\right)}v_b^{np}$$

$$v_c^{np} = \frac{1}{2}p_c\phi' + \frac{1}{2}\frac{\delta}{\sigma_{ac}}\frac{\sigma_{ac}}{\sigma_{ac}+\delta}w_a^{np} + \frac{1}{2}\frac{\sigma_{ac}}{\sigma_{ac}+\delta}v_b^{np}$$

$$v_c^{np} = \frac{1}{2}p_c\phi' + \frac{\delta}{2\sigma_{ac}+2\delta}w_a^{np} + \frac{\sigma_{ac}}{2\sigma_{ac}+2\delta}v_b^{np} \tag{21}$$

F.4 Solving for wages, no-poach agreement between B & C

Equations 16 through 21 comprise a system in six variables $\{w_a^{np}, v_a^{np}, w_b^{np}, v_b^{np}, w_c^{np}, v_c^{np}\}$.

$$w_a^{np} = \frac{1}{2}p_a\phi + \frac{1}{2}v_c^{np} - \frac{1}{2}\sigma_{ac}$$

$$v_a^{np} = \frac{1}{2}p_a\phi' + \frac{\sigma_{ac}}{2\sigma_{ac}+2\sigma_{ab}}w_b^{np} + \frac{\sigma_{ab}}{2\sigma_{ac}+2\sigma_{ab}}w_c^{np}$$

$$w_b^{np} = \frac{1}{2}p_b\phi + \frac{1}{2}v_a^{np} - \frac{1}{2}\sigma_{ba}$$

$$v_b^{np} = \frac{1}{2}p_b\phi' + \frac{1}{2}v_c^{np}$$

$$w_c^{np} = \frac{1}{2}p_c\phi + \frac{1}{2}v_a^{np} - \frac{1}{2}\sigma_{ac}$$

$$v_c^{np} = \frac{1}{2}p_c\phi' + \frac{\delta}{2\sigma_{ac}+2\delta}w_a^{np} + \frac{\sigma_{ac}}{2\sigma_{ac}+2\delta}v_b^{np}$$

To begin, substitute the equations for w_i^{np} into those for v_i^{np} to obtain a 3x3 system.

$$v_a^{np} = \frac{1}{2}p_a\phi' + \frac{\sigma_{ac}}{2\sigma_{ac}+2\sigma_{ab}}\left(\frac{1}{2}p_b\phi + \frac{1}{2}v_a^{np} - \frac{1}{2}\sigma_{ba}\right) + \frac{\sigma_{ab}}{2\sigma_{ac}+2\sigma_{ab}}\left(\frac{1}{2}p_c\phi + \frac{1}{2}v_a^{np} - \frac{1}{2}\sigma_{ac}\right)$$

$$v_b^{np} = \frac{1}{2}p_b\phi' + \frac{1}{2}v_c^{np}$$

$$v_c^{np} = \frac{1}{2}p_c\phi' + \frac{\delta}{2\sigma_{ac}+2\delta}\left(\frac{1}{2}p_a\phi + \frac{1}{2}v_c^{np} - \frac{1}{2}\sigma_{ac}\right) + \frac{\sigma_{ac}}{2\sigma_{ac}+2\delta}v_b^{np}$$

The first of the previous equations determines v_a by itself.

$$v_a^{np} = \frac{1}{2}p_a\phi^{'} + \frac{\sigma_{ac}}{2\sigma_{ac}+2\sigma_{ab}}\left(\frac{1}{2}p_b\phi + \frac{1}{2}v_a^{np} - \frac{1}{2}\sigma_{ba}\right) + \frac{\sigma_{ab}}{2\sigma_{ac}+2\sigma_{ab}}\left(\frac{1}{2}p_c\phi + \frac{1}{2}v_a^{np} - \frac{1}{2}\sigma_{ac}\right)$$
$$v_a^{np} = \frac{1}{2}p_a\phi^{'} + \frac{1}{2}\frac{\sigma_{ac}}{2\sigma_{ac}+2\sigma_{ab}}p_b\phi + \frac{1}{2}\frac{\sigma_{ac}}{2\sigma_{ac}+2\sigma_{ab}}v_a^{np} - \frac{1}{2}\frac{\sigma_{ac}}{2\sigma_{ac}+2\sigma_{ab}}\sigma_{ba} + \frac{1}{2}\frac{\sigma_{ab}}{2\sigma_{ac}+2\sigma_{ab}}p_c\phi + \frac{1}{2}\frac{\sigma_{ab}}{2\sigma_{ac}+2\sigma_{ab}}v$$
$$v_a^{np} = \frac{1}{2}p_a\phi^{'} + \frac{1}{2}\frac{\sigma_{ac}}{2\sigma_{ac}+2\sigma_{ab}}(p_b\phi - \sigma_{ba}) + \frac{1}{2}\frac{\sigma_{ab}}{2\sigma_{ac}+2\sigma_{ab}}(p_c\phi - \sigma_{ac}) + \frac{1}{2}\left(\frac{\sigma_{ac}}{2\sigma_{ac}+2\sigma_{ab}} + \frac{\sigma_{ab}}{2\sigma_{ac}+2\sigma_{ab}}\right)v_a^{np}$$

$$v_a^{np} - \frac{1}{2}\left(\frac{\sigma_{ac}}{2\sigma_{ac}+2\sigma_{ab}} + \frac{\sigma_{ab}}{2\sigma_{ac}+2\sigma_{ab}}\right)v_a^{np} = \frac{1}{2}p_a\phi^{'} + \frac{1}{2}\frac{\sigma_{ac}}{2\sigma_{ac}+2\sigma_{ab}}(p_b\phi - \sigma_{ba}) + \frac{1}{2}\frac{\sigma_{ab}}{2\sigma_{ac}+2\sigma_{ab}}(p_c\phi - \sigma_{ac})$$
$$v_a^{np}\left[1 - \frac{1}{2}\left(\frac{\sigma_{ac}}{2\sigma_{ac}+2\sigma_{ab}} + \frac{\sigma_{ab}}{2\sigma_{ac}+2\sigma_{ab}}\right)\right] = \frac{1}{2}p_a\phi^{'} + \frac{1}{2}\frac{\sigma_{ac}}{2\sigma_{ac}+2\sigma_{ab}}(p_b\phi - \sigma_{ba}) + \frac{1}{2}\frac{\sigma_{ab}}{2\sigma_{ac}+2\sigma_{ab}}(p_c\phi - \sigma_{ac})$$

$$v_a^{np} = \frac{\frac{1}{2}p_a\phi^{'} + \frac{1}{2}\frac{\sigma_{ac}}{2\sigma_{ac}+2\sigma_{ab}}(p_b\phi - \sigma_{ba}) + \frac{1}{2}\frac{\sigma_{ab}}{2\sigma_{ac}+2\sigma_{ab}}(p_c\phi - \sigma_{ac})}{1 - \frac{1}{2}\left(\frac{\sigma_{ac}}{2\sigma_{ac}+2\sigma_{ab}} + \frac{\sigma_{ab}}{2\sigma_{ac}+2\sigma_{ab}}\right)} \tag{22}$$

The remaining equations are a 2x2 system in $v_b$and v_c. Substituting for v_b gives the an equation solely in terms of v_c.

$$v_c^{np} = \frac{1}{2}p_c\phi^{'} + \frac{\delta}{2\sigma_{ac}+2\delta}\left(\frac{1}{2}p_a\phi + \frac{1}{2}v_c^{np} - \frac{1}{2}\sigma_{ac}\right) + \frac{\sigma_{ac}}{2\sigma_{ac}+2\delta}\left(\frac{1}{2}p_b\phi^{'} + \frac{1}{2}v_c^{np}\right)$$
$$v_c^{np} = \frac{1}{2}p_c\phi^{'} + \left(\frac{1}{2}\frac{\delta}{2\sigma_{ac}+2\delta}p_a\phi + \frac{1}{2}\frac{\delta}{2\sigma_{ac}+2\delta}v_c^{np} - \frac{1}{2}\frac{\delta}{2\sigma_{ac}+2\delta}\sigma_{ac}\right) + \left(\frac{1}{2}\frac{\sigma_{ac}}{2\sigma_{ac}+2\delta}p_b\phi^{'} + \frac{1}{2}\frac{\sigma_{ac}}{2\sigma_{ac}+2\delta}v_c^{np}\right)$$

$$v_c^{np} - \frac{1}{2}\frac{\delta}{2\sigma_{ac}+2\delta}v_c^{np} - \frac{1}{2}\frac{\sigma_{ac}}{2\sigma_{ac}+2\delta}v_c^{np} = \frac{1}{2}p_c\phi^{'} + \frac{1}{2}\frac{\delta}{2\sigma_{ac}+2\delta}(p_a\phi - \sigma_{ac}) + \frac{1}{2}\frac{\sigma_{ac}}{2\sigma_{ac}+2\delta}p_b\phi^{'}$$
$$v_c^{np}\left(1 - \frac{1}{2}\frac{\delta}{2\sigma_{ac}+2\delta} - \frac{1}{2}\frac{\sigma_{ac}}{2\sigma_{ac}+2\delta}\right) = \frac{1}{2}p_c\phi^{'} + \frac{1}{2}\frac{\delta}{2\sigma_{ac}+2\delta}(p_a\phi - \sigma_{ac}) + \frac{1}{2}\frac{\sigma_{ac}}{2\sigma_{ac}+2\delta}p_b\phi^{'}$$

$$v_c^{np} = \frac{\frac{1}{2}p_c\phi^{'} + \frac{1}{2}\frac{\delta}{2\sigma_{ac}+2\delta}(p_a\phi - \sigma_{ac}) + \frac{1}{2}\frac{\sigma_{ac}}{2\sigma_{ac}+2\delta}p_b\phi^{'}}{1 - \frac{1}{2}\frac{\delta}{2\sigma_{ac}+2\delta} - \frac{1}{2}\frac{\sigma_{ac}}{2\sigma_{ac}+2\delta}} \tag{23}$$

Using previously derived expressions gives solutions for the other endogenous variables.

$$v_b^{np} = \frac{1}{2}p_b\phi^{'} + \frac{1}{2}v_c^{np} \tag{24}$$

$$w_c^{np} = \frac{1}{2}p_c\phi + \frac{1}{2}v_a^{np} - \frac{1}{2}\sigma_{ac} \tag{25}$$

$$w_b^{np} = \frac{1}{2}p_b\phi + \frac{1}{2}v_a^{np} - \frac{1}{2}\sigma_{ba} \tag{26}$$

$$w_a^{np} = \frac{1}{2}p_a\phi + \frac{1}{2}v_c^{np} - \frac{1}{2}\sigma_{ac} \tag{27}$$

Appendix G Comparing equilibria

Recall that $\sigma_{ba} - \sigma_{ac} = \sigma_{ac} - \sigma_{bc} \equiv \delta$, $\beta_1 \equiv \left(\frac{1}{2+\frac{\delta}{\sigma_{bc}}}\right)$, and $\beta_2 \equiv \left(\frac{\sigma_{ac}\sigma_{bc}}{3\sigma_{ac}\sigma_{bc}+2\delta\sigma_{bc}+2\delta\sigma_{ac}}\right)$. To simplify comparisons, assume differences in cost parameters are small relative to the levels of cost parameters, so that $\beta_1 \approx \frac{1}{2}$ and $\beta_2 \approx \frac{1}{3}$. Additionally, expressions like $\frac{\delta}{2\sigma_{ac}}$ are then approximately equal to zero.

G.1 Poaching wages

To begin I substitute approximations into previously derived solutions.

$$v_c^* = \frac{\frac{1}{4}p_a\phi^{'} + \frac{1}{2}\frac{\delta}{\sigma_{ac}}p_a\phi + \frac{1}{2}\frac{\delta}{\sigma_{bc}}p_b\phi + \frac{1}{2\beta_2}p_c\phi^{'} - \delta}{\frac{1}{\beta_2} - \frac{49}{72}\frac{1}{\left(\frac{1}{\beta_1}-\frac{1}{6}-\frac{\delta}{4\sigma_{bc}}\right)} - \frac{\delta}{2\sigma_{ac}} - \frac{\delta}{2\sigma_{bc}} - \frac{1}{12}} + \frac{\frac{7}{6}\left(\frac{\frac{1}{4}p_a\phi^{'}+\frac{1}{2}\frac{1}{\beta_1}p_b\phi^{'}+\frac{1}{4}\frac{\delta}{\sigma_{bc}}p_c\phi-\frac{1}{4}\delta}{\frac{1}{\beta_1}-\frac{1}{6}-\frac{1}{4}\frac{\delta}{\sigma_{bc}}}\right)}{\frac{1}{\beta_2} - \frac{49}{72}\frac{1}{\left(\frac{1}{\beta_1}-\frac{1}{6}-\frac{\delta}{4\sigma_{bc}}\right)} - \frac{\delta}{2\sigma_{ac}} - \frac{\delta}{2\sigma_{bc}} - \frac{1}{12}}$$

$$v_c^* \approx \frac{\frac{1}{4}p_a\phi^{'} + \frac{3}{2}p_c\phi^{'} - \delta}{2 - \frac{49}{72}\frac{1}{\left(2-\frac{1}{6}\right)} - \frac{1}{12}} + \frac{\frac{7}{6}\left(\frac{\frac{1}{4}p_a\phi^{'}+\frac{1}{2}\frac{1}{\beta_1}p_b\phi^{'}+\frac{1}{4}\frac{\delta}{\sigma_{bc}}p_c\phi-\frac{1}{4}\delta}{2-\frac{1}{6}}\right)}{2 - \frac{49}{72}\frac{1}{\left(2-\frac{1}{6}\right)} - \frac{1}{12}}$$

$$v_c^* \approx \frac{\frac{1}{4}p_a\phi^{'} + \frac{3}{2}p_c\phi^{'} - \delta}{2 - \frac{49}{12}\frac{1}{11} - \frac{1}{12}} + \frac{\frac{7}{11}\left(\frac{1}{4}p_a\phi^{'} + \frac{1}{2}2p_b\phi^{'} - \frac{1}{4}\delta\right)}{2 - \frac{49}{12}\frac{1}{11} - \frac{1}{12}}$$

$$v_c^* \approx \frac{\frac{1}{4}p_a\phi^{'} + \frac{3}{2}p_c\phi^{'} - \delta}{\frac{264}{132} - \frac{49}{132} - \frac{11}{132}} + \frac{\left(\frac{7}{11}\frac{1}{4}p_a\phi^{'} + \frac{7}{11}p_b\phi^{'} - \frac{7}{11}\frac{1}{4}\delta\right)}{\frac{264}{132} - \frac{49}{132} - \frac{11}{132}}$$

$$v_c^* \approx \frac{\frac{1}{4}p_a\phi^{'} + \frac{3}{2}p_c\phi^{'} - \delta + \frac{7}{44}p_a\phi^{'} + \frac{7}{11}p_b\phi^{'} - \frac{7}{44}\delta}{\frac{204}{132}}$$

$$v_c^* \approx \frac{\left(\frac{1}{4} + \frac{7}{44}\right)p_a\phi^{'} + \frac{7}{11}p_b\phi^{'} + \frac{3}{2}p_c\phi^{'} - \left(1 + \frac{7}{44}\right)\delta}{\frac{204}{132}}$$

$$v_c^* \approx \frac{\left(\frac{11}{44} + \frac{7}{44}\right)p_a\phi^{'} + \frac{7}{11}p_b\phi^{'} + \frac{3}{2}p_c\phi^{'} - \left(\frac{44}{44} + \frac{7}{44}\right)\delta}{\frac{204}{132}}$$

$$v_c^* \approx \frac{\frac{9}{22}p_a\phi^{'} + \frac{7}{11}p_b\phi^{'} + \frac{3}{2}p_c\phi^{'} - \frac{51}{44}\delta}{\frac{204}{132}}$$

$$v_c^* \approx \left(\frac{132}{204}\frac{9}{22}\right)p_a\phi^{'} + \frac{132}{204}\frac{7}{11}p_b\phi^{'} + \frac{132}{204}\frac{3}{2}p_c\phi^{'} - \frac{132}{204}\frac{51}{44}\delta$$

$$v_c^* \approx \left(\frac{6}{204}\frac{9}{1}\right)p_a\phi^{'} + \frac{12}{204}\frac{7}{1}p_b\phi^{'} + \frac{66}{204}\frac{3}{1}p_c\phi^{'} - \frac{3}{204}\frac{51}{1}\delta$$

$$v_c^* \approx \frac{54}{204}p_a\phi^{'} + \frac{84}{204}p_b\phi^{'} + \frac{198}{204}p_c\phi^{'} - \frac{153}{204}\delta$$

One can apply the same approximations under the no-poach agreements.

$$
\begin{aligned}
v_c^{np} &= \frac{\frac{1}{2}\frac{\delta}{2\sigma_{ac}+2\delta}\left(p_a\phi - \sigma_{ac}\right) + \frac{1}{2}\frac{\sigma_{ac}}{2\sigma_{ac}+2\delta}p_b\phi^{'} + \frac{1}{2}p_c\phi^{'}}{1 - \frac{1}{2}\frac{\delta}{2\sigma_{ac}+2\delta} - \frac{1}{2}\frac{\sigma_{ac}}{2\sigma_{ac}+2\delta}} \\
v_c^{np} &\approx \frac{\frac{1}{2}\frac{1}{2}p_b\phi^{'} + \frac{1}{2}p_c\phi^{'}}{1 - \frac{1}{2}\frac{1}{2}} \\
v_c^{np} &\approx \frac{\frac{1}{4}p_b\phi^{'} + \frac{1}{2}p_c\phi^{'}}{\frac{3}{4}} \\
v_c^{np} &\approx \frac{4}{3}\frac{1}{4}p_b\phi^{'} + \frac{4}{3}\frac{1}{2}p_c\phi^{'} \\
v_c^{np} &\approx \frac{1}{3}p_b\phi^{'} + \frac{2}{3}p_c\phi^{'}
\end{aligned}
$$

Conditional on simplifying assumptions, now one can compare firm C's poaching wage with and without the no-poach agreement. Notice $\frac{84}{204} > \frac{1}{3}$ and $\frac{198}{204} > \frac{2}{3}$. A sufficient condition for $v_c^* > v_c^{np}$ is then $\frac{54}{204}p_a\phi^{'} - \frac{153}{204}\delta > 0$. This will be satisfied provided $p_a\phi^{'}$is sufficiently large. I now adopt this assumption and maintain it hereafter. The poaching wage for firm C falls under the agreement.

Now one can compare poaching wages for firm B.

$$
\begin{aligned}
v_b^* &= \frac{\frac{1}{4}p_a\phi^{'} + \frac{1}{2\beta_1}p_b\phi^{'} + \frac{1}{4}\frac{\delta}{\sigma_{bc}}p_c\phi - \frac{1}{4}\delta}{\frac{1}{\beta_1} - \frac{1}{6} - \frac{\delta}{4\sigma_{bc}}} + \frac{\frac{7}{12}}{\frac{1}{\beta_1} - \frac{1}{6} - \frac{\delta}{4\sigma_{bc}}}v_c^* \\
v_b^* &\approx \frac{\frac{1}{4}p_a\phi^{'} + \frac{1}{2\beta_1}p_b\phi^{'} - \frac{1}{4}\delta}{2 - \frac{1}{6}} + \frac{\frac{7}{12}}{2 - \frac{1}{6}}v_c^* \\
v_b^* &\approx \frac{\frac{1}{4}p_a\phi^{'} + \frac{1}{2}2p_b\phi^{'} - \frac{1}{4}\delta}{\frac{11}{6}} + \frac{\frac{7}{12}}{\frac{11}{6}}v_c^* \\
v_b^* &\approx \frac{6}{11}\left(\frac{1}{4}p_a\phi^{'} + p_b\phi^{'} - \frac{1}{4}\delta\right) + \frac{6}{11}\frac{7}{12}v_c^* \\
v_b^* &\approx \frac{3}{11}\frac{1}{2}p_a\phi^{'} + \frac{6}{11}p_b\phi^{'} - \frac{3}{11}\frac{1}{2}\delta + \frac{1}{11}\frac{7}{2}v_c^* \\
v_b^* &\approx \frac{3}{22}p_a\phi^{'} + \frac{6}{11}p_b\phi^{'} - \frac{3}{22}\delta + \frac{7}{22}v_c^*
\end{aligned}
$$

One can compare to firm B's poaching wage under the no-poach agreements.

$$
v_b^{np} = \frac{1}{2}p_b\phi^{'} + \frac{1}{2}v_c^{np}
$$

Notice $\frac{6}{11} > \frac{1}{2}$. By the results above $v_c^* > v_{np}$, but $\frac{7}{22} < \frac{1}{2}$, so the effect of the terms involving $v_c$is ambiguous. As before there is a sufficient condition for $v_b^* > v_b^{np}$: $p_a\phi^{'}$ must be large relative to δ so that $\frac{3}{22}\left(p_a\phi' - \delta\right) > \frac{1}{2}v_c^{np} - \frac{7}{22}v_c^*$. Under this condition $v_b^* > v_b^{np}$; the poaching wage for firm B falls under the agreement.

Lastly one can compare poaching wages for firm A. The poaching wage v_a^* in the ordinary equilibrium requires no simplification. To facilitate comparison I substitute for v_b^* and v_c^*.

$$v_a^* = \frac{1}{2}p_a\phi' + \frac{1}{3}v_b^* + \frac{1}{6}v_c^*$$
$$v_a^* \approx \frac{1}{2}p_a\phi' + \frac{1}{3}\left(\frac{3}{22}p_a\phi' + \frac{6}{11}p_b\phi' - \frac{3}{22}\delta + \frac{7}{22}v_c^*\right) + \frac{1}{6}\left(\frac{54}{204}p_a\phi' + \frac{84}{204}p_b\phi' + \frac{198}{204}p_c\phi' - \frac{153}{204}\delta\right)$$
$$v_a^* \approx \frac{1}{2}p_a\phi' + \frac{1}{3}\frac{3}{22}p_a\phi' + \frac{1}{3}\frac{6}{11}p_b\phi' - \frac{1}{3}\frac{3}{22}\delta + \frac{1}{3}\frac{7}{22}v_c^* + \frac{1}{6}\frac{54}{204}p_a\phi' + \frac{1}{6}\frac{84}{204}p_b\phi' + \frac{1}{6}\frac{198}{204}p_c\phi' - \frac{1}{6}\frac{153}{204}\delta$$
$$v_a^* \approx \frac{1}{2}p_a\phi' + \frac{1}{22}p_a\phi' + \frac{2}{11}p_b\phi' - \frac{1}{22}\delta + \frac{7}{66}v_c^* + \frac{9}{204}p_a\phi' + \frac{14}{204}p_b\phi' + \frac{33}{204}p_c\phi' - \frac{153}{1224}\delta$$
$$v_a^* \approx \left(\frac{1}{2} + \frac{1}{22} + \frac{9}{204}\right)p_a\phi' + \left(\frac{2}{11} + \frac{14}{204}\right)p_b\phi' + \frac{33}{204}p_c\phi' + \frac{7}{66}v_c^* - \left(\frac{153}{1224} + \frac{1}{22}\right)\delta$$
$$v_a^* \approx .59p_a\phi' + .25p_b\phi' + .16p_c\phi' + \frac{7}{66}\left(\frac{54}{204}p_a\phi' + \frac{84}{204}p_b\phi' + \frac{198}{204}p_c\phi' - \frac{153}{204}\delta\right) - .17\delta$$
$$v_a^* \approx .59p_a\phi' + .25p_b\phi' + .16p_c\phi' + \left(.028p_a\phi' + .044p_b\phi' + .1p_c\phi' - .08\delta\right) - .17\delta$$
$$v_a^* \approx .62p_a\phi' + .29p_b\phi' + .26p_c\phi' - .25\delta$$

The poaching wage under the agreement can be simplified as before.

$$v_a^{np} = \frac{\frac{1}{2}p_a\phi' + \frac{1}{2}\frac{\sigma_{ac}}{2\sigma_{ac}+2\sigma_{ab}}\left(p_b\phi - \sigma_{ba}\right) + \frac{1}{2}\frac{\sigma_{ab}}{2\sigma_{ac}+2\sigma_{ab}}\left(p_c\phi - \sigma_{ac}\right)}{1 - \frac{1}{2}\left(\frac{\sigma_{ac}}{2\sigma_{ac}+2\sigma_{ab}} + \frac{\sigma_{ab}}{2\sigma_{ac}+2\sigma_{ab}}\right)}$$
$$v_a^{np} \approx \frac{\frac{1}{2}p_a\phi' + \frac{1}{2}\frac{1}{2}\frac{\sigma_{ac}}{\sigma_{ac}+\sigma_{ab}}\left(p_b\phi - \sigma_{ba}\right) + \frac{1}{2}\frac{1}{2}\frac{\sigma_{ab}}{\sigma_{ac}+\sigma_{ab}}\left(p_c\phi - \sigma_{ac}\right)}{1 - \frac{1}{2}\left(\frac{\sigma_{ac}}{\sigma_{ac}+\sigma_{ab}} + \frac{\sigma_{ab}}{\sigma_{ac}+\sigma_{ab}}\right)}$$

I previously assumed $\sigma_{ba} - \sigma_{ac} = \sigma_{ac} - \sigma_{bc} \equiv \delta$ is small relative to both σ_{ac} and σ_{ab}. Then

$\sigma_{ac} + \sigma_{ab} = \sigma_{ac} + (\delta + \sigma_{ac}) \approx 2\sigma_{ac}$ and $\sigma_{ac} + \sigma_{ab} = (\sigma_{ab} - \delta) + \sigma_{ab} \approx 2\sigma_{ab}$.

$$v_a^{np} \approx \frac{\frac{1}{2}p_a\phi' + \frac{1}{4}\frac{1}{2}\left(p_b\phi - \sigma_{ba}\right) + \frac{1}{4}\frac{1}{2}\left(p_c\phi - \sigma_{ac}\right)}{1 - \frac{1}{2}\left(\frac{1}{2} + \frac{1}{2}\right)}$$

$$v_a^{np} \approx \frac{\frac{1}{2}p_a\phi' + \frac{1}{8}\left(p_b\phi - \sigma_{ba}\right) + \frac{1}{8}\left(p_c\phi - \sigma_{ac}\right)}{\frac{1}{2}}$$

$$v_a^{np} \approx 2\left(\frac{1}{2}p_a\phi' + \frac{1}{8}\left(p_b\phi - \sigma_{ba}\right) + \frac{1}{8}\left(p_c\phi - \sigma_{ac}\right)\right)$$

$$v_a^{np} \approx p_a\phi' + \frac{1}{4}\left(p_b\phi - \sigma_{ba}\right) + \frac{1}{4}\left(p_c\phi - \sigma_{ac}\right)$$

$$v_a^{np} \approx p_a\phi' + \frac{1}{4}p_b\phi + \frac{1}{4}p_c\phi - \frac{1}{4}\left(\sigma_{ba} + \sigma_{ac}\right)$$

One can see the effect on firm A's poaching wage is ambiguous. If switching is strongly productivity-reducing ($\phi' \ll \phi$) or switching costs $\sigma_{ba} + \sigma_{ac}$ are large relative to productivity gains, then $v_a^{np} < v_a^*$. I adopt and maintain this assumption. While equilibria with $v_a^{np} > v_a^*$ are possible, they feature increased loyalty wages at firms B and C (see below), inconsistent with the empirical setting under study.

G.2 Loyalty wages

The loyalty wages at firm C are $w_c^* = \frac{1}{2}p_c\phi + \frac{1}{2}v_b^* - \frac{1}{2}\sigma_{bc}$ and $w_c^{np} = \frac{1}{2}p_c\phi + \frac{1}{2}v_a^{np} - \frac{1}{2}\sigma_{ac}$. Under the assumption that differences in switching costs are small, the comparison hinges on the terms $\frac{1}{2}v_b^*$ and $\frac{1}{2}v_a^{np}$. From above, $v_b^* \approx \frac{3}{22}p_a\phi' + \frac{6}{11}p_b\phi' - \frac{3}{22}\delta + \frac{7}{22}v_c^* \approx \frac{3}{22}p_a\phi' + \frac{6}{11}p_b\phi' - \frac{3}{22}\delta + \frac{7}{22}\left(\frac{54}{204}p_a\phi' + \frac{84}{204}p_b\phi' + \frac{198}{204}p_c\phi' - \frac{153}{204}\delta\right) \approx$ and $v_a^{np} \approx p_a\phi' + \frac{1}{4}p_b\phi + \frac{1}{4}p_c\phi - \frac{1}{4}\left(\sigma_{ba} + \sigma_{ac}\right)$. Under the previous assumptions on productivity and switching costs, $w_c^{np} < w_c^*$.

Analysis of loyalty wages at firm B, $w_b^* = \frac{1}{2}p_b\phi + \frac{1}{2}v_c^* - \frac{1}{2}\sigma_{bc}$ and $w_b^{np} = \frac{1}{2}p_b\phi + \frac{1}{2}v_a^{np} - \frac{1}{2}\sigma_{ba}$, is similar. The comparison hinges on $\frac{1}{2}v_c^*$ and $\frac{1}{2}v_a^{np}$. Under the previous assumptions on productivity and switching costs, $w_b^{np} < w_b^*$.

For firm A the comparison of loyalty wages ($w_a^* = \frac{1}{2}p_a\phi + \frac{1}{2}v_c^* - \frac{1}{2}\sigma_{ac}$ and $w_a^{np} = \frac{1}{2}p_a\phi + \frac{1}{2}v_c^{np} - \frac{1}{2}\sigma_{ac}$) is straightforward. From $v_c^* > v_c^{np}$, it follows that $w_a^* > w_a^{np}$.