Online Appendix to
The Cyclical Behavior of Job Quality and Real Wage Growth

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Draft:

This appendix describes the data and presents a sensitivity analysis of the results presented in the main article to various sampling restrictions and variable definitions.

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A. Data Appendix

The analysis focuses on respondents in the cross-sectional sample, who at the time of the interview were not enrolled in school and were employed.

Wages: The wage is the hourly rate of pay constructed by the NLSY. Nominal wages are deflated using the annual CPI index (All Urban Consumers, U.S City Average, All Items) from the Bureau of Labor Statistics (base period 1982-84). Wages were deflated using the CPI of the year when the worker last worked for the job as reported at the time of the interview. Observations with missing wage information or real wages below $1 and above $100 are dropped.

Hours: These are the usual weekly hours worked. Observations with missing information on hours were dropped.

Class of the job: The sample includes workers in the private sector only, thus dropping government employees, self-employed and those working without pay.

Industry Classification: The NLSY has employed the 3-digit 1970 and 1980 Census classification system in the 1979-2000 surveys in order to code all jobs into industry groups. Beginning 2002, the 3-digit 2000 Census codes were used to classify industries of all jobs reported by the respondents. To minimize potential inconsistencies or the effect of coding changes due to switching from the 1970/1980 to 2000 classification system for respondents who did not change jobs between consecutive interviews, 9 broader industry groups are defined based on the reported industry classification. The groups are: Agriculture, Forestry and Fisheries; Mining; Construction; Manufacturing; Utilities, Transportation and Warehousing; Wholesale and Retail Trade; Finance, Insurance, Real Estate, Rental and Leasing; Professional, Scientific, Technical Services, Management, Administrative and Waste Management Services, Educational Services, Health Services, Accommodation and Food Services, Arts, Entertainment and Recreation, Other Services; Public Administration

Job start date: The starting date of the job is identified by subtracting tenure (constructed by the NLSY and measured in weeks) from the date the worker last worked for the job as reported at the interview date. Jobs that started prior to 1976 are disregarded.

Current age: The current age corresponding to each job observation is constructed as the difference between the year the worker last worked at the job as reported at the time of the interview and the birth year. The age at the start of the job is calculated as the difference between the start year of the job and the birth year of the respondent. We only consider jobs that started when the re-

spondent was 16 or older. Moreover, we restrict attention to workers with current age 21 years old and above.

Experience: This is actual experience measure in weeks constructed by adding for consecutive interviews the "total number of weeks the respondent worked since the last interview". This variable is constructed by the NLSY for all respondents of ages 16 years old and above.

Unemployment rate: The unemployment rate is the monthly, seasonally adjusted, civilian unemployment rate for ages 16+ obtained from the Bureau of Labor Statistics. The contemporaneous unemployment rate is the unemployment rate at the date (month, calendar year) when the respondent reported last working for the job. The initial unemployment rate corresponds to the unemployment rate at the date (month, calendar year) the job started. The minimum unemployment rate in the wage growth specifications is calculated as the historical minimum unemployment rate recorded between the date (month, calendar year) the job started and the last interview date (month, calendar year) before the contemporaneous year.

Labor market tightness: We follow Shimer (2005) to construct the series on market tightness. The constructed series uses the number of vacancies per 1000 unemployed from the JOLTS starting in December 2000. For years prior to 2004, the labor market tightness is computed by dividing the help wanted ad index from the Conference Board by the number of unemployed. The two series overlap for years 2000 to 2003. A consistent series was constructed by projecting the tightness measure from the JOLTS on the tightness measure from the Conference Board for 2000-2003, and then by extrapolating backwards. The projection equation is $\theta_{JOLTS} = 0.12 + 58.1 \times \theta_{CB}$ with a correlation coefficient of 0.98. Figure A.1 shows the resulting series along with the unemployment rate.

Training variables: At every survey respondents were asked if they had participated in any training programs since the previous interview. Detailed information, then, were collected on the duration, intensity and the type of the training spells. The training data used in our estimations cover 1979 to 2004.The earlier surveys, 1979 to 1986, do not provide these details for training spells that lasted less than a month. For longer spells, the respondents reported the beginning and ending dates of each training spell (in month and year) and the average number of hours a week spent for training. This enables a construction of the total time investment in training in hours since the last interview. If the respondent was currently enrolled in a training program, an additional dummy variable was created. Until

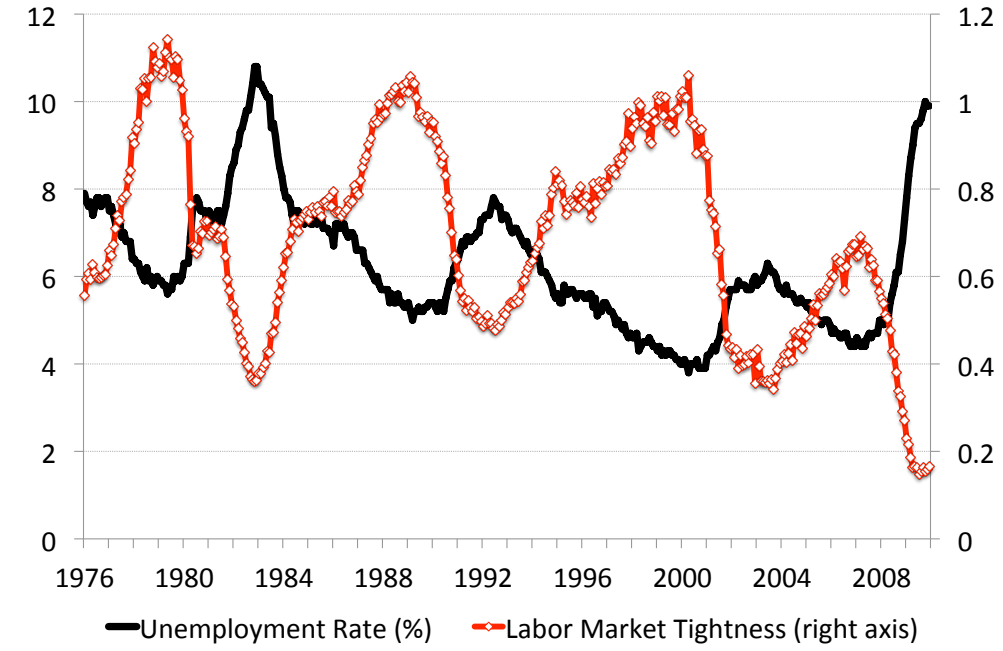

FIGURE A.1. CYCLICAL FLUCTUATIONS IN THE LABOR MARKET

1988, up to three training spells were recorded. Later this limit was raised to four. The respondents were however asked if they had fourth (fifth after 1986) training program to report. Based on this question, it is possible to calculate the number of workers for which this limit was binding. The limit was binding for a total of only 80 observations (about 0.2% of the sample) in all years.

B. Robustness of the Results to Sample Selection

In this section, we investigate the sensitivity of the results to sampling restrictions. Table B.1 reports the estimates from the main specification where the sum of (log) job duration and average tightness are included as a proxy for match quality along with the unemployment measures. This specification corresponds to the fourth column in Table 2. The results for the benchmark sample used in the text are reported in Column 5. Specifications to the left of Column 5 are less restrictive than the benchmark sample, and those to the right are more restrictive (see table notes for detailed sampling restrictions). The proxy for match quality and the minimum unemployment rate are significant in all of the specifications in Table B.1. The estimated elasticity of wages to the minimum unemployment rate

is second lowest in Column 5. In more restricted samples, e.g. full time workers with only one job at the time of the interview, the evidence for contractual variation in wages is stronger. The initial unemployment rate, however, becomes insignificant when multiple job holders and part-time jobs are excluded from the sample. This suggests that the market for full-time jobs is best described by contracts where workers do not commit to employment but firms do.

Table B.2 reports estimates when job duration and average tightness are included separately in the regressions. The two primary results discussed in the main text are observed in all of the samples. The coefficient on average tightness is never positive, confirming our first conclusion that separations do not lead to procyclical variation in average match quality. Second, the coefficient on the minimum unemployment rate is consequently smaller than the figure in corresponding sample in Table B.1 in all of the columns.

Table B.3 replaces average tightness with minimum and maximum tightness measures during the job spell. This specification is comparable to the last column in Table 2, replicated in the fifth column here. That the minimum unemployment rate is significant and the maximum tightness is not can be seen in all of the samples.

B.1. Wage Growth Regressions

Next we analyze the sensitivity of wage growth regression in Table 1 to sampling restrictions. The results for the benchmark sample used in the text are reported in Column 5. Specifications to the left of Column 5 of Table B.4 are less restrictive than the benchmark sample, and those to the right are more restrictive (see table notes for detailed sampling restrictions). The change in the minimum unemployment rate is statistically significant in all of the specifications in Table B.4. The coefficients vary between -5.5% and -2.6%, comparable to the estimates obtained from wage level regressions in Tables B.2 and B.3.

B.2. Tightness versus Unemployment Rate

The original paper by BD used the unemployment rate to gauge the cyclical conditions in the labor market whereas Hagedorn and Manovskii (2013) use the concept of labor market tightness. In principle, one could redefine measures of contractual variation using labor market tightness instead of the unemployment rate. To that end, we computed the maximum tightness between the time of hire, t_0, and the time of the wage observation $t \in \{t_0, .., T\}$ to replace the minimum

Table B.1—Robustness of the Estimates to Sampling Restrictions

	(1) $\log w$	(2) $\log w$	(3) $\log w$	(4) $\log w$	(5) $\log w$	(6) $\log w$	(7) $\log w$	(8) $\log w$
U_t	0.31	0.14	0.12	0.27	0.33	0.10	−0.13	−0.07
	(0.39)	(0.30)	(0.29)	(0.24)	(0.23)	(0.30)	(0.32)	(0.33)
$\log(duration \times \bar{\theta}_j)$	6.64^{***}	6.60^{***}	6.06^{***}	5.81^{***}	5.61^{***}	6.05^{***}	3.99^{***}	3.33^{***}
	(0.37)	(0.33)	(0.34)	(0.30)	(0.28)	(0.38)	(0.47)	(0.48)
U_{t_0}	0.30	−0.30	−0.45	−0.64	-0.71^{*}	−0.61	−0.54	−0.18
	(0.53)	(0.43)	(0.43)	(0.34)	(0.31)	(0.38)	(0.44)	(0.45)
U_t^{min}	-3.48^{***}	-2.46^{***}	-2.41^{***}	-1.91^{***}	-2.00^{***}	-2.54^{***}	-3.11^{***}	-3.49^{***}
	(0.77)	(0.58)	(0.56)	(0.46)	(0.43)	(0.61)	(0.69)	(0.69)
N	81,000	67,126	61,796	61,199	58,967	47,292	34,710	30,774

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Samples: All restrictions are added cumulatively. The fifth column corresponds to the benchmark sample used in the main text. (1) Basic sample: all workers over the age of 21 and all jobs that started in 1976 or later and where the respondent was at least 16 years of age at the time of hire. (2) drops jobs outside the private sector. (3) drops observations where the respondent was enrolled in school. (4) drops wages less than $1 an hour and more than $100 an hour in 1982-1984 dollars. (5) drops jobs with less than 15 hours of work per week. (6) drops workers who hold multiple jobs at the time of the interview. (7) drops workers who are not working at the time of the interview. (8) drops part-time jobs (those with 15 to 34 hours of work per week).

TABLE B.2—ROBUSTNESS OF THE ESTIMATES TO SAMPLING RESTRICTIONS

	(1) $\log w$	(2) $\log w$	(3) $\log w$	(4) $\log w$	(5) $\log w$	(6) $\log w$	(7) $\log w$	(8) $\log w$
U_t	−0.20	−0.49	−0.46	−0.22	−0.14	−0.32	−0.41	−0.28
	(0.42)	(0.30)	(0.31)	(0.25)	(0.23)	(0.31)	(0.33)	(0.34)
U_{t_0}	0.26	−0.38	−0.52	-0.71^{*}	-0.77^{*}	−0.68	−0.55	−0.19
	(0.54)	(0.44)	(0.44)	(0.35)	(0.32)	(0.39)	(0.45)	(0.46)
U_t^{min}	-4.69^{***}	-3.91^{***}	-3.78^{***}	-3.07^{***}	-3.13^{***}	-3.57^{***}	-3.80^{***}	-4.02^{***}
	(0.85)	(0.66)	(0.63)	(0.52)	(0.49)	(0.70)	(0.75)	(0.74)
$\log(duration)$	6.02^{***}	6.00^{***}	5.54^{***}	5.28^{***}	5.10^{***}	5.59^{***}	3.79^{***}	3.15^{***}
	(0.34)	(0.31)	(0.30)	(0.27)	(0.25)	(0.34)	(0.44)	(0.46)
$\log \bar{\theta}_j$	−2.71	-4.69^{*}	-4.60^{*}	-3.19^{*}	-3.18^{*}	−2.40	−3.23	−2.46
	(2.32)	(1.86)	(1.89)	(1.61)	(1.55)	(1.99)	(2.33)	(2.38)
N	81,000	67,126	61,796	61,199	58,967	47,292	34,710	30,774

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Samples: All restrictions are added cumulatively. The fifth column corresponds to the benchmark sample used in the main text. (1) Basic sample: all workers over the age of 21 and all jobs that started in 1976 or later and where the respondent was at least 16 years of age at the time of hire. (2) drops jobs outside the private sector. (3) drops observations where the respondent was enrolled in school. (4) drops wages less than $1 an hour and more than $100 an hour in 1982-1984 dollars. (5) drops jobs with less than 15 hours of work per week. (6) drops workers who hold multiple jobs at the time of the interview. (7) drops workers who are not working at the time of the interview. (8) drops part-time jobs (those with 15 to 34 hours of work per week).

TABLE B.3—ROBUSTNESS OF THE ESTIMATES TO SAMPLING RESTRICTIONS

	(1) $\log w$	(2) $\log w$	(3) $\log w$	(4) $\log w$	(5) $\log w$	(6) $\log w$	(7) $\log w$	(8) $\log w$
U_t	−0.60	−0.76*	−0.71*	−0.47	−0.40	−0.56	−0.52	−0.40
	(0.40)	(0.30)	(0.31)	(0.25)	(0.23)	(0.32)	(0.33)	(0.34)
U_{t_0}	0.33	−0.37	−0.54	−0.67	−0.73*	−0.63	−0.59	−0.19
	(0.59)	(0.49)	(0.49)	(0.40)	(0.37)	(0.43)	(0.48)	(0.50)
U_t^{min}	−4.24***	−3.47***	−3.50***	−2.71***	−2.75***	−3.33***	−3.80***	−4.05***
	(0.91)	(0.69)	(0.67)	(0.52)	(0.50)	(0.76)	(0.80)	(0.76)
$\log(duration)$	4.44***	4.80***	4.56***	4.21***	3.99***	4.50***	3.19***	2.43***
	(0.57)	(0.46)	(0.45)	(0.37)	(0.34)	(0.48)	(0.64)	(0.66)
$\log \theta_j^{min}$	−7.84***	−7.03***	−6.24***	−5.87***	−6.03***	−5.56***	−4.08*	−4.30*
	(1.61)	(1.39)	(1.36)	(1.20)	(1.18)	(1.35)	(1.58)	(1.69)
$\log \theta_j^{max}$	5.69	3.20	1.62	3.41	3.66	3.32	−0.41	0.32
	(3.59)	(2.75)	(2.72)	(2.27)	(2.23)	(3.18)	(3.58)	(3.41)
N	81,000	67,126	61,796	61,199	58,967	47,292	34,710	30,774

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Samples: All restrictions are added cumulatively. The fifth column corresponds to the benchmark sample used in the main text. (1) Basic sample: all workers over the age of 21 and all jobs that started in 1976 or later and where the respondent was at least 16 years of age at the time of hire. (2) drops jobs outside the private sector. (3) drops observations where the respondent was enrolled in school. (4) drops wages less than $1 an hour and more than $100 an hour in 1982-1984 dollars. (5) drops jobs with less than 15 hours of work per week. (6) drops workers who hold multiple jobs at the time of the interview. (7) drops workers who are not working at the time of the interview. (8) drops part-time jobs (those with 15 to 34 hours of work per week).

TABLE B.4—REAL WAGE GROWTH AND UNEMPLOYMENT RATE: SENSITIVITY TO SAMPLE SELECTION

	(1) $\Delta \log w$	(2) $\Delta \log w$	(3) $\Delta \log w$	(4) $\Delta \log w$	(5) $\Delta \log w$	(6) $\Delta \log w$	(7) $\Delta \log w$	(8) $\Delta \log w$	(9) $\Delta \log w$
ΔU_t	1.27^{**}	0.60	0.76^{*}	0.37	0.31	0.28	0.27	0.27	0.45
	(0.47)	(0.36)	(0.34)	(0.25)	(0.24)	(0.23)	(0.24)	(0.23)	(0.34)
ΔU^{min}	-5.53^{***}	-2.72^{**}	-3.00^{**}	-2.84^{***}	-2.64^{***}	-2.62^{***}	-3.42^{***}	-3.60^{***}	-4.16^{***}
	(1.36)	(0.93)	(0.94)	(0.73)	(0.63)	(0.71)	(0.88)	(0.70)	(0.84)
N	43,653	35,750	32,336	31,908	30,869	24,960	20,175	18,144	10,785

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Samples: All restrictions are added cumulatively. The fifth column corresponds to the benchmark sample used in the main text. (1) Basic sample: all workers over the age of 21 and all jobs that started in 1976 or later and where the respondent was at least 16 years of age at the time of hire. (2) drops jobs outside the private sector. (3) drops observations where the respondent was enrolled in school. (4) drops wages less than $1 an hour and more than $100 an hour in 1982-1984 dollars. (5) drops jobs with less than 15 hours of work per week. (6) drops workers who hold multiple jobs at the time of the interview. (7) drops workers who are not working at the time of the interview. (8) drops part-time jobs (those with 15 to 34 hours of work per week).

Table B.5—Real Wage Growth and Unemployment Rate: Sensitivity to the definition of U_{min}

	(1) $\Delta \log w$	(2) $\Delta \log w$	(3) $\Delta \log w$	(4) $\Delta \log w$	(5) $\Delta \log w$	(6) $\Delta \log w$	(7) $\Delta \log w$	(8) $\Delta \log w$	(9) $\Delta \log w$
ΔU_t	1.81^{***}	0.66	0.72^{*}	0.21	0.15	0.19	0.14	0.11	0.16
	(0.48)	(0.37)	(0.35)	(0.24)	(0.24)	(0.23)	(0.23)	(0.23)	(0.34)
ΔU_{HM}^{min}	-7.89^{***}	-2.78^{**}	-2.60^{**}	-1.83^{*}	-1.66^{*}	-1.96^{**}	-2.49^{***}	-2.48^{**}	-2.35^{*}
	(1.49)	(0.94)	(0.98)	(0.74)	(0.66)	(0.69)	(0.71)	(0.76)	(0.99)
N	43,653	35,750	32,336	31,908	30,869	24,960	20,175	18,144	10,785

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: Table uses the Hagedorn and Manovskii (2013) construction of the minimum unemploymet rate. All sampling restrictions are added cumulatively. The fifth column corresponds to the benchmark sample used in the main text. (1) Basic sample: all workers over the age of 21 and all jobs that started in 1976 or later and where the respondent was at least 16 years of age at the time of hire. (2) drops jobs outside the private sector. (3) drops observations where the respondent was enrolled in school. (4) drops wages less than $1 an hour and more than $100 an hour in 1982-1984 dollars. (5) drops jobs with less than 15 hours of work per week. (6) drops workers who hold multiple jobs at the time of the interview. (7) drops workers who are not working at the time of the interview. (8) drops part-time jobs (those with 15 to 34 hours of work per week).

unemployment rate measure in our regressions. This is different than the maximum tightness measure that serves as a proxy for match quality. To approximate match quality, the maximum is taken over the *entire* duration of the job, t_0 to T. As a result, the proxy variable does not vary during the job spell. Therefore, the identification of the contractual variable comes from variations in wages during the job spell, whereas the identification for the match proxy comes from differences in wages across jobs. The results are reported in Table B.6 and lead to the same qualitative conclusions as in Section IV.

C. Reconciliation with Hagedorn and Manovskii (2013)

While the results in Columns (1) and (4) of Table 2 are qualitatively similar to Hagedorn and Manovskii (2013), who also use the NLSY, the point estimates are somewhat different. In particular, they find the coefficient on U^{min} to be statistically zero in the fourth column when match quality is controlled for, and conclude against the presence of wage contracts. The discrepancy between the two results arises from differences in samples as our data includes more recent waves of the NLSY and in the construction of U^{min}. Below, we reconcile the difference by first replicating their sampling restrictions in our data and then running our regressions in their data. While this aligns the point estimates, it does not change our earlier conclusion that the primary concern is one of specification.

To compare our findings, we make two changes: first, we drop the waves 2006 and 2008 from our sample, and, second, we reconstruct U^{min}. With respect to the latter, Hagedorn and Manovskii (2013) interpret the wage reported by a worker to be the *average* wage since the last interview date. Consequently, they average all the right-hand-side variables including, in particular, U^{min}.[1] The time interval between consecutive interviews typically varies between 1 and 2 years as the NLSY switched from annual to biannual interviews after 1994. It can be much longer when the respondent misses interview cycles. This interpretation is not warranted by the data. The questions underlying the wage information in the NLSY explicitly refer to the respondent's "*current or most recent assignment*" with the employer and represent the usual rate of pay, where "*Usually is 50 percent of the time or more, or your most frequent schedule during the past 4*

[1]Specifically, they first compute the minimum unemployment rates between t_0, the start period of the job, and all the periods between t_0 and t, the period when a wage observation is reported. Denote this variable by $U^{min}_{t0,j}$ for $j = t_0, t_0+1, ..t$. Suppose the previous wage observation reported by the worker is in period $t-k$. Then they compute the average of the minimum unemployment rates: $U^{min}_{HM} = \frac{1}{k}(\sum_{j=t-k}^{t} U^{min}_{t0,j})$. They associate this variable with the wage observation reported in period t, w_t.

or 5 months".[2] We therefore follow BD in adopting the conventional approach of attributing the reported wage to the most recent period (see also Bils (1985), Grant (2003) among many others), and construct U^{min} by taking the minimum between the job-start period t_0 and the interview period t. For comparison, we denote the conventional measure by U^{min}_{BD} in this section.

Table C.1 shows the results. Columns 1-4 exclude data from 2006 and 2008. The first column regresses wages on the total tightness and U_t.[3] The second column introduces U_0 and U^{min}_{HM} and replicates the finding that the latter is statistically zero when the log-sum of job duration and average tightness is included in the regression. When U^{min}_{HM} is replaced with the conventional measure in the third column, the elasticity of the wage with respect to the minimum unemployment rate becomes significantly negative at -1.29% compared to -0.61% in the second column.[4] The remaining difference between this and the elasticity of -2.00% reported in the fourth column of Table 2 is then attributable to the last two waves of the NLSY.

To see why the two measures yield different results, first note that averaging does not affect variables that are constant on the job, such as proxies for match quality, but those that vary during the job spell, such as the minimum unemployment rate. In particular, it biases the coefficient of U^{min} toward zero if the reported wage is in fact the most recent wage. Consider, for instance, the recovery period after the 1982 recession, where the unemployment rate zigzagged its way down to 5% from its peak of 10.8%. The solid line in Figure C.1 shows the behavior of U^{min} during this period in monthly frequency. Note the flat portions when the contemporanous unemployment rate temporarily rises back before it declines again. In a contractual market, one would expect wages to be constant when the minimum unemployment remains flat. The dotted and the marked lines show the Hagedorn and Manovskii (2013) measure assuming 1-year and 2-year intervals between the wage observations. Because of averaging, these measures keep declining when there are no wage adjustments, reducing their correlation

[2]The expressions in italics are taken from the NLSY questionnaire for the employer supplement available online at https://www.bls.gov/nls/79quex/r20/y79r20empsup.pdf.

[3]We do not make any other changes at the moment. In particular, we do not average the other explanatory variables and do not construct a secondary proxy for match quality based on the employment cycle, consisting of consecutive job cycles where the agent in principle makes job-to-job transitions. It will become apparent that these differences are inconsequential when we run our regressions in their data, where all of these variables are readily available.

[4]For robustness, we also re-estimated our benchmark difference regression in the last column of Table 1. Limiting the sample to NLSY waves 2004 or earlier changes the estimate from -2.64% to -2.30% (s.e. 0.63). Replacing the conventional measure of U_{min} with the average measure reduces it to -1.50% (s.e. 0.67). The detailed description and results for various sampling restrictions can be found in Table B.5.

with wages.[5] Given the observed distribution of time gaps between interviews in the data, this particular discrepancy between the two measures happens in 43% of the wage observations in the sample. As might be expected, we find the discrepancy between the two measures to be the widest when the time interval between interviews is larger: when we re-estimate the specification in Column (2) of Table C.1 using U^{min}_{HM}, but limiting the sample to interviews that are at most a year apart, we obtain an elasticity of -1.25% (s.e. 0.43).

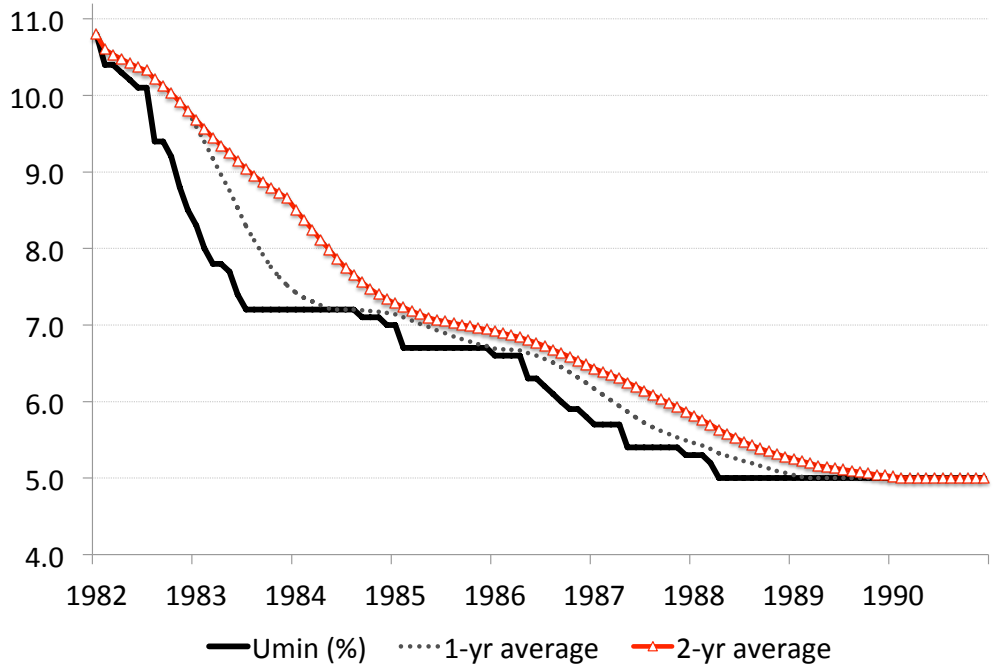

FIGURE C.1. MINIMUM UNEMPLOYMENT DURING POST-1982 RECOVERY

Note: Figure shows the evolution of the minimum monthly unemployment rate for a worker who started a job at the peak of the 1982 recession.

There are further indications that suggest that the reported wages in the data are indeed the most recent wages. First, if they were not, then the estimated coefficient on the conventional measure should have been attenuated toward zero relative to U^{min}_{HM} because of measurement error. Comparing columns (2) and (3) in Table C.1 points to the contrary. Second, if the respondents were reporting an average wage, then the reported wages should be lower for workers with a

[5]The unconditional correlation between wages and U^{BD}_{min} is -0.31 in the data, whereas it is -0.17 between wages and U^{HM}_{min}.

larger gap between the interviews since wages are generally increasing over the life-cycle. When we include the interview time gap as a regressor, the coefficient is statistically zero instead (0.0005 with s.e. 0.0012).

While the differences in samples and measurement change the point estimates, they do not change the general patterns, and, hence, our conclusions. The fourth column in Table C.1 includes job duration and average tightness separately, which reduces the coefficient on U_{BD}^{min} to -2.27%. The coefficients on duration and average tightness confirm our earlier conclusion that there is selection in unobserved match quality, but it is acyclical as average tightness is statistically zero. The last column brings back the 2006 and 2008 data for comparison. The coefficient further declines to -3.13%. These additional waves coincide with the recovery period after the 2001 recession. Since the unemployment rate declines during the recovery, including this period introduces additional variation in U^{min}.

Similar results are obtained when we conduct our regressions using the data supplement to Hagedorn and Manovskii (2013) provided by the American Economic Review on their website. We were not able to match the data file to the original NLSY data. However, we were able to construct the relevant variables within the provided dataset. In particular, we computed the job duration by taking the maximum job tenure ever observed during the job spell. We deduced the quarter when the job started by taking the difference between the interview period and job tenure. This allowed us to merge our unemployment measures (initial and minimum unemployment) with their data. One remaining difference between our samples are the extreme wage observations due to NLSY's imputation of hourly wages. While we use wage observations between 1$ and $100 an hour in 1982 dollars, Hagedorn and Manovskii (2013) report including more extreme values: those between 0.1$ and $1,000 an hour. It is not clear to us what year's price index is used. Therefore, to make our regressions comparable, we excluded the lowest and highest 1% of the observations.

The results are reported in Table C.2. The first column replicates the findings in Table 1 of their paper: when the proxies for match quality are included, the initial and the minimum unemployment rate are insignificant. The elasticity of the wage with respect to U_{HM}^{min} is -0.35% (s.e. 0.63). The second column replaces the unemployment measures with the conventional measure used by BD. The coefficient on the minimum unemployment rate is now significantly negative at -1.50%. The third column includes job duration and average tightness separately. As in Tables 2 and C.1, the estimates suggest that the selection in match quality is

acyclical as the coefficient on average tightness is statistically insignificant.[6] More importantly, the coefficient on the minimum unemployment rate is significant and negative. Columns (4) to (6) repeat the regressions excluding the proxy for match quality based on the employment cycle, q_2^{HM}. Compared to Column (1), the current unemployment rate slightly increases and becomes significant in Column (4). Compared to Column (3), the coefficient on average tightness slightly increases in Column (6) and becomes statistically significant. The coefficients otherwise remain similar in all three specifications. Excluding this proxy for match quality therefore does not affect our results in a significant way.

Overall, both Tables C.1 and C.2 confirm our earlier conclusion that the selection in match quality through separations is not procyclical, and, therefore including proxies for match quality has no bearing for the evidence on dynamic contracts in the wage data.

D. Job Training and Human Capital Models

An important component of a worker's wage is their human capital. Could a systematic variation in human capital accumulation over the business cycle explain our findings? Unlikely. Generic models of on-the-job training (e.g. Ben Porath (1967)) predict countercyclical investment in training: since wages are generally procyclical, it is rational to invest in human capital during recessions, and work during booms. But then workers who are hired during booms, and those who experience favorable market conditions on-the-job would have accumulated less human capital, leading to *lower* wages. In addition, since there are decreasing returns to human capital investment, these workers would also experience *faster* wage growth relative to those hired in recessions. Both of these predictions are in contrast with our findings and the implications of the implicit contracts model. Nonetheless, one could argue for a model with procyclical job training. If, for instance, the employer bears the costs of training, then potential liquidity problems during recessions may lead to lower training activity.

To empirically evaluate the implications of training and human capital for our findings, we directly control for training activity using the available measures in the NLSY. The NLSY questions workers on the amount of time spent on training

[6] In the appendix to Hagedorn and Manovskii (2013), the authors test the sensitivity of their results to the separation of job duration and average tightness in two steps. First, they estimate $\hat{\Gamma}$ by running $\log w = \beta_1(\log duration + \log \bar{\theta}_j) + X\Gamma$, where X includes all the other variables. Then they regress $\log w - \hat{\Gamma}X$ on $\log duration$ and $\log \bar{\theta}_j$ separately. By giving the first pass to $\log duration + \log \bar{\theta}_j$, this approach favors the specification where the two proxies are combined together.

activities since the last time the worker was interviewed. We constructed two variables: total hours of training activity between two wage observations, and the total cumulative amount of training since the worker first entered the labor market. Although the training measures are imperfect, as probably most informal training activity goes unrecorded, we think that the available measures could give us an idea about the plausibility of a human capital explanation of our results (see Kaymak (2014) for a detailed description of the training measures).

Overall, controlling for training does not change the findings. In the wage level regression, the coefficient on the initial unemployment rate is -0.96 (s.e. 0.34) and the coefficient on the minimum unemployment rate is -2.62 (s.e. 0.51). The return to a year of job training is 7.5%. In the wage growth regression, the coefficient on ΔU^{min} is -2.29 (s.e. 0.63), similar to the benchmark estimate of -2.64 reported in Table 1. Based on these results, we conclude that our empirical findings are not likely to be driven by cyclical fluctuations in human capital or training activity.

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TABLE B.6—USING LABOR MARKET TIGHTNESS TO TEST FOR CONTRACTS

	(1) $\log w$	(2) $\log w$	(3) $\log w$	(4) $\log w$	(5) $\log w$
$\log \theta_t$	−0.01	−0.01	0.00	0.01	0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
$\log \theta_{ijt_0}$	0.02	0.03	0.03*	0.03	
	(0.02)	(0.01)	(0.02)	(0.02)	
$\log \theta_{ijt}^{max}$	10.64***	4.38*	9.32***	6.39**	11.83***
	(2.20)	(1.96)	(2.26)	(2.28)	(2.14)
$\log(duration \times \bar{\theta}_{ij})$		5.78***			
		(0.28)			
$\log(duration)_{ij}$			5.19***	3.86***	
			(0.26)	(0.36)	
$\log \bar{\theta}_{ij}$			−2.14		
			(1.81)		
$\log \theta_{ij}^{min}$				−5.95***	
				(1.24)	
$\log \theta_{ij}^{max}$				6.62*	
				(2.61)	
N	58,967	58,967	58,967	58,967	46,028

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: Table replaces the initial and the minimum unemployment rates used by Beaudry and DiNardo (1991) to test for implicit contracts with the initial and the maximum labor market tightness since the start of the job.

TABLE C.1—WAGES, UNEMPLOYMENT HISTORY AND PROXIES FOR MATCH QUALITY: SAMPLE RESTRICTIONS AND VARIABLE DEFINITIONS OF HAGEDORN AND MANOVSKII (2013)

	(1) $\log w$	(2) $\log w$	(3) $\log w$	(4) $\log w$	(5) $\log w$
U_t	-0.93^{***}	-0.14	0.06	-0.33	-0.14
	(0.19)	(0.22)	(0.22)	(0.23)	(0.23)
U_{t_0}		-1.34^{***}	-1.01^{**}	-1.07^{**}	-0.77^{*}
		(0.28)	(0.31)	(0.32)	(0.32)
U_{HM}^{min}		-0.61			
		(0.35)			
U_{BD}^{min}			-1.29^{**}	-2.27^{***}	-3.13^{***}
			(0.43)	(0.49)	(0.49)
$\log(duration \times \bar{\theta}_j)$	6.08^{***}	5.80^{***}	5.76^{***}		
	(0.28)	(0.28)	(0.28)		
$\log(duration)$				5.21^{***}	5.10^{***}
				(0.25)	(0.25)
$\log \bar{\theta}_j$				-1.67	-3.18^{*}
				(1.60)	(1.55)
N	53,932	53,932	53,932	53,932	58,967

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: Columns (1)-(4) use the NLSY 1979 waves up until 2004. U_{HM}^{min} is the minimum unemployment rate computed with the same method as Hagedorn and Manovskii (2013). U_{BD}^{min} is the conventional measure used by Beaudry and DiNardo (1991). See text for definitions.

TABLE C.2—WAGES, UNEMPLOYMENT HISTORY AND PROXIES FOR MATCH QUALITY: HAGEDORN AND MANOVSKII (2013) DATA

	(1) $\log w$	(2) $\log w$	(3) $\log w$	(4) $\log w$	(5) $\log w$	(6) $\log w$
$U_{HM,t}$	-0.94^{*}			-0.90		
	(0.46)			(0.46)		
U_{HM,t_0}	-0.05			-0.26		
	(0.39)			(0.38)		
$U^{min}_{HM,t}$	-0.35			-0.27		
	(0.63)			(0.63)		
$\log \bar{\theta_j} \times$ *duration*	7.00^{***}	6.89^{***}		7.07^{***}	6.97^{***}	
	(0.38)	(0.39)		(0.38)	(0.39)	
q_2^{HM}	2.54^{***}	2.56^{***}	2.68^{***}			
	(0.40)	(0.41)	(0.40)			
$U_{BD,t}$		-0.44	-1.01^{*}		-0.41	-0.96^{*}
		(0.43)	(0.43)		(0.43)	(0.43)
$U^{min}_{BD,t}$		-1.50^{*}	-1.88^{**}		-1.44^{*}	-1.80^{*}
		(0.67)	(0.69)		(0.67)	(0.69)
U_{BD,t_0}		0.46	0.38		0.27	0.20
		(0.34)	(0.34)		(0.33)	(0.33)
$\log \bar{\theta_j}$			1.89			2.16^{*}
			(1.08)			(1.08)
$\log$ *duration*			6.82^{***}			6.90^{***}
			(0.39)			(0.39)
N	41,887	41,883	41,883	41,887	41,883	41,883

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table D.1—Training, Unemployment and Wage Growth

	(1)	(2)
Dependent Var.	$\log w$	$\Delta \log w$
U_t	0.02	
	(0.23)	
U_{ij0}	-0.96^{**}	
	(0.34)	
U_{ijt}^{min}	-2.62^{***}	
	(0.51)	
$\sum_t Tr_t/2000$	7.53^{***}	
	(0.81)	
ΔU_t		0.16
		(0.25)
ΔU^{min}		-2.29^{***}
		(0.63)
$Tr_t/2000$		1.44
		(1.61)
N	53,932	27,849

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: All specifications control for differences in cubic polynomials of experience and tenure, differences in a quadratic time trend, and indicators for industry and region. Tr_t denotes the training activity between two consecutive wage observations, and $\sum Tr_t(/2000)$ denotes the total cumulative training of a worker. Data comes from the 1979 cohort of the NLSY (1979 - 2004). Sample includes men of ages 21 and older who work full time in the private sector. Coefficients and standard errors are multiplied by 100. Standard errors are clustered by start year and current year interactions.