Monopsony in Movers: The Elasticity of Labor Supply to Firm Wage Policies

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Online Appendix

A Additional Tables and Figures

Table A1: **Relationship between AKM Wage components and separations**

	(1)	(2)		(3)		
	Firm	Firm	Worker	Firm	Worker	Match
All separations	-1.342	-0.739	-0.641	-0.746	-0.636	-3.279
	(0.085)	(0.078)	(0.016)	(0.078)	(0.016)	(0.04)
E-E separations	-1.677	-1.005	-0.762	-1.019	-0.753	-4.867
	(0.127)	(0.118)	(0.023)	(0.117)	(0.023)	(0.069)
E-N separations	-1.209	-0.605	-0.595	-0.613	-0.59	-3.103
	(0.075)	(0.07)	(0.014)	(0.07)	(0.014)	(0.053)
E-E recruits	0.413	0.423	-0.058	0.421	-0.056	0.238
	(0.059)	(0.05)	(0.013)	(0.05)	(0.013)	(0.009)
Pct. EE-recruits	0.464	0.482	0.482	0.482	0.482	0.482
Labor Supply Elasticity	2.69	1.38	1.496	1.407	1.479	8.582
	(0.199)	(0.185)	(0.038)	(0.184)	(0.038)	(0.106)
Obs (millions)	69.072	68.598			68.598	
Regressors						
Firm FE	Y	Y	Y	Y	Y	Y
Worker FE		Y	Y	Y	Y	Y
Match FE				Y	Y	Y

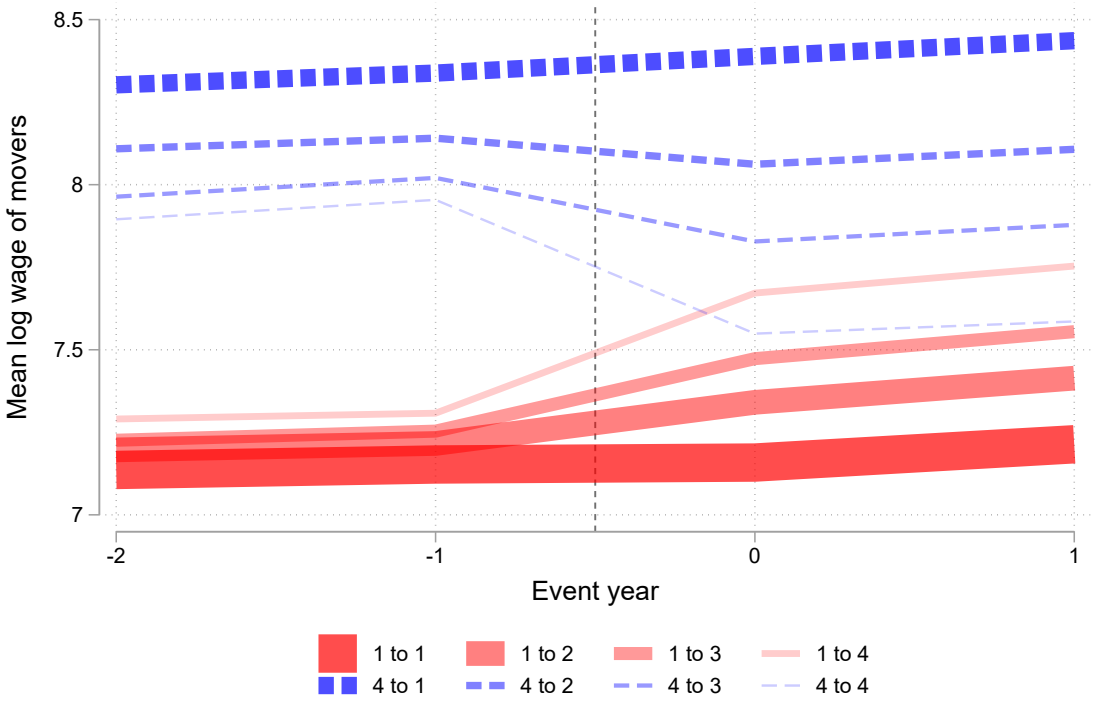
Note: Each supercolumn row indicates a single regression. Specification 1 is reproduced for comparison as the linear specification using the AKM firm fixed effect. Specification 2 adds the AKM worker fixed effect as a regressor. Specification 3 adds the match effect, which is calculated as the average residual per worker-firm match, where the residual is the hourly wage minus the AKM firm and worker fixed effects. Fixed effects are trimmed at their 2.5% tails – see text for sample construction.

Table A2: **Supplementary estimates for AKM firm wage and separations**

	(1)	(2)	(3)
All separations	-1.342	-1.19	-2.059
	(0.085)	(0.076)	(0.095)
E-E separations	-1.677	-1.53	-2.565
	(0.127)	(0.116)	(0.136)
E-N separations	-1.209	-1.016	-1.843
	(0.075)	(0.064)	(0.096)
E-E recruits	0.413	0.353	0.351
	(0.059)	(0.053)	(0.064)
Pct. EE-recruits	0.464	0.482	0.464
Labor Supply Elasticity	2.69	2.441	4.392
	(0.199)	(0.183)	(0.216)
Obs (millions)	69.072	68.598	69.072
BLM			Y
F-stat			270
Firm FE from			
Main sample	Y		Y
CCK		Y	

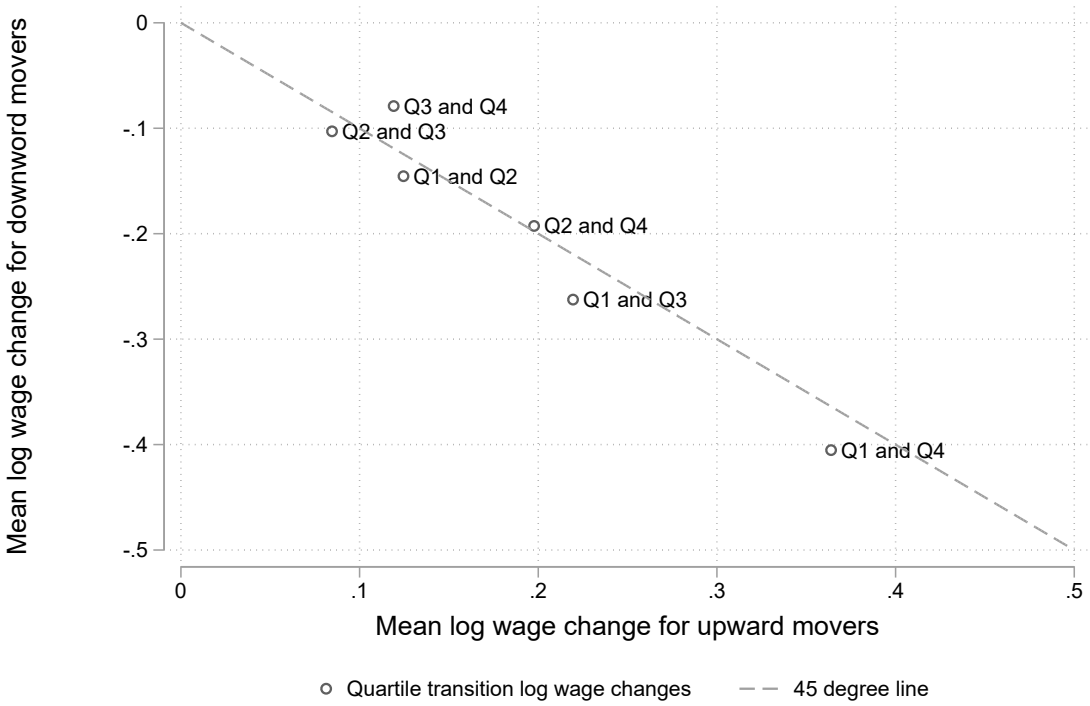
Note: Specification 1 reproduces the AKM linear specification for comparison. Specification 2 uses the firm effects estimated using code from Card, Cardoso and Kline (2016). Specification 3 uses the BLM firm deciles as instruments, based on the procedure described in Bonhomme, Lamadon and Manresa (2019). Fixed effects are trimmed at their 2.5% tails – see text for sample construction.

Figure A1: **Changes in hourly wages and incidence of job separations for quartile-to-quartile transitions**



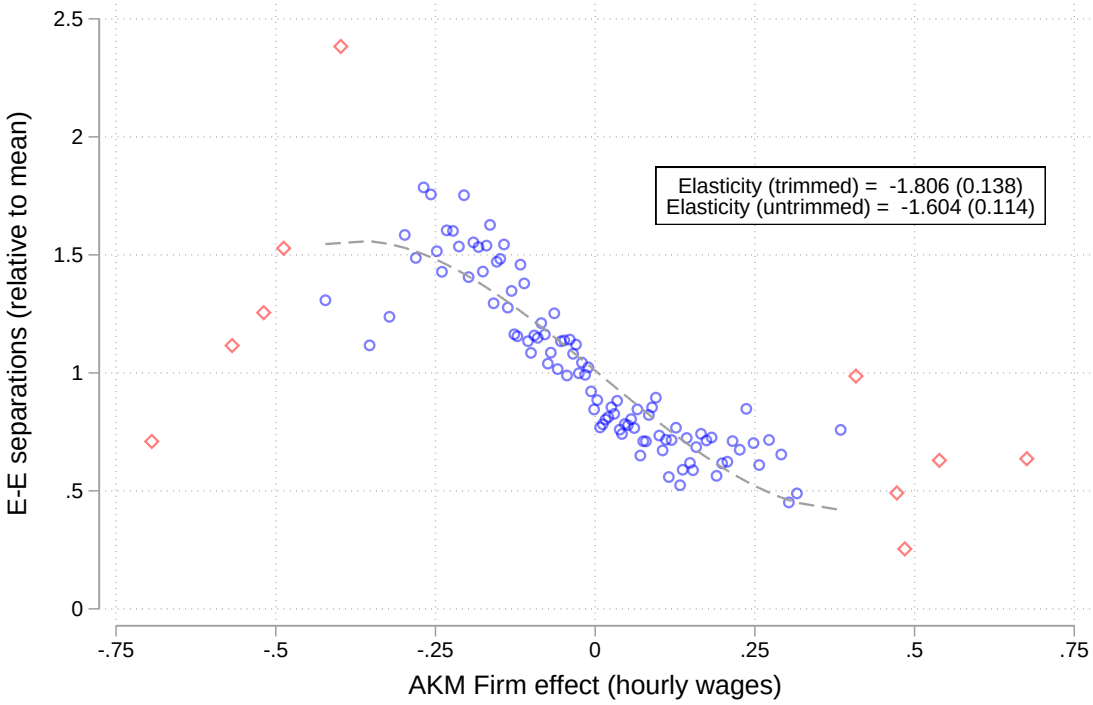
Note: The legend indicates origin quartile to destination quartile, where quartiles are defined along the distribution of the average firm wage, using only workers who stay at the firm over the period. The change in wage is shown for movers, who are defined as workers who make a job-to-job transition at any point over the period and are observed for at least 9 consecutive quarters at the same firm before and after. The quarter of separation and the following quarter are omitted since these represent quarters that were partially worked, and are particularly susceptible to measurement error in wages. This exercise is repeated for each 6-year period (2000-2005, 2006-2011 and 2012-2017), the mover wage profiles are stacked, and the averages of the event quarter by quartile-transition categories are plotted. The thickness of the lines is proportional to the number of job-to-job separations between the relevant quartiles over the full panel 2000-2017 (not restricting by tenure). Low quartile firms have much higher job-to-job separation rates as indicated by the thickness of the linesthan the high quartile firms. Moreover, the flows are not symmetric: more workers move from low to high wage quartiles (red solid lines) than vice versa (blue dashed lines), which is consistent with high quartile firms being higher rent jobs. The asymmetric flows across quartiles capture the separations elasticity; increases in wages have more separations than decreases in wages. This figure shows simultaneously the lack of wage changes prior to a move (flat pre-move trends), the effects firms have on wages (the magnitude of an individual wage change after a move) and that the volume of flows between firms are correlated with those effects (the thickness of the lines). Together this suggests that firm wage policies may be identifiable from switchers, even as they influence the direction and volume of switching.

Figure A2: **Symmetry plot of log wage changes for quartile-to-quartile transitions**



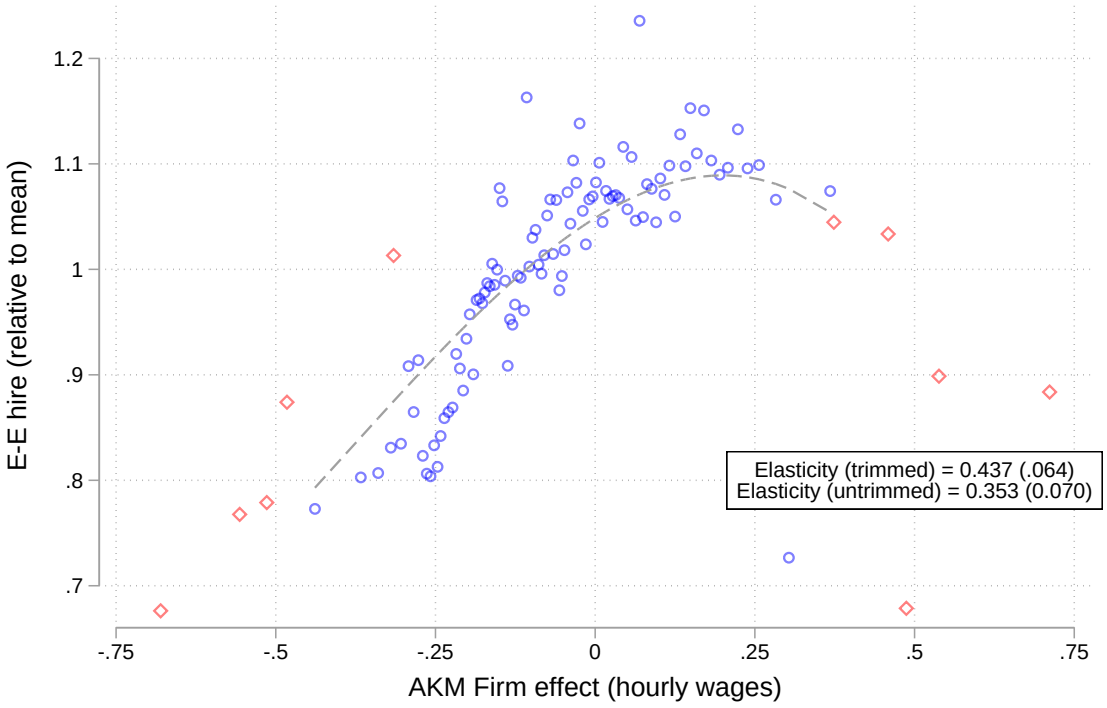
Note: The figure shows the quartile to quartile log wage changes corresponding to the quartile transition event study above. Upward mover indicates that the worker moved from a lower quartile to a higher quartile; downward mover indicates the worker moved to a higher quartile. For example, the point labelled 'Q1 and Q4' shows the average log wage change for movers from quartile 1 to quartile 4 on the horizontal axis, and for movers from quartile 4 to quartile 1 on the vertical axis. The dotted line shows the 45 degree (negative) slope from the origin: symmetric downward and upward log wage changes would lie on this line.

Figure A3: **Job-to-job separations and firm wage effects**



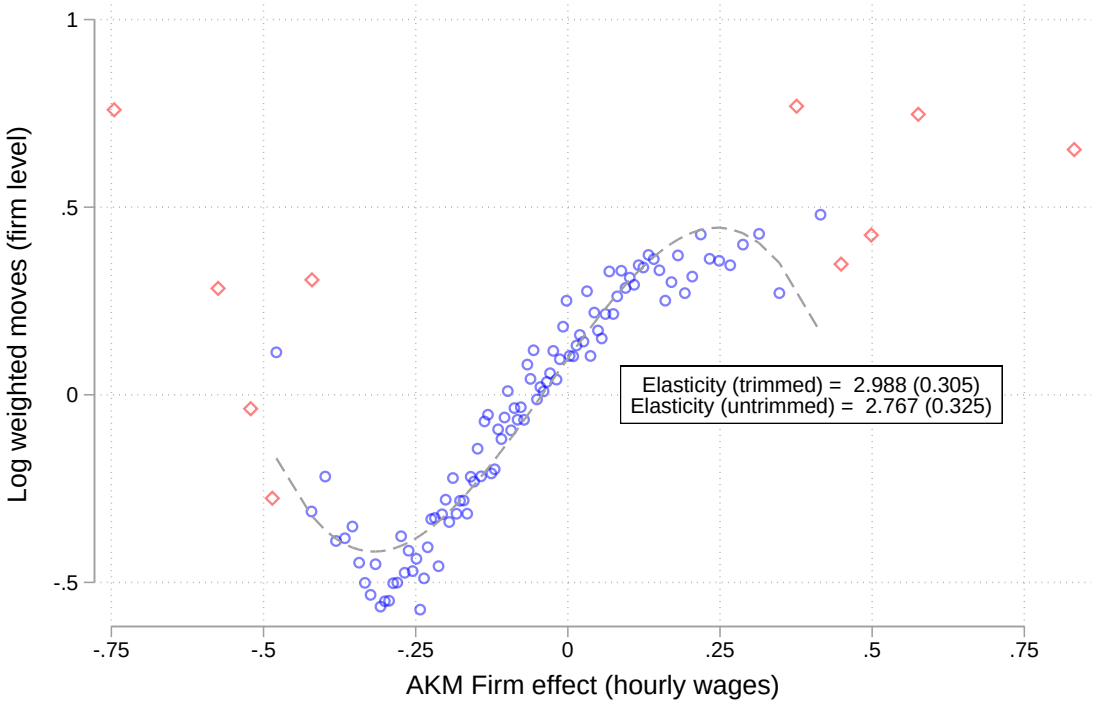
Note: The figure illustrates the split sample approach using a control function. Residuals are calculated from a regression of own-sample firm effects on the complement-sample firm effects, and used as a control in a regression of E-E separations on own-sample firm effects. The plotted points show the binned scatter points of this latter regression (i.e. depicting the partial correlation). The vertical axis is E-E separations divided by mean E-E separations such that the slope of the line represents the elasticity. The blue points represent quantiles of the trimmed sample, which excludes the top and bottom 2.5 percent of the firm effects distribution. The red points represent quantiles of the excluded sample only, which we consider outliers. The trendline is a cubic polynomial fitted to the trimmed sample.

Figure A4: **Job-to-job hires and firm wage effects**



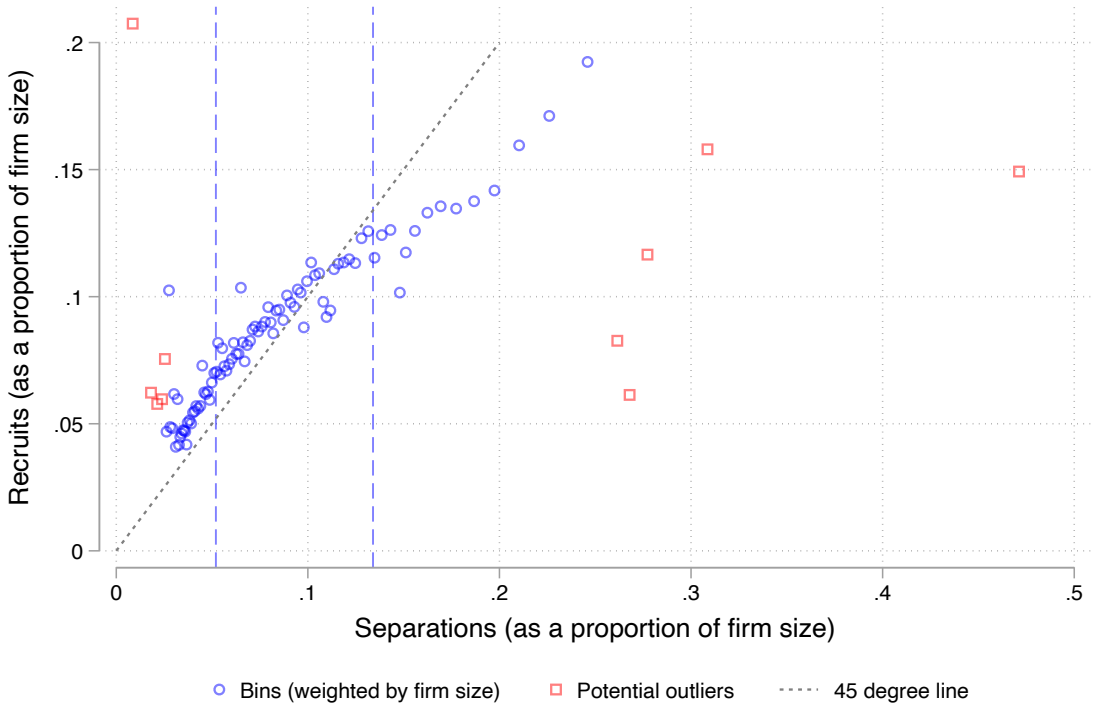
Note: The figure illustrates the split sample approach using a control function. The plotted points show the E-E hires against own-sample AKM firm effects, while controlling for the residuals from a regression of own-sample firm effects on the complement-sample firm effects. The sample is restricted to observations corresponding to hires. The vertical axis is E-E hires divided by mean E-E hires such that the slope of the line represents the elasticity. The blue points represent quantiles of the trimmed sample, which excludes the top and bottom 2.5 percent of the firm effects distribution. The red points represent quantiles of the excluded sample only, which we consider outliers. The trendline is a cubic polynomial fitted to the trimmed sample.

Figure A5: **Labor supply elasticity and firm wage effects**



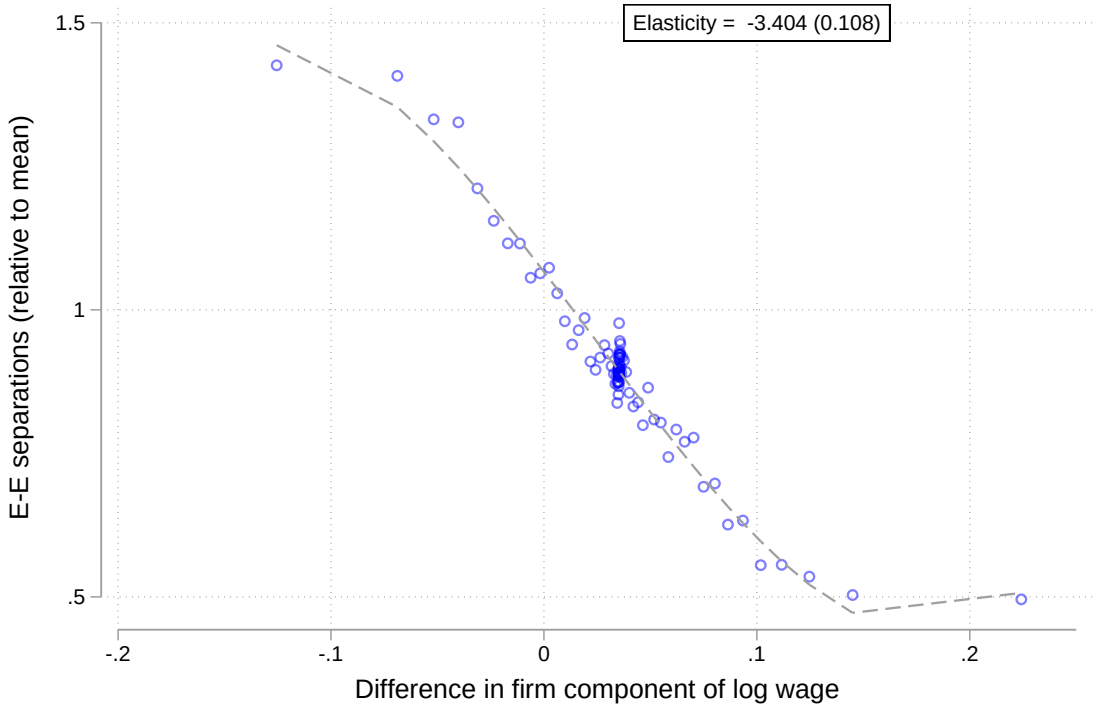
Note: The figure illustrates the split sample approach using a control function, for the labor supply elasticity estimated at the firm (not worker) level. The plotted points show the weighted average of log firm E-E separations, log firm E-N separations and log firm E-E hires against the AKM firm wage effects. The residuals from a regression of own-sample firm effects on the complement-sample firm effects are controlled for. The slope of the line represents the labor supply elasticity, where the reported coefficient corresponds to the fitted bins. The sample is restricted to the trimmed sample, which excludes the top and bottom 2.5 percent of the firm effects distribution. The trendline is a cubic polynomial fitted to the trimmed sample. Points are plotted at the firm level and weighted by firm size.

Figure A6: **Firm separations versus recruits**



Note: The data is plotted at the firm level, with quarterly separations and recruits calculated as a proportion of firm size by firm for each 6 year period. Points are plotted at the firm level and weighted by firm size. Firms are classified as outliers in this figure if they are in the top or bottom 5% tails of the firm separations distribution. The 45 degree line from the origin indicates equal separations and recruits. The dashed vertical lines indicate the interquartile range (p25 and p75 of the separations rate).

Figure A7: **Job-to-job re-separations and wages**



Note: The plotted points are restricted to the first 16 quarters after initial separation from the origin firm. The vertical axis indicates the probability of E-E separation from the intermediate firm, divided by the average E-E separations. The figure shows the instrumental variables relationship between E-E separations and change in log own wage, using a control function, i.e. controlling for the residuals from a regression of change in log own wage on change in log firm wage. The specification includes fixed effects for interacted calendar time by origin firm by worker tenure at origin firm (8 bins) by initial wage at the origin firm (8 bins), and are clustered at the level of origin firm by calendar time. See text for sample construction.

B Data

This is supplementary material to the data description in the main text. Our data sample covers the period 2000-2017. Oregon experienced recessions in 2001-2002 and 2008-2009 along with the rest of the country: the 2008 recession features prominently with a sharp rise in the unemployment rate and an ensuing decline in the labor force participation rate (see figure B1). We explain in detail the construction of the main sample, present summary statistics, and plot the inequality trends in Oregon using our administrative hourly wage data.

The primary variables in the data by quarterly record are the calendar quarter date, the worker identifier unique to each worker, the firm identifier (where each firm identifier may be associated with multiple establishments within Oregon), number of hours worked in the quarter, the total earnings paid to the worker for the quarter. We also observe the industry of the worker (recorded as a NAICS code), and the location (recorded as the FIPS code)[1], though these are only used for heterogeneity estimates and controls for some robustness checks.

B.1 Sample Construction

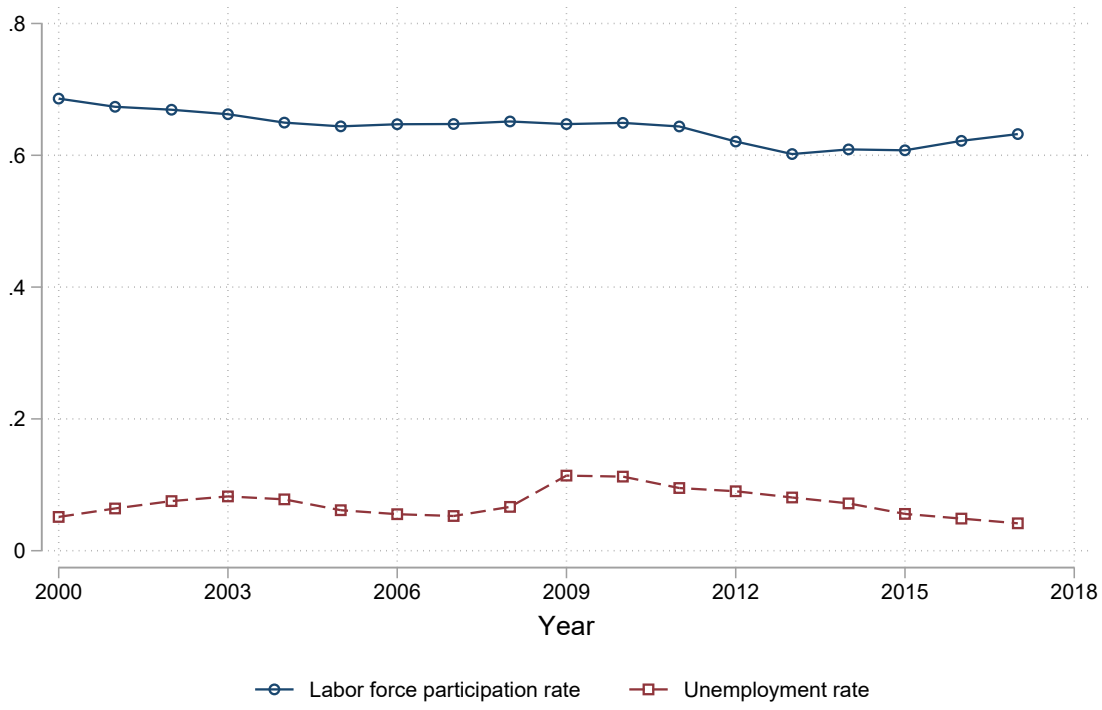
The data were cleaned in the following order, with corresponding summary statistics shown in table 1. We attempt to follow the literature using matched employer-employee data as exemplified by **card2013workplace**; **lachowska2020firm**; **lamadon2019imperfect**; **song2018firming**; **sorkin2018ranking**.

1. We begin with records which are uniquely identified by worker-firm-quarter from 2000 quarter 1 to 2017 quarter 4.[2] 136 million such observations exist,

[1] The county of many workers is missing for a large proportion of the records; additionally due to data limitations restricting the link between specific establishments and workers, the Portland metro zone estimates allocate workers to a zone if at least 90 percent of the employees of their firm are working in a single zone.

[2] Although we have access to 1998 and 1999, we discard these years because the wage distributions

Figure B1: **Oregon employment, 2000-2017**



Note: Data from the monthly CPS for Oregon, for the years 2000-2017 using individual population weights.

corresponding to 317,000 different firms, and 5.3 million workers.

2. We define an employment spell as a group of consecutive quarters for the same worker and firm identifiers.[3] Note that the separations variable, which is important for our main analysis, is defined at this point: separation is equal to one at the end of any employment spell, and Employment to Employment (E-E) separation is equal to 1 if separation is 1 and the worker is employed at another firm in the current or following quarter. Similarly, hire is equal to one at the start of any spell, and E-E hire is equal to 1 if hire is 1 and the worker

in these years are implausibly different from the rest of the panel (or corresponding years from other data sources). This likely reflect problems associated with the first years of data collection.

[3] A firm identifier may correspond to several distinct branches within the same firm.

is employed at another firm in the current or previous quarter. Employment to Non-Employment (N-E) moves are the complement to E-E moves: N-E separations are separations that are not E-E separations, and E-E hires are hires that are not E-E hires. We set wages to missing at the beginning and end of any spell, so as to keep comparability of full-quarter wages and avoid severe measurement error in hours due to partial quarters.

3. We drop entire employment spells with

   (a) Less than 100 hours per quarter on average over the employment spell, which is equivalent to less than 8 hours per week. This helps to exclude extremely irregular part time work, and is similar to one of the few other studies that observe hourly wages: **lachowska2020firm** drop workers who workers fewer than 400 hours in the year. The number of observations decrease from 136 to 120 million.

   (b) Hourly wage less than $2 (in 2017 dollars) in any quarter over the employment spell, because it is difficult to imagine a reason this may apply to a regular worker aside from measurement error – this only drops 1 million observations. This restriction is similar to **lachowska2020firm** who drop workers with hourly wages below $2 (2005 dollars). **card2013workplace**; **lachowska2020firm**; **sorkin2018ranking** drop workers with annual earnings below about $3,000, which for a 40-hour workweek corresponds to $1.50 per hour (both well below the federal minimum wage). **song2018firming** restricts to workers earning the equivalent of minimum wage for 40 hours per week over 13 weeks, and **lamadon2019imperfect** restrict to workers earnings $15,000 per year.

   (c) Fewer than 3 quarters in length, which drops an additional 9 million ob-

servations. This ensures that there is at least one full quarter observation (aside from hiring and separation quarters), giving at least one reliable hourly wage per worker-firm match, which is essential for our analysis. In a similar vein, **sorkin2018ranking** restricts to at least 2 quarters.

4. We then convert to a worker panel. For any worker-quarter, we keep the observation which belongs to the spell with the highest ave earnings – this corresponds to a dominant employer and keeps spells intact. Note that a separation is still counted if a worker's spell was cut off. **lamadon2019imperfect**; **card2013workplace**; **song2018firming**; **sorkin2018ranking** share this restriction of selecting the highest earning observation for a worker-quarter. We further exclude workers with more than 9 different employers in any year, following **lachowska2020firm**.

5. By 6-year panel (2000-2005, 2006-2011 and 2012-2017), we drop firms with fewer than 20 workers in any year or firms classified as public administration. **song2018firming** restrict to firms with at least 20 employees per year, and **sorkin2018ranking** chooses a threshold of 15 workers per year. Our large sample restriction is motivated by the estimation of the AKM firm effects, which requires a sufficient number of observations per firm.

Quarterly and hourly wages are each winsorized at the 1st and 99th percentiles to reduce noise from outliers. A limitation shared by most papers with matched employer-employee data is that we cannot distinguish between E-E and E-N moves for workers that move out of state. We also do not observe any non-wage worker characteristics: for example, we do not observe age, so cannot restrict to workers aged 20-60 as in comparable studies (**card2013workplace**; **song2018firming**). We do observe firm industry and location (county level), which we use for heterogeneity in the analysis.

B.2 Summary Statistics of Data

Broadly, our main sample is a quarterly worker-level panel restricted to large private sector firms in Oregon over 2000-2017 (see table B1). In total, we have 87.6 million observations, consisting of 3.4 million workers and 55,000 firms. Compared to the full universe of observations, our main sample has about two-thirds of all workers, and less than one-fifth of the firms (mainly due to the firm size restriction). Average annual worker earnings and weekly hours are substantially higher, again mainly due to the firm size restriction together with the wage-size correlation. The exclusion of short employment spells decreases the separations rate by about half, as well as the number of firms per worker. In our main sample, the mean separation rate is 8% per quarter, with about half of hires directly from other firms.[4]

The AKM analysis is implemented on the connected set of firms, which for this quarterly panel only exclude a few thousand observations. The full panel is divided into 6-year periods, with an AKM regression run on each 6 year panel and its constituent split samples. We observe more than one firm for 40% of worker within each 6-year panel, which facilitates the AKM estimation off movers in the sample. The sample statistics are broadly similar across the panels, with a slight increase in real earnings over time. Employment-Employment hires are lowest in the middle panel, which includes the 2008 recession.

As explained in the main text, the main worker-quarter panel is used to extract a matched event study panel. All Employment-Employment separations in the main worker-quarter panel are identified, an event-window around each E-E separation is isolated (9 pre-separation and 17 post-separation), and all such event-windows are stacked. The firm before the E-E separation is the Origin firm, the firm after the E-E separation is the Intermediate firm, and the firm after that (to which the worker

[4]The quarterly separation rate is 17% before sample restrictions, which is similar to the separation rate of 0.15 reported by **webber2015firm** using the LEHD.

Table B1: **Sample statistics for Oregon 2000-2017**

	Obs (total, millions)	Workers (total, millions)	Firms (total)	Earnings (mean, annual)	Hours (mean, weekly)	No. firms per worker (mean)	Separations (mean, quarterly)	E-E hire (mean, quarterly)
Period: 2000-2017								
All	136	5.3	316,910	27,169	27.49	5.71	16.6%	31.4%
Hours¡100	120	4.7	302,541	29,636	30.54	4.13	12.1%	33.1%
wage¿2	119	4.7	301,997	29,719	30.55	4.13	12.1%	33.1%
Spell¿2	110	3.7	249,034	32,057	31.53	2.95	7.6%	35.2%
Priv. large	87.6	3.4	54,663	44,103	32.44	2.53	7.7%	46.9%
Connected	87.6	3.4	54,580	44,101	32.44	2.53	7.7%	46.9%
Period: 2000-2005								
All	27.5	2.1	31,429	42,147	32.66	1.60	8.1%	48.5%
Split 1	13.7	1.0	31,410	42,136	32.66	1.60	8.1%	48.5%
Split 2	13.8	1.0	31,407	42,157	32.66	1.60	8.1%	48.5%
Period: 2006-2011								
All	29.1	2.1	31,788	44,975	32.33	1.55	7.5%	45.2%
Split 1	14.5	1.0	31,772	44,968	32.33	1.55	7.5%	45.1%
Split 2	14.6	1.0	31,772	44,982	32.33	1.55	7.5%	45.2%
Period: 2012-2017								
All	30.9	2.2	32,913	45,023	32.35	1.58	7.6%	46.9%
Split 1	15.5	1.1	32,898	44,993	32.35	1.58	7.6%	46.9%
Split 2	15.5	1.1	32,892	45,053	32.35	1.58	7.6%	46.9%

Note: The first three columns indicate totals (observations and workers are in millions) and other columns indicate means. "No. of firms" refers to the average number of firms a worker is at over the full corresponding period (either 6-year panel or full 18 year panel). Separations and E-E hire (proportion of hires from employment) are given in percentage terms. Earnings are in real dollars adjusted to 2017 using the Portland CPI. The top rows show the consecutive exclusion of employment spells based on hours (less than 100 hours per quarter on average), then wage (spell with any quarter less than $2 wage), then spell length (less than 3 quarters). Priv. large indicates firms with more than 20 workers and not in public administration. All summary statistics for the 6-year panels refer to the corresponding 6-year panel connected set with the full set of sample restrictions.

're-separates') is the Final firm.

We additionally restrict to workers who were at the Origin firm for at least 4 quarters (whereas in the main worker-quarter panel, spells of 3 quarters are admitted), such that there are at least 2 full quarters of wage observations. This facilitates the main specification which conditions on the initial and end wages at Origin (end wage enters through the transition wage difference with the Intermediate firm). To reduce the impact of outliers, we winsorize the 1% top and bottom tails of the change in own log wage at transition between Origin and Intermediate firms. While the main worker-quarter panel is from 2000 to 2017, note that the 8-quarter pre-transition and 16-quarter post-transition windows imply that the period of admissible transitions between Origin and Intermediate is actually from 2002 to 2013.

Sample statistics for this matched event study panel are presented in table B2. The full sample has nearly 900,000 initial E-E separations, each with an associated event-window, corresponding to just under 700,000 workers and 30,000 Origin firms. There are 175,000 unique Origin firm by calendar quarter 'events', with an average of 245 workers each. These workers move out to more intermediate firms (about 40,000). Earnings are roughly similar to the main worker-quarter panel, and hours are slightly higher. Although we use a 16 quarter post window, just over a third of the initial E-E separations end up re-separating to a final firm. These workers have lower average earnings. Note that tenure in table B2 is censored 16 quarters post event.

The main estimation specification includes fixed effects for Origin firm by calendar quarter by worker tenure at Origin (8 categories) by wage at hire at Origin (8 categories). The estimable sample is substantially smaller, as it requires sufficient observations in every interacted fixed effects cell (see panel B). About 40% of the initial E-E separations survive, corresponding to 4,000 Origin firms and 21,000 Origin firm quarter events. Over 10,000 Intermediate firms are in this main estimation

Table B2: **Sample statistics for matched event study panel**

	Obs (total)	Workers (total)	Firms (total)	Events (total)	Workers per event (mean)	Earnings (mean, annual)	Hours (mean, weekly)	Tenure (mean, censored)
Panel A: Full sample								
Origin firm	872228	663279	27869	173257	245	42852	33.67	6.1
Intermediate firm	872228	663279	38522			44331	35.04	8.6
Final firm	313019	204549	23319			39944	35.04	5.0
Panel B: Main estimation sample								
Origin firm	346261	259415	4011	20771	527	43871	34.25	6.0
Intermediate firm	346261	259306	10215			45574	35.45	8.8
Final firm	117765	75964	7674			39581	34.93	5.0

Note: All employment-employment separations in the main worker-quarter panel are identified, an event-window isolated (8 pre-separation and 16 post-separation), and stacked. The first four columns indicate totals and other columns indicate means. 'Events' refers to the total number of origin firm-quarters within which workers are compared. Earnings are annualized from quarterly earnings tenure for the origin firm is censored at 8 quarters; and for both the intermediate and final firm are censored at 16 quarters after initial separation. Main estimation sample indicates the estimable sample for the main specification, which includes firm by calendar quarter by tenure (8 categories) by wage at hire (8 categories), all for the origin firm.

sample. As for the full sample, about a third of these initial E-E separations end up re-separating to a final firm.

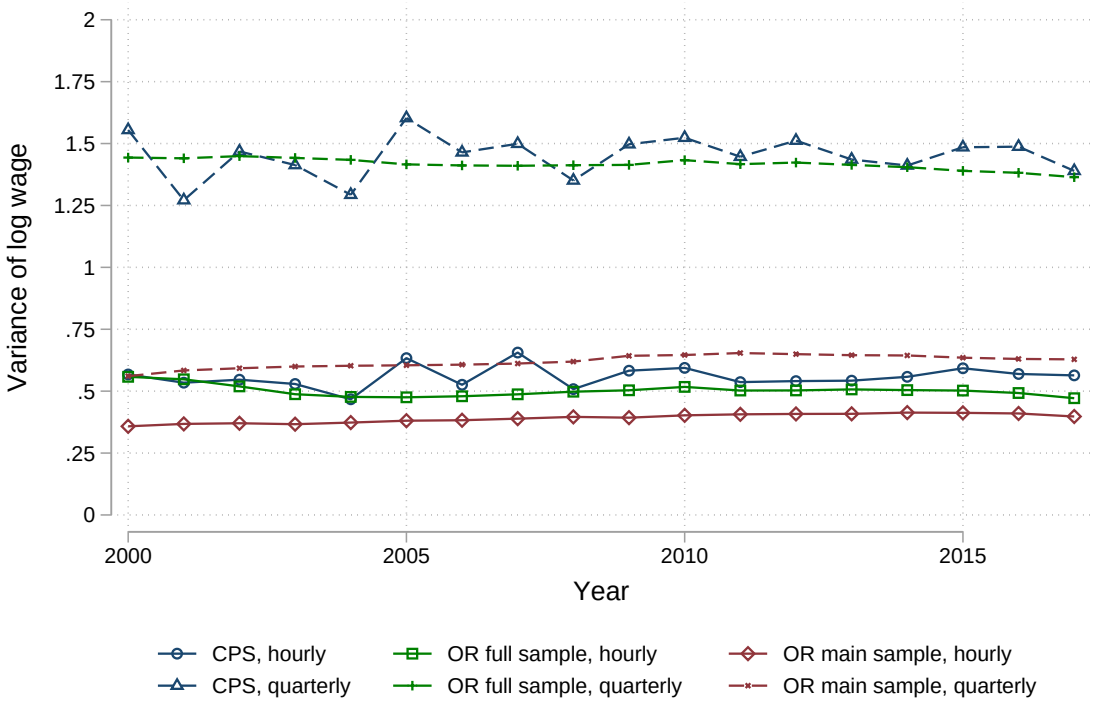
B.3 Inequality Trends

During the 2000-2017 period, the variance in log hourly wages was mostly stable (figure B2). This pattern is similar when we consider hourly or quarterly earnings, and when we consider CPS data or the full universe of workers in our sample. Our main estimation sample (full quarter observations at large firms, as described in the data section) shows a slight increase in log variance. Figure B2 shows that the level of the variance is similar using CPS survey data or the full universe of our records, about 1.5 for log quarterly earnings and 0.5 for log hourly wage. The level of variance for our main sample is much smaller for log quarterly earnings, as expected from the

restrictions on part time work (low hours and short spells), and slightly smaller for log hourly wages.

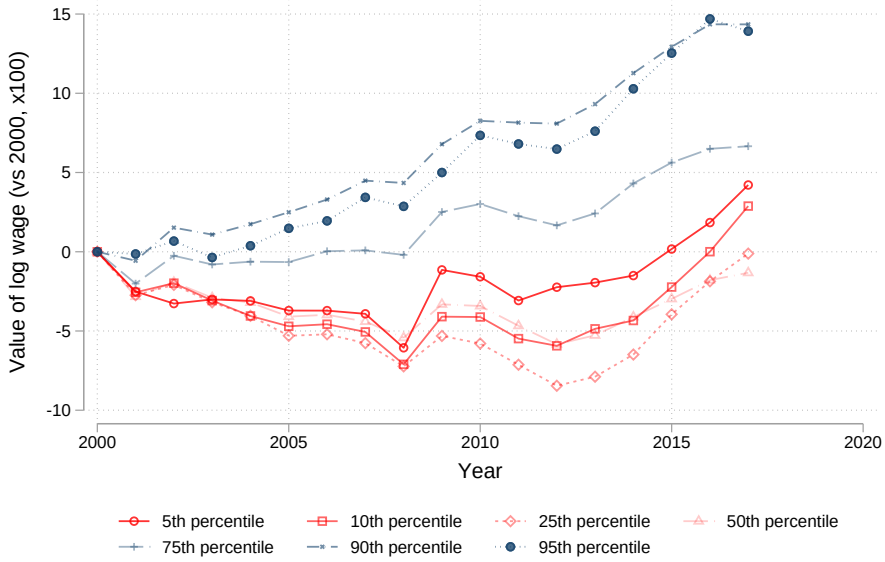
The overall variance of log wages masks considerable heterogeneity in trends by wage percentile, as shown in Figure B3 (using the full universe of observations). During this period, the largest growth in hourly wages occurred at the top (e.g., 95th percentile and 90th percentiles), while the real wage fell on net at the middle (50th percentile). However, during the same time wages rose at the bottom (5th and 10th percentiles), in part likely due to Oregon's minimum wage policies. Overall, hourly wage inequality grew in the upper half of the distribution, mirroring other states (**lachowska2020firm**), even while inequality fell in the bottom half. The patterns are qualitatively similar when we consider quarterly earnings instead; however, the 90-50 gap in earnings grew somewhat more than the equivalent gap in hourly wages over this period.

Figure B2: **Oregon wage variance, CPS versus UI data**

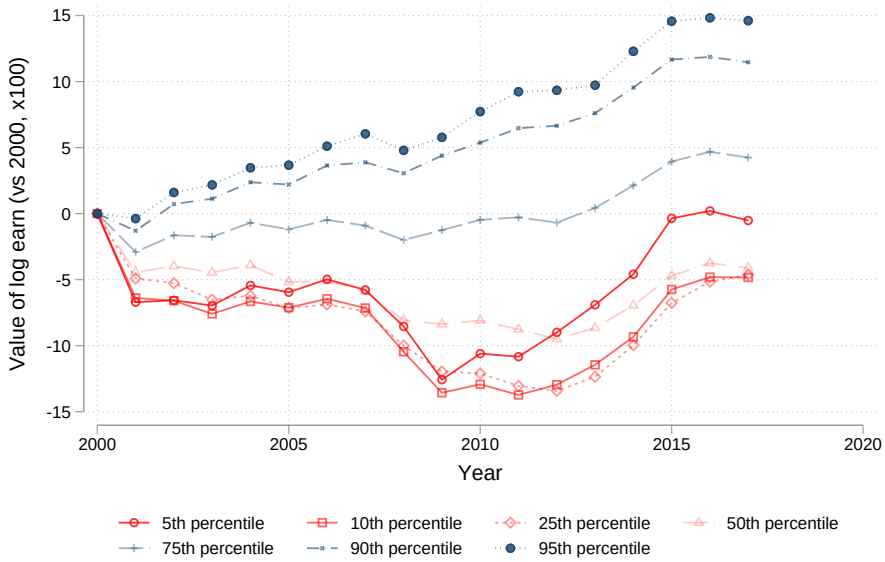


Note: OR indicates our Oregon unemployment insurance data, and CPS indicates CPS-ORG data for Oregon weighted by the population weight that is provided. The CPS and OR full samples include all workers (any firm size), while the OR main sample is used for our main analysis and is described in our data section in text. For CPS, the quarterly wage variable is total income from salary and wages for each survey respondent over the year divided by 4, and hourly wages is further divided by a variable for the usual number of hours worked in a week (multiplied by 13). Wages are deflated to base year 2017 using Portland CPI.

Figure B3: **Oregon wage percentile trends**



(a) Hourly wages



(b) Quarterly earnings

Note: Earnings are in real Dollars adjusted to 2017 using the Portland CPI. The sample corresponds to the main worker-quarter panel (after restrictions).

C AKM

C.1 Procedure

We restrict to the largest connected set using the 'igraph' package in R, after which we use the Stata-based high dimensional fixed effects estimator provided by Sergio Correia to regress wages on firm, worker and calendar-quarter fixed effects. This applies to each of the fixed effects samples separately: for example, the firm fixed effects for the first split sample of 2000-2005 are found by restricting the main worker panel to the first split sample in 2000-2005, finding the largest connected set of firms, and then estimating the AKM.

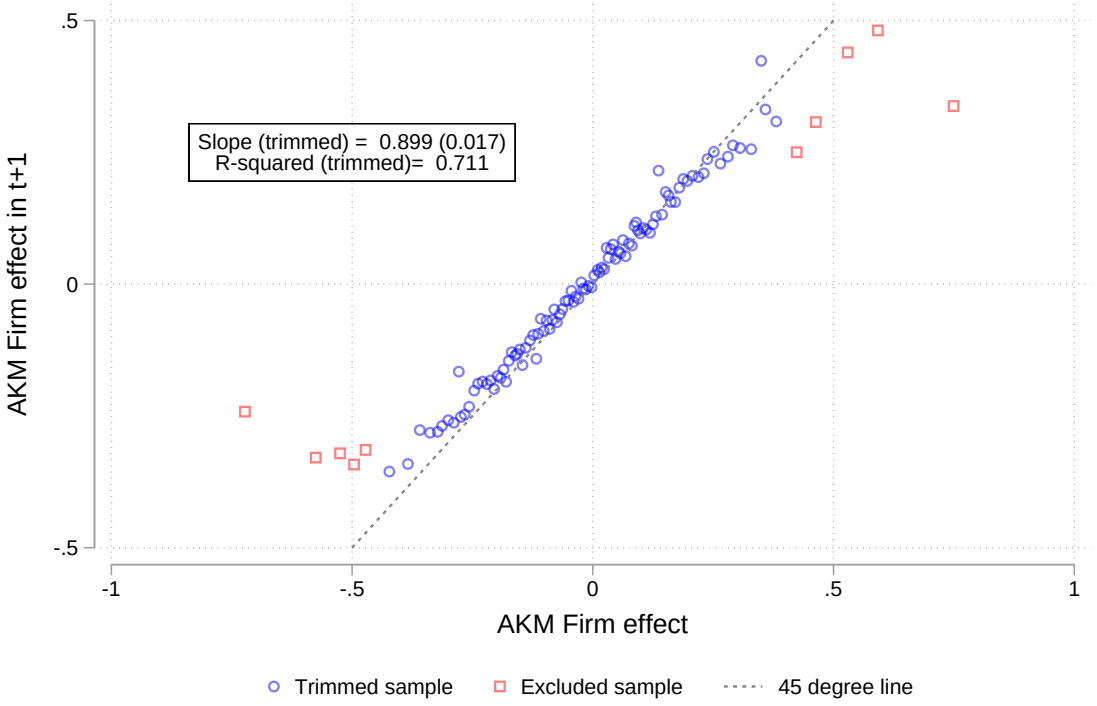
We check the estimates firm fixed effects using the procedure from **card2015bargaining**, which is downloadable online. The correlation for the firm effects is 0.91, and for the worker effects is 0.99. The wage variance decompositions are also very similar (see below).

The AKM estimates by stacked 6-year sample are persistent. Figure C1 presents a plot of current versus next period firm hourly wage effects, with a resulting trimmed slope of 0.9 and R-squared of 0.7. The persistence across years of firm wage policies is consistent with the findings in **lachowska2020firm**.

C.2 Decomposition

Table C1 provides the AKM decomposition in hourly wage and quarterly earnings inequality, for 6 year blocks between 2000-2017, as well as for the full panel. For both log quarterly earnings and log hourly wages, there is a slight increase in the overall variance between the 2000-2005 and 2012-2017 periods (0.37 to 0.41 for wages, and 0.59 to 0.64 for earnings). In the full panel, firm effects explain around 19% (14%) of the variance of quarterly earnings (hourly wages), and worker effects

Figure C1: **Persistence of AKM firm hourly wage effects**



Note: AKM firm wage effects are estimated for each 6 year period (2000-2005, 2006-2011 and 2012-2017) using hourly wages. For each firm, the AKM firm effect is plotted against its firm effect in the next 6-year period, and binned. The red indicates censored firm effects, which represent the 2.5% top and bottom tails of the firm effects distribution. Points are plotted at the firm level and weighted by firm size.

explain around 48% (55%) of the variance. There is also assortative matching of workers and firms, with the covariance term explaining around 14% (18%) of the variance. Consistent with other work, we see a clear increase in the covariance term for both wages and earnings over this period consistent with greater sorting. At the same time, there is a slight increase in the firm component of quarterly earnings variance, but a small decrease in the case of hourly wages. The R-squared is 0.8 to 0.9 for all AKM regressions, and is higher for hourly wages compared to quarterly earnings. It is also not much lower than the R-squared on a comparable match effects model (fixed effects for every job, instead of additive fixed effects for workers and firms as imposed by AKM), which for the 2012-2017 period using hourly wages is 0.91 (0.9 for AKM). This implies that the variation in log wages explained by match effects is small.

Comparable studies find similar AKM decompositions. Using annual earnings data for the US over the years 2000-2008, **sorkin2018ranking** finds that firm effects explain 14% of the log variance, worker effects explain 51%, and the covariance term explains 10%. **lamadon2019imperfect**; **song2018firming** find a lower AKM firm effects share of 9% using annual earnings for a similar period. **lachowska2020firm** find using data from Washington over 2002-2014 for their annual log earnings AKM decomposition (plug-in version) that firm effects explain 19%, worker effects 54%, and the covariance term 17%; similarly to us, they also find that the share explained by firm effects decreases (to 11%) when using hourly wages instead of quarterly earnings.

Our preferred AKM specification relies on split-sample estimation. Table C2 provides the decomposition for each split sample using hourly wages, which is very similar across the two split samples and compared to the full sample decomposition above. Panel C shows some cross-sample statistics: the percentage covariance be-

Table C1: **AKM decomposition**

	2000-2005	2006-2011	2012-2017	2000-2017
Panel A: Earnings				
Var(Y)	0.592	0.63	0.639	0.621
% Var(Firm FE)	15%	15%	16%	19%
% Var(Worker FE)	58%	58%	56%	48%
% Var(Residual)	15%	15%	14%	21%
% 2×Cov(Firm FE, Worker FE)	11%	12%	14%	14%
% 2×Cov(Y, Firm FE)	42%	43%	46%	52%
Obs (millions)	22.60	25.20	25.70	73.40
Adjusted R^2	0.836	0.844	0.852	0.79
Panel B: Wage				
Var(Y)	0.37	0.395	0.409	0.392
% Var(Firm FE)	12%	11%	10%	14%
% Var(Worker FE)	62%	63%	63%	55%
% Var(Residual)	13%	11%	10%	17%
% 2×Cov(Firm FE, Worker FE)	14%	16%	17%	18%
% 2×Cov(Y, Firm FE)	37%	37%	38%	45%
Obs (millions)	22.60	25.20	25.70	73.40
Adjusted R^2	0.863	0.888	0.9	0.844

Note: All subsets use the relevant connected set, where the main sample is restricted to private firms larger than 20 workers (full sample description in text). Firm fixed effects are censored at the 2.5 percent upper and lower tails of the firm distribution. For reference, the full jobs model adjusted R^2 for 2000-2017 is 0.88, and for 2012-2017 is 0.91.

tween own-sample and complement-sample fixed effects is lower than the direct firm effects variance in Table C1, and the percentage explained by the covariance between own sample worker effects and complement sample firm effects is higher than the comparable covariance in table C1.

Finally, we show that the AKM decomposition is very similar using code from **card2015bargaining** (table C3). As in table C1, for the last period the share explained by firm effects is lowest and the covariance between worker and firm effects is highest. The separations elasticity using these firm effects is also similar (if slightly lower), presented in table A2.

C.3 Limited Mobility Bias

A prominent threat to the AKM estimation of firm effects is limited mobility bias (**andrews2008high**). We replicate the comparisons in **lachowska2020firm** for our data to show that limited mobility bias likely becomes less severe with a longer panel and better measurement of wages (table C4).

Our panel has two advantages in addressing limited mobility bias. Firstly, a longer panel allows for more movers between firms, which is the source of identification for the AKM firm effects. The quarterly frequency, as compared to the annual data of many other studies, picks up more movers within the same time period. Secondly, insofar as firm pay policies correspond to *hourly* wages, annual earnings as used by many studies are a noisy measure of the firm effect. We observe hours, which allows us to estimate the firm effects on hourly wages directly.

These advantages of the panel contribute to better measurement of the AKM components. The first two columns show 2-year panels, and should be compared to the second 2 columns which show 6-year panels. The share of variance explained by the firm effects decreases for the longer panel where more movers are observed, most

Table C2: **AKM decomposition for split samples**

	2000-2005	2006-2011	2012-2017
Panel A: Sample 1			
Var(Y)	0.37	0.395	0.409
% Var(Firm FE)	12%	12%	11%
% Var(Worker FE)	63%	64%	64%
% Var(Residual)	13%	11%	10%
% 2 Cov(Firm FE, Worker FE)	13%	14%	16%
% 2 Cov(Y, Firm FE)	37%	37%	38%
Obs (millions)	11.259	12.552	12.823
R^2	0.864	0.888	0.9
Panel B: Sample 2			
Var(Y)	0.37	0.395	0.409
% Var(Firm FE)	12%	12%	11%
% Var(Worker FE)	63%	64%	64%
% Var(Residual)	13%	11%	10%
% 2 Cov(Firm FE, Worker FE)	13%	14%	16%
% 2 Cov(Y, Firm FE)	37%	37%	37%
Obs (millions)	11.254	12.557	12.813
R^2	0.864	0.889	0.9
Panel C: Complement sample			
Var(Y)	0.37	0.395	0.409
% Cov($FirmFE_{own}$, $FirmFE_{complement}$)	11%	10%	9%
% 2 Cov($WorkerFE_{own}$, $FirmFE_{complement}$)	16%	17%	19%
Obs (millions)	22.227	24.808	25.33

Note: All subsets use the relevant connected set, where the main sample is restricted to private firms larger than 20 workers (full sample description in text). The main sample is randomly split into two samples, stratifying by whether the worker moved firms and clustering by worker. Firm fixed effects are estimated using log hourly wages, and censored at the 2.5 percent upper and lower tails of the firm distribution. Panel C shows the share of log wage variation explained by the covariance between the firm effects from a worker's own sample and the firm effects estimated using the alternate split-sample estimate for each worker's firm (comparable to the share explained by the variance of the firm effects); and the covariance between each individual's worker effect and the alternate split-sample firm effect estimate.

Table C3: **AKM decomposition using alternative code**

	2000-2005	2006-2011	2012-2017
Var(Y)	0.369	0.394	0.409
% Var(Firm FE)	12%	12%	11%
% Var(Worker FE)	63%	64%	64%
% Var(Residual)	13%	11%	10%
% 2 Cov(Firm FE, Worker FE)	13%	13%	16%
% 2 Cov(Y, Firm FE)	37%	37%	38%
Obs (millions)	22.397	25.037	25.562
Adjusted R^2	0.863	0.896	0.900

Note: AKM firm effects are estimated using Matlab code from Card, Cardoso, and Kline (2015), for log hourly wages in the main worker-quarter panel (full sample description in text). All subsets use the relevant connected set.

noticeably for the annual earnings measure where we expect more noise.[5] A similar pattern is observed for the share of variance explained across the panels: within each column, the share explained by firm effects decreases with better wage measures. On the other hand, the covariance between firm and worker effects rises dramatically as the panel length increases and the earnings measure improves.

Lower variance of firm effects and higher covariance between worker and firm effects are the two predictions of reductions in limited mobility bias, which both come through clearly for our data. Overall, comparing column 2 panel A (short panel, annual earnings) to column 4 panel C (longer panel, hourly wage), the share of log variance explained by firm effects decreases from 20% to 10%. The share explained by sorting, i.e. the covariance term, increases from 2% (suggesting very little sorting) to 17% (suggesting substantial sorting). Both features echo the findings of **bonhomme2020much**; **lachowska2020firm**.

[5]The last column shows the full panel, where the share of variance explained increases, likely due to actual increases in the variance, for example since more firms are included.

Table C4: **AKM variance decomposition by panel length**

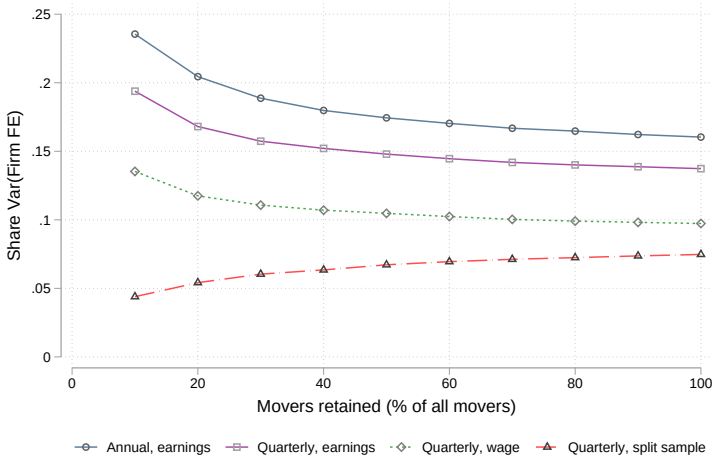
	2-Year Panels		6-Year Panels		Full panel
	2002-2003	2013-2014	2000-2005	2012-2017	2000-2017
Panel A: Annual earnings					
Var(Y)	0.528	0.584	0.56	0.603	0.596
% Var(Firm FE)	23%	20%	17%	18%	21%
% Var(Worker FE)	80%	75%	62%	59%	49%
% 2×Cov(Firm FE, Worker FE)	-6%	2%	13%	16%	15%
Obs (millions)	1.81	2.02	6.61	7.51	21.80
Panel B: Quarterly earnings					
Var(Y)	0.588	0.639	0.592	0.639	0.621
% Var(Firm FE)	18%	16%	15%	16%	19%
% Var(Worker FE)	70%	66%	58%	56%	48%
% 2×Cov(Firm FE, Worker FE)	1%	7%	11%	14%	14%
Obs (millions)	7.46	8.48	22.40	25.60	73.40
Panel C: Hourly wage					
Var(Y)	0.366	0.41	0.37	0.409	0.392
% Var(Firm FE)	13%	10%	12%	10%	14%
% Var(Worker FE)	70%	72%	62%	63%	55%
% 2×Cov(Firm FE, Worker FE)	8%	12%	14%	17%	18%
Obs (millions)	7.46	8.48	22.40	25.60	73.40

Note: Earnings are quarterly total earnings; wages are quarterly hourly wages. All subsets use the relevant connected subset of the main panel (sample description in text).

Finally, we replicate the mobility bias figure presented in **lamadon2019imperfect**, while adding our improved measures of the firm effects for comparison. Figure C2 shows that as the share of movers retained increases, the share of log variance explained by the variance in firm effects decreases substantially for the annualized earnings panel (by about 8 percentage points) – as expected when limited mobility bias is reduced. However, as argued above, the reduction in share explained is lower using quarterly earnings (6 percentage points), or hourly wage (4 percentage points). Moreover, the bias when using our split sample measure (predicting own-sample firm effect by complement-sample firm effect) is in the *opposite* direction:

the share of variance explained increases with share of movers retained.

Figure C2: **Mobility bias by varying share of movers**



Notes: The sample is restricted to the period 2013 to 2017 for comparability to other studies. The figure shows the proportion of wage variance accounted for by the estimated wage premia, where the horizontal axis indicates a subset of the data that randomly retains the corresponding share of movers. All subsets use the relevant connected set of firms. Firm fixed effects are censored at the 2.5 percent tails of the firm distribution. The blue line indicates an annualized panel using total earnings, the purple indicates the quarterly panel using total earnings, and the green indicates the quarterly panel using hourly wages. The red indicates the quarterly panel using hourly wages, where the split sample approach is used such that each firm's wage effect is the predicted value from a regression of own-sample firm effect on the complement sample firm effect.