Supplemental Appendix - Macro Recruiting Intensity from Micro Data

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This Appendix is organized as follows. Section A contains additional figures and tables. Section B provides details on our analytical derivations. Section C provides additional details on variable construction.

A Additional figures and tables

This appendix section contains additional figures and tables referenced in the main text.

Categories for j are quintiles of:	Level of aggregation for i			
	NAICS1	NAICS2	NAICS3	NAICS4
Industry	-	0.77 (0.009)	0.79 (0.007)	0.74 (0.004)
Age	0.84 (0.009)	0.77 (0.006)	0.76 (0.004)	0.73 (0.003)
Size	0.83 (0.011)	0.77 (0.009)	0.66 (0.005)	0.65 (0.004)
Wage	0.78 (0.010)	0.74 (0.006)	0.76 (0.004)	0.72 (0.003)
Separation rate	0.70 (0.011)	0.72 (0.007)	0.75 (0.004)	0.73 (0.003)
Quit rate	0.73 (0.012)	0.73 (0.008)	0.77 (0.004)	0.77 (0.003)
Turnover rate	0.48 (0.027)	0.62 (0.017)	0.68 (0.007)	0.69 (0.005)
Emp. growth rate	0.71 (0.011)	0.71 (0.008)	0.72 (0.005)	0.72 (0.003)

Table A1: Coefficient estimates - With jt fixed effects

Notes: This table replicates Table 1, but with the following modification. In each case equation (14), but with fixed effects δ_t and ξ_j replaced with the joint fixed effect δ_{jt}. This implies that the only variation used to estimate the coefficient β presented in this table is: *within-group-j-month-t*, *across-industries-i*.

Categories for j are quintiles of:	Level of aggregation for i			
	NAICS1	NAICS2	NAICS3	NAICS4
Industry	-	0.78 (0.013)	0.75 (0.008)	0.75 (0.004)
Age	0.78 (0.011)	0.80 (0.007)	0.75 (0.004)	0.73 (0.003)
Size	0.83 (0.011)	0.78 (0.009)	0.69 (0.006)	0.68 (0.004)
Wage	0.75 (0.011)	0.75 (0.007)	0.74 (0.004)	0.73 (0.003)
Separation rate	0.78 (0.012)	0.77 (0.008)	0.76 (0.004)	0.74 (0.003)
Quit rate	0.72 (0.014)	0.73 (0.009)	0.76 (0.004)	0.76 (0.003)
Turnover rate	0.71 (0.024)	0.72 (0.016)	0.72 (0.007)	0.73 (0.004)
Emp. growth rate	0.62 (0.011)	0.67 (0.009)	0.70 (0.005)	0.73 (0.003)

Table A2: Coefficient estimates - With ij and t fixed effects

Notes: This table replicates Table 1, but with the following modification. In each case equation (14), but with fixed effect ξ_j replaced with the joint fixed effect ξ_{ij}. This implies that the only variation used to estimate the coefficient β presented in this table is: *within-group-j-industry-i*, *across-months-t*.

Categories for j are quintiles of:	Level of aggregation for i			
	NAICS1	NAICS2	NAICS3	NAICS4
Industry	-	71228	17245	5553
Age	27303	14758	3546	1134
Size	27303	14758	3608	1178
Wage	22753	12318	2989	956
Separation rate	22753	12135	2941	936
Quit rate	22753	12225	2984	952
Turnover rate	22752	12135	2936	936
Emp. growth rate	22753	12602	3138	1099

Table A3: Sample size in each ij cell

Notes: In the estimation described in Table A2, we estimate fixed effects ϕ_{ij}. For each estimation, this table gives the average number of observations in each (ij)-cell.

Categories for j are quintiles of:	Level of aggregation for i			
	NAICS1	NAICS2	NAICS3	NAICS4
A. **Grouped by establishment's current residual**				
Within-NAICS3-month log wage residual quantile	0.78 (0.010)	0.74 (0.006)	0.76 (0.004)	0.72 (0.003)
Within-NAICS3-month wage growth $(t-1,t)$ residual quantile	0.71 (0.011)	0.71 (0.008)	0.72 (0.005)	0.72 (0.003)
Within-NAICS3-month wage growth $(t,t+1)$ residual quantile	0.70 (0.011)	0.71 (0.008)	0.71 (0.005)	0.72 (0.003)
B. **Grouped by establishment's average residual**				
Within-NAICS3-month log wage residual quantile	0.80 (0.010)	0.75 (0.006)	0.76 (0.004)	0.72 (0.003)
Within-NAICS3-month wage growth $(t-1,t)$ residual quantile	0.76 (0.011)	0.78 (0.008)	0.74 (0.005)	0.74 (0.003)
Within-NAICS3-month wage growth $(t,t+1)$ residual quantile	0.73 (0.010)	0.75 (0.007)	0.74 (0.005)	0.74 (0.003)

Table A4: Coefficient estimates - Grouping by residualized wages and wage growth

Notes: This table replicates Table 1, but with the following modification. The variables that we use to group firms into groups j are residuals. Take a variable x_{emt} for establishment e in NAICS3 industry m in period t. We regress x_{emt} on mt-fixed effects, call the residual $\widetilde{x}_{emt}$. We then group firms into groups j by quintiles of either: (Panel A) grouped every period by $\widetilde{x}_{emt}$, (Panel B) grouped by the establishment mean of $\widetilde{x}_{emt}$ over the sample. For x we consider (a) log $Wage_{emt}$, where $Wage_{emt} = Payroll_{emt}/Employment_{emt}$, (b) growth in $Wage_{emt}$ between $t-1$ and t (where t is a quarter), (c) growth in $Wage_{emt}$ between t and $t+1$.

Categories for j are quintiles of:	Level of aggregation for i			
	NAICS1	NAICS2	NAICS3	NAICS4
A. **Grouped by establishment's current residual**				
Within-NAICS3-month log wage residual quantile	0.75 (0.011)	0.75 (0.007)	0.74 (0.004)	0.73 (0.003)
Within-NAICS3-month wage growth $(t-1,t)$ residual quantile	0.62 (0.011)	0.67 (0.009)	0.70 (0.005)	0.73 (0.003)
Within-NAICS3-month wage growth $(t,t+1)$ residual quantile	0.61 (0.011)	0.66 (0.009)	0.69 (0.005)	0.73 (0.003)
B. **Grouped by establishment's average residual**				
Within-NAICS3-month log wage residual quantile	0.78 (0.011)	0.78 (0.007)	0.75 (0.004)	0.74 (0.003)
Within-NAICS3-month wage growth $(t-1,t)$ residual quantile	0.71 (0.011)	0.77 (0.008)	0.75 (0.005)	0.76 (0.003)
Within-NAICS3-month wage growth $(t,t+1)$ residual quantile	0.68 (0.011)	0.75 (0.008)	0.75 (0.005)	0.75 (0.003)

Table A5: Coefficient estimates - Grouping by residualized wages and wage growth - With jt fixed effects

Notes: This replicates the above Table A4, with the addition of jt fixed effects, as in Table A1, above.

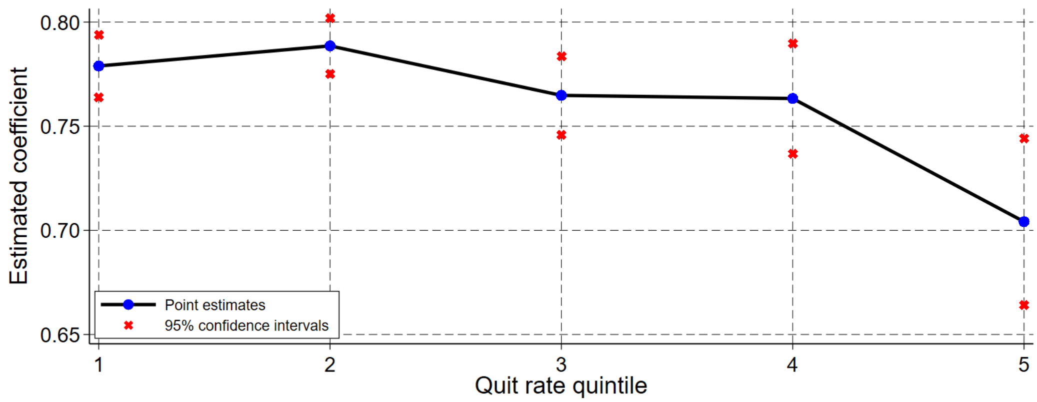

Figure A1: Coefficient estimates - Separately for quit rate quintiles

Notes: This figures provides point estimates similar to Table 1, but with the following modification. In each case we run the entire analysis *only* for establishments within a particular quintile of quit rates q_{it}.

Categories for j are quintiles of	**Aggregation level for i**	**1. Aggregate recruiting intensity**					**2. Composition**		
		Slack	Growth	Comp.	Cov.	β_{Comp}	Between	Within	Cov.
Industry	NAICS2	0.42	0.09	0.02	0.47	0.098	0.39	0.24	0.37
	NAICS3	0.42	0.08	0.03	0.47	0.109	0.29	0.37	0.34
	NAICS4	0.40	0.10	0.05	0.45	0.119	0.32	0.64	0.04
Age	NAICS1	0.52	0.07	0.06	0.35	0.079	0.19	0.38	0.43
	NAICS2	0.47	0.09	0.04	0.40	0.063	0.14	0.51	0.35
	NAICS3	0.45	0.10	0.04	0.41	0.070	0.10	0.68	0.22
	NAICS4	0.42	0.10	0.14	0.34	0.139	0.13	0.52	0.35
Size	NAICS1	0.53	0.07	0.02	0.38	0.038	0.09	0.68	0.23
	NAICS2	0.46	0.10	0.03	0.41	0.057	0.49	1.24	-0.73
	NAICS3	0.39	0.12	0.05	0.44	0.095	0.21	1.01	-0.22
	NAICS4	0.38	0.12	0.08	0.42	0.116	0.05	0.82	0.13
Wage	NAICS1	0.48	0.09	0.04	0.39	0.052	0.22	0.41	0.37
	NAICS2	0.46	0.11	0.05	0.38	0.059	0.26	0.48	0.26
	NAICS3	0.46	0.10	0.05	0.39	0.071	0.12	0.72	0.16
	NAICS4	0.43	0.11	0.08	0.38	0.098	0.07	0.80	0.13
Separation rate	NAICS1	0.40	0.11	0.06	0.43	0.111	0.47	0.20	0.33
	NAICS2	0.41	0.10	0.07	0.42	0.108	0.42	0.25	0.33
	NAICS3	0.45	0.10	0.07	0.38	0.081	0.38	0.40	0.22
	NAICS4	0.47	0.11	0.09	0.33	0.065	0.36	0.64	0.00
Quit rate	NAICS1	0.48	0.11	0.05	0.36	0.036	0.32	0.29	0.39
	NAICS2	0.48	0.11	0.06	0.35	0.037	0.30	0.44	0.26
	NAICS3	0.56	0.11	0.07	0.26	-0.008	0.40	0.76	-0.16
	NAICS4	0.63	0.13	0.12	0.12	-0.053	0.48	1.03	-0.51
Turnover rate	NAICS1	0.28	0.12	0.14	0.46	0.229	1.15	0.31	-0.46
	NAICS2	0.36	0.12	0.12	0.40	0.150	0.88	0.29	-0.17
	NAICS3	0.41	0.12	0.11	0.36	0.106	0.76	0.31	-0.07
	NAICS4	0.43	0.12	0.11	0.34	0.097	0.47	0.25	0.28
Emp. growth rate	NAICS1	0.43	0.12	0.03	0.42	0.055	0.27	0.48	0.25
	NAICS2	0.44	0.12	0.04	0.40	0.056	0.28	0.55	0.17
	NAICS3	0.42	0.11	0.04	0.43	0.085	0.06	0.77	0.17
	NAICS4	0.42	0.11	0.07	0.40	0.099	0.03	0.82	0.15
Average		0.44	0.105	0.065	0.39	0.08	0.33	0.56	0.12

Table A6: Decomposing aggregate recruiting intensity - ALTERNATIVE $\alpha = 0.15$

Notes: This table replicates Table 2 from the main text with the following difference. For every row, we assume that the matching function elasticity $\alpha = 0.15$ when constructing all terms that enter the variance decomposition.

Categories for j are quintiles of	Aggregation level for i	1. Aggregate recruiting intensity					2. Composition		
		Slack	Growth	Comp.	Cov.	β_{Comp}	Between	Within	Cov.
Industry	NAICS2	0.57	0.03	0.02	0.38	0.098	0.13	0.47	0.40
	NAICS3	0.57	0.03	0.03	0.37	0.109	0.09	0.57	0.34
	NAICS4	0.54	0.03	0.05	0.38	0.119	0.11	0.73	0.16
Age	NAICS1	0.69	0.02	0.06	0.23	0.079	0.05	0.64	0.31
	NAICS2	0.64	0.03	0.04	0.29	0.063	0.05	0.69	0.26
	NAICS3	0.62	0.03	0.04	0.31	0.070	0.03	0.79	0.18
	NAICS4	0.57	0.04	0.14	0.25	0.139	0.05	0.69	0.26
Size	NAICS1	0.72	0.02	0.02	0.24	0.038	0.02	0.81	0.17
	NAICS2	0.63	0.03	0.03	0.31	0.057	0.16	1.02	-0.18
	NAICS3	0.52	0.05	0.05	0.38	0.095	0.09	0.99	-0.08
	NAICS4	0.51	0.06	0.08	0.35	0.116	0.02	0.87	0.11
Wage	NAICS1	0.66	0.03	0.04	0.27	0.052	0.07	0.62	0.31
	NAICS2	0.63	0.04	0.05	0.28	0.059	0.09	0.63	0.28
	NAICS3	0.63	0.03	0.05	0.29	0.071	0.04	0.81	0.15
	NAICS4	0.58	0.04	0.08	0.30	0.098	0.02	0.87	0.11
Separation rate	NAICS1	0.54	0.04	0.06	0.36	0.111	0.18	0.39	0.43
	NAICS2	0.56	0.04	0.07	0.33	0.108	0.15	0.45	0.40
	NAICS3	0.61	0.03	0.07	0.29	0.081	0.13	0.56	0.31
	NAICS4	0.63	0.04	0.09	0.24	0.066	0.13	0.71	0.16
Quit rate	NAICS1	0.65	0.04	0.05	0.26	0.036	0.11	0.50	0.39
	NAICS2	0.65	0.04	0.06	0.25	0.037	0.11	0.60	0.29
	NAICS3	0.76	0.04	0.07	0.13	-0.008	0.13	0.76	0.11
	NAICS4	0.86	0.04	0.13	-0.03	-0.053	0.15	0.90	-0.05
Turnover rate	NAICS1	0.35	0.07	0.14	0.44	0.229	0.66	0.25	0.09
	NAICS2	0.48	0.06	0.12	0.34	0.150	0.40	0.33	0.27
	NAICS3	0.56	0.05	0.11	0.28	0.106	0.31	0.37	0.32
	NAICS4	0.58	0.05	0.11	0.26	0.097	0.18	0.41	0.41
Emp. growth rate	NAICS1	0.58	0.05	0.03	0.34	0.055	0.11	0.61	0.28
	NAICS2	0.60	0.04	0.04	0.32	0.056	0.11	0.65	0.24
	NAICS3	0.57	0.04	0.04	0.35	0.085	0.02	0.85	0.13
	NAICS4	0.57	0.04	0.07	0.32	0.099	0.01	0.88	0.11
Average		0.60	0.039	0.066	0.29	0.08	0.13	0.66	0.22

Table A7: Decomposing aggregate recruiting intensity - ALTERNATIVE $\alpha = 0.50$

Notes: This table replicates Table 2 from the main text with the following difference. For every row, we assume that the matching function elasticity $\alpha = 0.50$ when constructing all terms that enter the variance decomposition.

Categories for j are quintiles of	**Aggregation level for i**	**1. Aggregate recruiting intensity**					**2. Composition**		
		Slack	Growth	Comp.	Cov.	β_{Comp}	Between	Within	Cov.
Industry	NAICS2	0.56	0.05	0.01	0.38	0.063	0.17	0.42	0.41
	NAICS3	0.54	0.04	0.02	0.40	0.082	0.13	0.53	0.34
	NAICS4	0.58	0.05	0.04	0.33	0.066	0.11	0.77	0.12
Age	NAICS1	0.56	0.04	0.06	0.34	0.089	0.13	0.45	0.42
	NAICS2	0.61	0.05	0.04	0.30	0.035	0.08	0.62	0.30
	NAICS3	0.61	0.05	0.04	0.30	0.034	0.06	0.74	0.20
	NAICS4	0.61	0.05	0.13	0.21	0.080	0.06	0.64	0.30
Size	NAICS1	0.59	0.05	0.02	0.34	0.044	0.06	0.72	0.22
	NAICS2	0.62	0.05	0.03	0.30	0.023	0.25	1.06	-0.31
	NAICS3	0.67	0.05	0.04	0.24	-0.007	0.12	0.83	0.05
	NAICS4	0.68	0.05	0.08	0.19	0.000	0.05	0.79	0.16
Wage	NAICS1	0.62	0.05	0.03	0.30	0.027	0.12	0.52	0.36
	NAICS2	0.66	0.05	0.05	0.24	0.008	0.13	0.57	0.30
	NAICS3	0.62	0.05	0.05	0.28	0.035	0.07	0.76	0.17
	NAICS4	0.63	0.05	0.08	0.24	0.039	0.03	0.84	0.13
Separation rate	NAICS1	0.62	0.05	0.06	0.27	0.037	0.18	0.39	0.43
	NAICS2	0.61	0.05	0.06	0.28	0.049	0.17	0.43	0.40
	NAICS3	0.62	0.05	0.06	0.27	0.040	0.17	0.51	0.32
	NAICS4	0.67	0.05	0.09	0.19	0.011	0.14	0.67	0.19
Quit rate	NAICS1	0.68	0.05	0.05	0.22	-0.016	0.15	0.44	0.41
	NAICS2	0.69	0.05	0.06	0.20	-0.012	0.14	0.53	0.33
	NAICS3	0.73	0.06	0.07	0.14	-0.038	0.20	0.70	0.10
	NAICS4	0.82	0.07	0.13	-0.02	-0.083	0.23	0.86	-0.09
Turnover rate	NAICS1	0.68	0.05	0.10	0.17	0.009	0.30	0.34	0.36
	NAICS2	0.67	0.05	0.10	0.18	0.024	0.28	0.38	0.34
	NAICS3	0.67	0.05	0.10	0.18	0.018	0.27	0.38	0.35
	NAICS4	0.67	0.05	0.10	0.18	0.018	0.18	0.41	0.41
Emp. growth rate	NAICS1	0.68	0.05	0.03	0.24	-0.021	0.16	0.53	0.31
	NAICS2	0.67	0.05	0.03	0.25	-0.011	0.15	0.58	0.27
	NAICS3	0.62	0.05	0.03	0.30	0.024	0.05	0.83	0.12
	NAICS4	0.63	0.05	0.06	0.26	0.038	0.02	0.86	0.12
Average		0.64	0.050	0.060	0.25	0.02	0.14	0.62	0.24

Table A8: Decomposing aggregate recruiting intensity - ALTERNATIVE $\gamma = 0.82$

Notes: This table replicates Table 2 from the main text with the following difference. We assume that $\gamma = 0.82$ in every row, rather than the value presented in Table 1.

Categories for j are quintiles of	Aggregation level for i	1. Aggregate recruiting intensity					2. Composition		
		Slack	Growth	Comp.	Cov.	β_{Comp}	Between	Within	Cov.
Industry	NAICS2	0.49	0.06	0.02	0.43	0.091	0.29	0.22	0.49
	NAICS3	0.45	0.06	0.03	0.46	0.117	0.33	0.18	0.49
	NAICS4	0.42	0.06	0.05	0.47	0.149	0.33	0.18	0.49
Age	NAICS1	0.50	0.05	0.04	0.41	0.100	0.28	0.22	0.50
	NAICS2	0.52	0.05	0.03	0.40	0.093	0.25	0.25	0.50
	NAICS3	0.45	0.06	0.03	0.46	0.123	0.33	0.18	0.49
	NAICS4	0.37	0.06	0.08	0.49	0.200	0.36	0.16	0.48
Size	NAICS1	0.55	0.04	0.02	0.39	0.086	0.20	0.31	0.49
	NAICS2	0.48	0.05	0.03	0.44	0.105	0.29	0.21	0.50
	NAICS3	0.39	0.07	0.05	0.49	0.155	0.42	0.13	0.45
	NAICS4	0.34	0.06	0.09	0.51	0.218	0.42	0.12	0.46
Wage	NAICS1	0.47	0.06	0.03	0.44	0.104	0.33	0.18	0.49
	NAICS2	0.47	0.06	0.04	0.43	0.108	0.33	0.18	0.49
	NAICS3	0.46	0.06	0.06	0.42	0.122	0.34	0.18	0.48
	NAICS4	0.40	0.06	0.07	0.47	0.172	0.36	0.16	0.48
Separation rate	NAICS1	0.53	0.06	0.03	0.38	0.070	0.28	0.22	0.50
	NAICS2	0.51	0.06	0.04	0.39	0.085	0.29	0.21	0.50
	NAICS3	0.49	0.06	0.06	0.39	0.103	0.31	0.19	0.50
	NAICS4	0.40	0.06	0.11	0.43	0.194	0.34	0.17	0.49
Quit rate	NAICS1	0.51	0.08	0.02	0.39	0.043	0.37	0.15	0.48
	NAICS2	0.50	0.08	0.03	0.39	0.064	0.36	0.16	0.48
	NAICS3	0.54	0.07	0.05	0.34	0.061	0.31	0.20	0.49
	NAICS4	0.50	0.06	0.08	0.36	0.108	0.31	0.20	0.49
Turnover rate	NAICS1	0.49	0.08	0.09	0.34	0.089	0.38	0.14	0.48
	NAICS2	0.50	0.08	0.10	0.32	0.094	0.37	0.15	0.48
	NAICS3	0.48	0.07	0.14	0.31	0.132	0.37	0.16	0.47
	NAICS4	0.40	0.06	0.17	0.37	0.219	0.36	0.16	0.48
Emp. growth rate	NAICS1	0.38	0.09	0.04	0.49	0.134	0.50	0.08	0.42
	NAICS2	0.41	0.08	0.04	0.47	0.118	0.45	0.11	0.44
	NAICS3	0.43	0.07	0.05	0.45	0.127	0.39	0.14	0.47
	NAICS4	0.40	0.06	0.06	0.48	0.169	0.35	0.17	0.48
Average		0.46	0.064	0.057	0.42	0.12	0.34	0.18	0.48

Table A9: Decomposing aggregate recruiting intensity - Baseline has (ij)-fixed effects

Notes: This table replicates Table 2, but with the following modification. In each case equation (14), but with fixed effect ξ_j replaced with the joint fixed effect ξ_{ij}. This implies that the only variation used to estimate the coefficient β presented in this table is: *within-group-j-industry-i*, *across-months-t*. The ϕ_{ij} terms are then computed and used in the decomposition.

Categories for j are quintiles of	Aggregation level for i	1. Aggregate recruiting intensity				2. Composition		
		Slack	Growth	Comp.	Cov.	Between	Within	Cov.
A. **Grouped by establishment's current residual**								
Within-NAICS3-month log wage residual quantile	NAICS1	0.55	0.06	0.04	0.35	0.15	0.49	0.36
	NAICS2	0.52	0.08	0.05	0.35	0.18	0.53	0.29
	NAICS3	0.52	0.07	0.05	0.36	0.08	0.75	0.17
	NAICS4	0.49	0.08	0.08	0.35	0.05	0.83	0.12
Within-NAICS3-month wage growth $(t-1,t)$ residual quantile	NAICS1	0.49	0.09	0.03	0.39	0.20	0.52	0.28
	NAICS2	0.50	0.08	0.04	0.38	0.20	0.58	0.22
	NAICS3	0.47	0.08	0.04	0.41	0.04	0.80	0.16
	NAICS4	0.48	0.08	0.07	0.37	0.02	0.84	0.14
Within-NAICS3-month wage growth $(t,t+1)$ residual quantile	NAICS1	0.48	0.09	0.03	0.40	0.26	0.51	0.23
	NAICS2	0.50	0.09	0.04	0.37	0.25	0.60	0.15
	NAICS3	0.46	0.08	0.03	0.43	0.06	0.78	0.16
	NAICS4	0.47	0.07	0.07	0.39	0.03	0.83	0.14
B. **Grouped by establishment's average residual**								
Within-NAICS3-month log wage residual quantile	NAICS1	0.57	0.06	0.03	0.34	0.13	0.52	0.35
	NAICS2	0.53	0.07	0.05	0.35	0.16	0.50	0.34
	NAICS3	0.52	0.07	0.05	0.36	0.08	0.72	0.20
	NAICS4	0.49	0.08	0.08	0.35	0.04	0.80	0.16
Within-NAICS3-month wage growth $(t-1,t)$ residual quantile	NAICS1	0.54	0.07	0.04	0.35	0.16	0.50	0.34
	NAICS2	0.56	0.06	0.04	0.34	0.13	0.61	0.26
	NAICS3	0.51	0.07	0.03	0.39	0.06	0.78	0.16
	NAICS4	0.50	0.07	0.08	0.35	0.02	0.83	0.15
Within-NAICS3-month wage growth $(t,t+1)$ residual quantile	NAICS1	0.50	0.08	0.03	0.39	0.18	0.52	0.30
	NAICS2	0.52	0.07	0.04	0.37	0.16	0.65	0.19
	NAICS3	0.49	0.07	0.03	0.41	0.05	0.79	0.16
	NAICS4	0.48	0.07	0.08	0.37	0.02	0.84	0.14
Average		0.51	0.075	0.048	0.37	0.11	0.67	0.22

Table A10: Decomposing aggregate recruiting intensity - Grouping by residualized wages and wage growth

Notes: This table replicates Table 2, but with the following modification. The variables that we use to group firms into groups j follow Table A4.

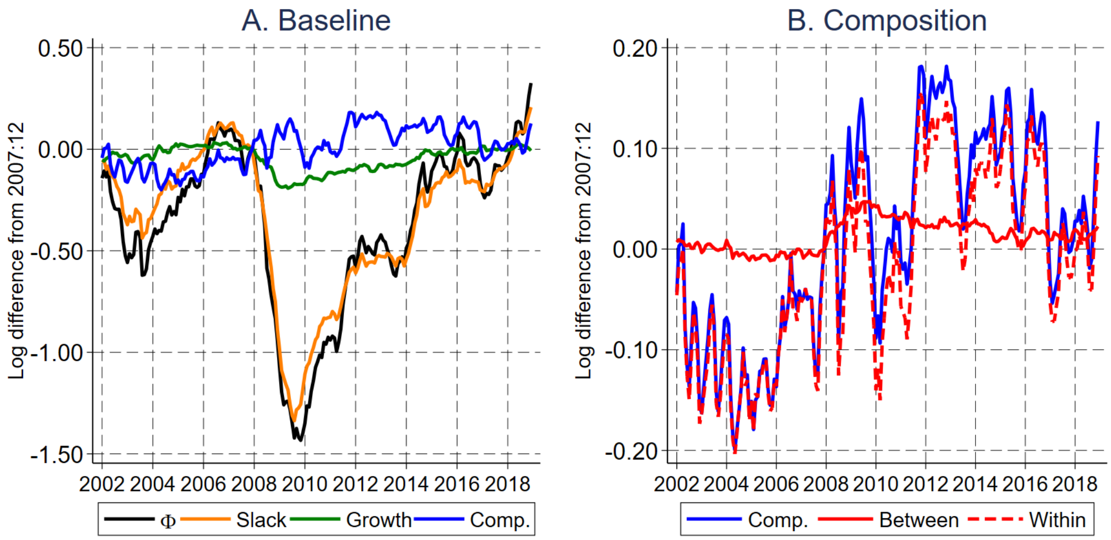

Figure A2: Decomposing aggregate recruiting intensity - ALTERNATIVE $\gamma = 0.82$

Notes: This figure replicates Figure 6 from the main text with the following difference. We assume that $\gamma = 0.82$ rather than the value presented in Table 1.

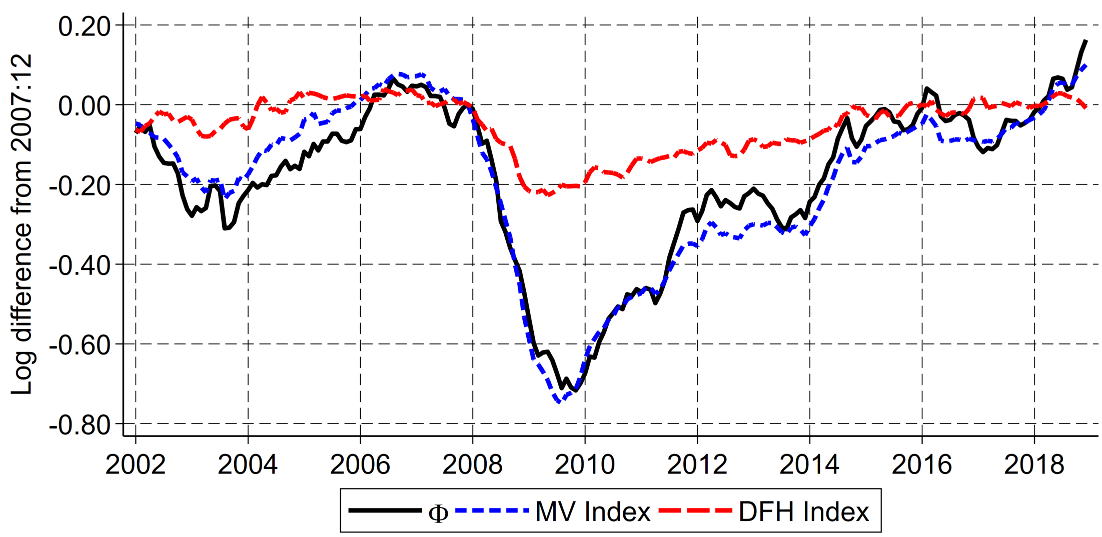

Figure A3: Indexes of aggregate recruiting intensity - ALTERNATIVE $\gamma = 0.82$

Notes: This figure replicates Figure 8 from the main text with the following difference. We assume that $\gamma = 0.82$ rather than the value presented in Table 1.

B Mathematical details

This section contains (1) the proof of Proposition 1 and (2) the derivation of the daily filling rate and vacancy flow rate used in the text.

B.1 Proof of Proposition 1

We begin by working explicitly with a cost function in the form of $\mathcal{C}_i(e_{it}, v_{it}, n_{it}) = x_i C(e_{it}, v_{it}/n_{it})$, and in the necessity part of the proof show that this is the only way in which v and n can enter. Let $\widetilde{v} = (v/n)$ denote the vacancy rate, and $\widetilde{h} = (h/n)$ denote the hiring rate. The hiring problem can be written as follows:

$$\min_{e_{it}, v_{it}} x_i C\left(e_{it}, \frac{v_{it}}{n_{it}}\right) v_{it} \qquad \text{s.t.} \qquad h_{it} = Q_t^* \phi_i e_{it} v_{it}$$

which, removing it subscripts for convenience, and setting $\phi_i = 1$ without loss of generality, we write as:

$$\min_{e, \widetilde{v}} xC\left(e, \widetilde{v}\right) \widetilde{v} n \qquad \text{s.t.} \qquad \widetilde{h} = Q^* e \widetilde{v} \tag{B1}$$

Sufficiency. We first show the following. If C is an isoelastic function $m(\cdot)$ of two, additive, isoelastic functions $g(e)$ and $f(\widetilde{v})$, then the solution to (B1) delivers a vacancy yield $h/v = \widetilde{h}/\widetilde{v}$ and vacancy rate $\widetilde{v}$ that are log-linear in the hiring rate $\widetilde{h}$.

The first order conditions of the problem imply the following optimality condition, which along with the hiring constraint can be solved for $e\left(Q^*, \widetilde{h}\right)$ and $\widetilde{v}\left(Q^*, \widetilde{h}\right)$:

$$C_e\left(e, \widetilde{v}\right) e = C_v\left(e, \widetilde{v}\right) \widetilde{v} + C\left(e, \widetilde{v}\right). \tag{B2}$$

Note that since x scales the cost function, it does not appear in the optimality condition. Despite affecting the firms' dynamic decision that controls $\widetilde{h}$, x does not affect the recruiting input decision. If $C(e, \widetilde{v})$ has the form just described:

$$C(e, \widetilde{v}) = m\Big(g(e) + f\left(\widetilde{v}\right)\Big),$$

then the optimality condition (B2) can be written:

$$g\left(e\right)\left[\left(\frac{m'(g(e)+f(\widetilde{v}))(g(e)+f(\widetilde{v}))}{m(g(e)+f(\widetilde{v}))}\right)\left(\frac{g'(e)e}{g(e)}\right) - 1\right] = f\left(\widetilde{v}\right)\left[\left(\frac{m'(g(e)+f(\widetilde{v}))(g(e)+f(\widetilde{v}))}{m(g(e)+f(\widetilde{v}))}\right)\frac{f'(\widetilde{v})\widetilde{v}}{f(\widetilde{v})} + 1\right]$$

Since m, g and f are constant elasticity functions, with elasticities γ_m, γ_v and γ_e respectively, this condition reduces to

$$g(e)\left[\gamma_m \gamma_e - 1\right] = f(\widetilde{v})\left[\gamma_m \gamma_v + 1\right]. \tag{B3}$$

Given that g and f are isoelastic, the solution to (B3) is of the form $\widetilde{v} = \Omega e^{\omega}$. Substituting this into the hiring technology $\widetilde{h} = Q^* e \widetilde{v}$ gives

$$\widetilde{h} = \Omega Q^* e^{1+\omega} \quad \Longrightarrow \quad e = \Omega^{-\frac{1}{1+\omega}} Q^{*-\frac{1}{1+\omega}} \widetilde{h}^{\frac{1}{1+\omega}}. \quad \overset{\widetilde{h} = Q^* e \widetilde{v}}{\Longrightarrow} \quad \frac{\widetilde{h}}{\widetilde{v}} = \Omega^{-\frac{1}{1+\omega}} Q^{\frac{\omega}{1+\omega}} \widetilde{h}^{\frac{1}{1+\omega}}.$$

Since $\widetilde{h} = Q^* e\widetilde{v}$ then it is immediate that $\widetilde{v}$ is also isoelastic in $\widetilde{h}$. Since γ_m only appears in the constant Ω, it can be normalized to one (i.e. $m(x) = x$) as we do in the paper without any impact on the key properties of the recruiting policies.

Necessity. We want to show the following. Suppose that under optimality the vacancy yield and vacancy rate are isoelastic in the hiring rate. Then the cost function takes the following form, where g and f are isoelastic: $C(e,v,n) = \left[g(e) + f\left(\frac{v}{n}\right)\right]$. Given our previous result that constant elasticity m only affects policy function constants we ignore it here. We proceed in five steps.

Step 1. We begin by simplifying the statement that we wish to prove. First, we show that if the supposition is true, then $\widetilde{v}$ and recruiting intensity must be isoelastic with respect to each other, i.e. have a constant elasticity relationship, as in $\widetilde{v} = \Psi e^{\psi}$. By the supposition $(\widetilde{h}/\widetilde{v})$ is log-linear in $\widetilde{h}$. From the hiring constraint $(\widetilde{h}/\widetilde{v}) = Q^* e$. Therefore e is log-linear in $\widetilde{h}$: $e = \Omega\widetilde{h}^{\omega}$, which implies that $\widetilde{h}$ is an isoelastic function of e. Substituting this isoelastic function of e into the hiring constraint for $\widetilde{h}$ gives

$$\Omega^{-\frac{1}{\omega}} e^{\frac{1}{\omega}} = Q^* e\widetilde{v}.$$

The relationship between e and $\widetilde{v}$ is therefore constant elasticity: $\widetilde{v} = \Psi e^{\psi}$ for some Ψ and ψ.

Second, the supposition requires that the first order conditions hold. These give the optimality condition (B2).

Combining these two points allows us to simplify the statement that we wish to prove:

> *Suppose the optimality condition $C_e(e,\widetilde{v})\, e = C_v(e,\widetilde{v})\,\widetilde{v} + C(e,\widetilde{v})$ implies that $\widetilde{v} = \Psi e^{\psi}$, for some Ψ, ψ. Then $C(e,\widetilde{v}) = m\left(g(e) + f(\widetilde{v})\right)$, with isoelastic $m(x)$, $g(e)$ and $f(\widetilde{v})$.*

We construct the proof by contradiction. Under the assumption that the cost function is not isoleastic, obtaining an optimal relation between e and $\tilde{v}$ that features constant elasticity leads to a contradiction.

Step 2. We establish a particular implication in the case that $C(e,\widetilde{v})$ is **not** additively separable. Taking (B2), and rearranging:

$$e = \left[\frac{C_v(e,\widetilde{v})}{C_e(e,\widetilde{v})}\widetilde{v}\right] + \left[\frac{C(e,\widetilde{v})}{C_e(e,\widetilde{v})}\right]. \tag{B4}$$

In order for the supposition to hold, this must imply that $e = \Omega\widetilde{v}^{\omega}$. If C is **not** additively separable, then this requires that $e^{\frac{\omega-1}{\omega}}$ can be factored out of both terms on the right side of (B4), leaving only terms involving $\widetilde{v}$:

$$\frac{C_v(e,\widetilde{v})\,\widetilde{v}}{C_e(e,\widetilde{v})} = \Gamma_1(\widetilde{v})\, e^{\frac{\omega-1}{\omega}} \qquad , \qquad \frac{C(e,\widetilde{v})}{C_e(e,\widetilde{v})} = \Gamma_2(\widetilde{v})\, e^{\frac{\omega-1}{\omega}}.$$

Moreover, to obtain $e = \Omega\widetilde{v}^{\omega}$ we require that $\Gamma_1(\widetilde{v}) = \Gamma_1\widetilde{v}^{\gamma}$ and $\Gamma_2(\widetilde{v}) = \Gamma_2\widetilde{v}^{\gamma}$, so that we can add the terms on the right side of (B4). Imposing this condition and then dividing the above two expressions gives

$$\frac{C_v(e,\widetilde{v})\,\widetilde{v}}{C(e,\widetilde{v})} = \frac{\Gamma_1}{\Gamma_2}.$$

For this condition to hold, then it must be the case that $C(e,\widetilde{v}) = \Theta g(e) v^{\theta}$. We prove this last step at the end of the proof in **Lemma 1**.

Step 3. We show that if $C(e,\widetilde{v}) = \Theta g(e) v^{\theta}$, then there is no way for the supposition to hold. Under this functional form the optimality condition (B2) becomes:

$$\begin{aligned} C_e(e,\widetilde{v})\, e &= C_v(e,\widetilde{v})\,\widetilde{v} + C(e,\widetilde{v}), \\ \left[\Theta g'(e)\widetilde{v}^{\theta}\right] e &= \left[\theta\Theta g(e)\widetilde{v}^{\theta-1}\right] v + \Theta g(e) v^{\theta}. \end{aligned}$$

Since $\widetilde{v}^{\theta}$ can be factored out of both sides, the optimality condition implies that e is independent of $\widetilde{v}$ which violates the supposition.

Step 4. From steps 2 and 3 above we have established by contradiction that C must be additively separable for the supposition to hold. Now we show that if C is separable, then g and e must be isoelastic for the supposition to hold. If $C(e,\widetilde{v}) = m(g(e) + f(v))$, then the optimality condition can be written

$$\frac{m'(g(e)+f(\widetilde{v}))(g(e)+f(\widetilde{v}))}{m(g(e)+f(\widetilde{v}))} g_e(e)\, e - g(e) = \frac{m'(g(e)+f(\widetilde{v}))(g(e)+f(\widetilde{v}))}{m(g(e)+f(\widetilde{v}))} f_v(v)\, v - f(v).$$

The supposition requires that the addition of functions on both left and right sides are isoelastic in e and $\widetilde{v}$. This requires that m, g and f are themselves isoelastic.[31]

Step 5. Finally, note that the dependence of $C(e,v,n)$ on $\widetilde{v}$ and not v and n separately can be shown. In terms of sufficiency we have already covered this. In terms of necessity, if (v,n) entered not as $\widetilde{v} = (v/n)$, then the first order conditions would produce an extra term involving n's which would violate the requirement imposed by the data of an isoelastic relationship between $\widetilde{v}$ and e.

Lemma 1. *If a function $f(x,y)$ has the property that*

$$\frac{f_x(x,y)x}{f(x,y)} = c,$$

where c is a constant, then $f(x,y) = h(y)x^c$ for some function $h(y)$.

Proof. *Rearrange the above expression:*

$$\frac{f_x(x,y)}{f(x,y)} = \frac{c}{x}.$$

Integrating both sides and, without loss of generality, writing the constants of integration $\log h_1(y)$*, and* $\log h_2(y)$*:*

$$\log h_1(y) + \log f(x,y) = \log h_2(y) + c\log x.$$

[31] It is immediate that the terms involving m must both be constants, and hence m is isoelastic. The terms are the same and if they involve both or either of $\widetilde{v}$ and $\widetilde{e}$ will not result in an isoelastic relationship between e and $\widetilde{v}$. To observe that f and g are isoelastic consider the following. We require that $F_x(x)x - F(x) = ax^b$. The left side can be written $F(x)\left[F_x(x)x/F(x) - 1\right]$. Therefore we require the term in the bracket to be a constant. This will only be the case if $F(x)$ is a constant elasticity function. We then require that the term outside the bracket is isoelastic. Therefore $F(x)$ must be isoelastic.

Exponentiating delivers our the functional form we wished to establish:

$$f(x,y) \quad = \quad \underbrace{\frac{h_2(y)}{h_1(y)}}_{:=h(y)} x^c.$$

Policies. We now derive the policy functions in the text. Without loss of generality we let $C(e,\widetilde{v}) = c_m \left(c_e e^{\gamma_e} + c_v \widetilde{v}^{\gamma_v}\right)^{\gamma_m}$. Recalling equation (B3), the first order conditions implied

$$g(e)\left[\gamma_m\gamma_e - 1\right] = f(\widetilde{v})\left[\gamma_m\gamma_v + 1\right] \qquad \rightarrow \qquad \widetilde{v}(e) = \underbrace{\left[\frac{c_e}{c_v}\frac{\gamma_m\gamma_e - 1}{\gamma_m\gamma_v + 1}\right]^{\frac{1}{\gamma_v}}}_{:=\kappa} e^{\frac{\gamma_e}{\gamma_v}}$$

which is of the form $\widetilde{v}(e) = \Psi e^{\psi}$ as required. Proceeding as above, (i) substituting in for $\widetilde{v}$ in the hiring function $\widetilde{h}_{it} = Q^* e_{it}\widetilde{v}(e_{it})$, (ii) solving for e_{it} as a function of $\widetilde{h}_{it}$ and Q_t^*, (iii) multiplying by Q_t^* to convert e_{it} into the vacancy yield, (iv) taking logs:

$$\log\left(\frac{h_{it}}{v_{it}}\right) \quad = \quad -\frac{1}{\gamma_e+\gamma_v}\log\kappa + \frac{\gamma_e}{\gamma_e+\gamma_v}\log Q_t^* + \frac{\gamma_e}{\gamma_e+\gamma_v}\log\phi_i + \frac{\gamma_v}{\gamma_e+\gamma_v}\log\left(\frac{h_{it}}{n_{it}}\right).$$

The vacancy rate can then be obtained from $\widetilde{v}(e)$:

$$\log\left(\frac{v_{it}}{n_{it}}\right) \quad = \quad \frac{1}{\gamma_e+\gamma_v}\log\kappa - \frac{\gamma_e}{\gamma_e+\gamma_v}\log Q_t^* - \frac{\gamma_e}{\gamma_e+\gamma_v}\log\phi_i + \frac{\gamma_e}{\gamma_e+\gamma_v}\log\left(\frac{h_{it}}{n_{it}}\right).$$

One can observe immediately that summing the two equations delivers $\log(h_{it}/n_{it})$, which verifies that the hiring constraint holds.

B.2 Daily hiring model of DFH

Here we present the model and computations that underlie the estimates of the (i) daily job filling rate, (ii) daily vacancy flow rate referenced in the text and figures. We progress the results of their paper to arrive at a simple set of equations that can be solved numerically.

Define the following variables. Hires at firm i on day s of month t are h_{ist}. Vacancies at the end of the day are v_{ist}. Let f_{it} be the *daily job filling rate*, such that $h_{ist} = f_{it} v_{is-1t}$, assumed to be constant over the month t. Let θ_{it} be the *daily vacancy in-flow rate* and δ_{it} be the daily exogenous vacancy out-flow rate such that

$$v_{ist} = (1 - f_{it})(1 - \delta_{it}) v_{is-1t} + \theta_{it}.$$

Let there be τ days in a month. We observe the following in the JOLTS microdata: (i) *monthly hires* $h_{it} = \sum_{s=1}^{\tau} h_{ist}$, (ii) beginning of month vacancies $v_{it-1} = v_{i0t}$, (iii) end of month vacancies $v_{it} = v_{i\tau t-1}$.

Our aim is to use these data and the above equations to estimate $f_{it}, \theta_{it}, \delta_{it}$. Iterating on the vacancy equation, vacancies at any day s can be written in terms of $f_{it}, \theta_{it}, \delta_{it}$ and v_{it-1}:

$$v_{is-1t} = \left[1 - f_{it} - \delta_{it} + \delta_{it} f_{it}\right]^{s-1} v_{it-1} + \theta_{it} \sum_{j=1}^{s-1} \left[1 - f_{it} - \delta_{it} + \delta_{it} f_{it}\right]^{j-1}.$$

Using $h_{it} = \sum_{s=1}^{\tau} h_{ist} = \sum_{s=1}^{\tau} f_{it} v_{is-1t}$ and this expression:

$$h_{it} = f_{it} v_{it-1} \sum_{s=1}^{\tau} \left[1 - f_{it} - \delta_{it} + \delta_{it} f_{it}\right]^{s-1} + f_{it} \theta_{it} \sum_{s=1}^{\tau} (\tau - s) \left[1 - f_{it} - \delta_{it} + \delta_{it} f_{it}\right]^{s-1}. \tag{B5}$$

Evaluating the vacancy equation at the end of the month, we also have

$$v_{it} = \left[(1 - f_{it})(1 - \delta_{it})\right]^{\tau} v_{it-1} + \theta_{it} \sum_{j=1}^{\tau} \left[(1 - f_{it})(1 - \delta_{it})\right]^{j-1}. \tag{B6}$$

Equations (B5) and (B6) are two equations in three unknowns $\{f_{it}, \theta_{it}, \delta_{it}\}$. As in DFH we simplify this by assuming that δ_{it} is equal to the daily layoff rate ξ_{it}. The daily layoff rate is computed by taking month layoffs ℓ_{it} divided by employment n_{it} and then dividing by τ: $\xi_{it} = (\ell_{it} / \tau n_{it})$. Setting $\delta_{it} = \xi_{it}$ makes (B5) and (B6) two equations in two unknowns $\{f_{it}, \theta_{it}\}$.

We can make some progress beyond DFH by applying results in algebra for finite sums. Let $x_{it} = 1 - f_{it} - \delta_{it} + \delta_{it} f_{it}$. Plugging this in:

$$\begin{aligned} v_{it} &= x_{it}^{\tau} v_{it-1} + \theta_{it} \sum_{j=1}^{\tau} x_{it}^{j-1}, \\ h_{it} &= f_{it} \left[\sum_{s=1}^{\tau} x_{it}^{s-1}\right] v_{it-1} + f_{it} \theta_{it} \left[\sum_{s=1}^{\tau} (\tau - s) x_{it}^{s-1}\right]. \end{aligned}$$

Manipulating these obtains two expressions that can be computed sequentially given x_{it}:

$$\theta_{it} = \frac{v_{it} - x_{it}^{\tau} v_{it-1}}{g_0(x_{it})} \tag{B7}$$

$$f_{it} = \frac{h_{it}}{g_0(x_{it}) v_{it-1} + \theta_{it} g_1(x_{it})} \tag{B8}$$

where the functions g_0 and g_1 are given by

$$g_0(x) = \frac{1 - x^{\tau}}{1 - x} \quad , \quad g_1(x) = \frac{\tau - g_0(x)}{1 - x}.$$

This implies a simple algorithm:

1. Guess $f_{it}^{(0)}$ and use this to compute $x_{it}^{(0)} = (1 - \delta_{it})(1 - f_{it}^{(0)})$.
2. Use equation (B7) to compute $\theta_{it}^{(0)}$, then equation (B8) to compute $f_{it}^{(1)}$.

- Iterate until $\left| f_{it}^{(k+1)} - f_{it}^{(k)} \right| < \varepsilon$.

In practice this converges after a very few iterations. In the figures and text instead of plotting θ_{it} directly, we transform θ_{it} into a monthly rate as a fraction of employment: $\theta_{it} \tau / n_{it}$.

C Empirical details

This section contains additional details about the data used in our estimation.

C.1 Trends in data

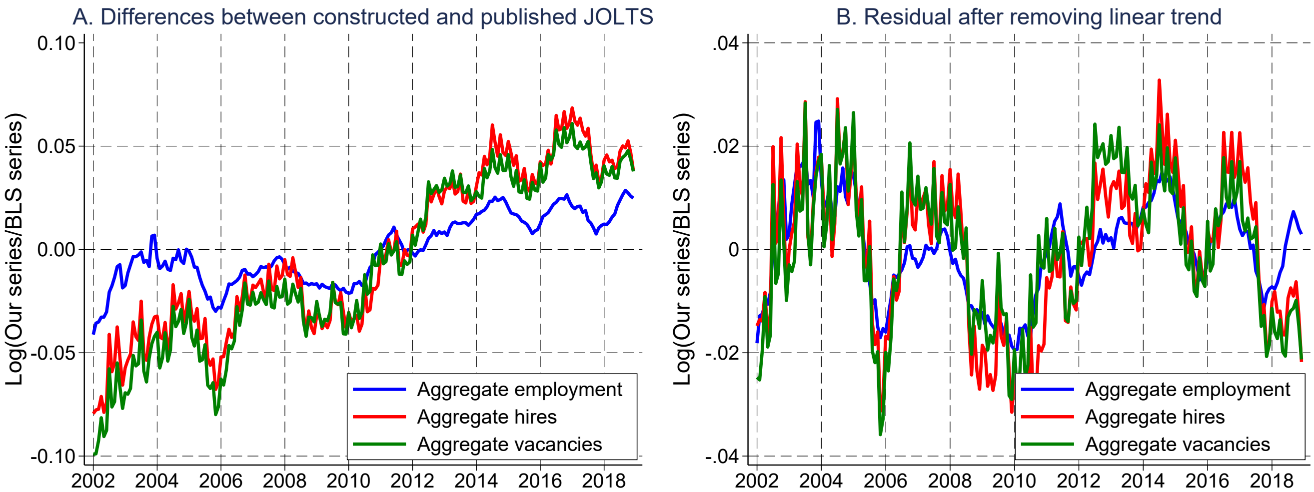

Figure C1: Trends in our data relative to published JOLTS aggregates

Figure C1A compares our construction of aggregate hires, employment and vacancies to officially published BLS data. For a given series X_t we first adjust our series for mean differences from published series in logs. Figure C1A then plots the ratio of the log of our adjusted series to the published series. As can be observed for all three series there is a trend in the bias, with our series being slightly less than the published data in the early part of the sample, and slightly larger in the latter part. This may be due to differences in compilation of published data or imputation in either data set. To account for these differences we take a linear trend out of both our data and the published data—both in logs—saving the residuals from the regression using our data. We then put the trend of the published data back into our residualized data. Figure C1B, plots the log difference between our final data and published data. There is now no longer any trend in bias between the two series, and differences are small, everywhere less than 3 percent in magnitude. There is some cyclicality but this is small. Importantly as our main measures in the paper consist of various ratios of H_t, N_t and V_t, we find that the difference relative to published series move in step across the three variables. Finally, and separately, we take a linear time trend out of each of these series.

C.2 Microdata details

- All data are at the *establishment* level
- Age is defined as the number of years since the establishment first reported having more than one employee.
- QCEW data are reported quarterly but contain monthly payroll and employment at the establishment. These were checked for consistency against the JOLTS.

NAICS categories	Industry categories from DFH
21	Mining, Quarrying, and Oil and Gas Extraction
23	Construction
31,32,33	Manufacturing
22, 42, 48, 49	Utilities; Wholesale Trade; Transportation and Warehousing
44, 45	Retail Trade
51	Information
52, 53	Finance and Insurance; Real Estate and Rental and Leasing
54, 55, 56	Professional Services, Management, Administrative Services
62	Health Care and Social Assistance
71, 72	Arts, Entertainment, and Recreation; Accommodation and Food Services
81	Accommodation and Food Services
>90	Government

Table C1: Categorization of industries used in analysis

- Industry categorizations are given in Table C1. We drop Agriculture (11) and Educational Services (61) due to data collection issues that we were informed of by BLS staff.
- Participation in external researcher programs using employment and wage microdata are at the discretion of the states, which run the unemployment insurance programs report data used in the QCEW. Accessibility varies from project to project. Our project was granted access to data from 37 states: AL, AR, AZ, CA, CT, DE, GA, HI, IA, IN, KS, MD, ME MN, MO, MT, NJ, NM, NV, OH, OK, SC, SD, TN, TX, UT, VA, WA, WI, and WV. These represent over 70 percent of the population. The 5 largest states not included are FL, MI, NC, NY, and PA. Throughout we restrict our sample to the states made available to us. This avoids changing samples when only using JOLTS data, versus when also using establishment age or wage, for which we require the QCEW.
- All aggregation is performed using weights provided by the BLS that adjust for systematic bias in survey non-response rates, and generate a representative sample.
- For further details on data definitions and statistical methods see the *BLS Handbook of Methods - Chapter 18 - Job Openings and Labor Turnover Survey*.