

# Did the Housing Price Bubble Clobber Local Labor Market Job and Worker Flows When It Burst? - Online Appendix

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## I. Data appendix

### A. QWI data

The U.S. Census Bureau has published its local labor market indicators, known as the Quarterly Workforce Indicators (QWI), since 2003. Over the course of the 2000s, these data became national and now cover 92 percent of the private non-agricultural workforce (Abowd and Vilhuber, 2011). The complete set of detailed flows – job creations, job destructions, accessions, separations, churning, earnings, and earnings changes – are available for 566 micropolitan areas and 357 Metropolitan Statistical Area (MSA)s). For most of these areas, the data are available from the mid-1990s onwards. There are very few data suppressions, and these affect only certain items – earnings data are never suppressed (see Abowd et al. (2009) for a detailed description). The data include statistics by age, sex, race, ethnicity and education. We focus our attention on full-quarter jobs and the associated earnings. Full-quarter jobs are those for which the individual has positive earnings from a given employer in at least three consecutive quarters. From such an earnings pattern, continuous employment throughout (at least) the middle quarter is inferred (see Abowd et al. (2009) for the precise definition of this and the other QWI-related concepts used in this article). Full-quarter jobs exclude very short jobs – those lasting only portions of one or two quarters. The average full-quarter earnings

$zw_3$  associated with full-quarter jobs  $f$  are a good approximation of a wage rate. We also use average earnings  $zwf_s$  associated with separations from full-quarter jobs  $f_s$ , and equivalently, average earnings  $zwfa$  associated with accessions to full-quarter jobs  $fa$ . Finally, the associated job creation and destruction rates  $fjcr$  and  $fjdr$  are also part of the QWI.

QWI are provided by the U.S. Census Bureau, and can be downloaded from the VirtualRDC<sup>1</sup>. The QWI are released at the county, Workforce Investment Board (WIB), and Core-Based Statistical Area (CBSA) level. The geographic definitions stem from TIGER 2006 Second Edition. For the CBSA files, a total of 566 micropolitan areas and 357 MSAs are defined in the QWI.

For this paper, data on the 365 MSAs were extracted from the R2011Q3 release of the QWI, covering data through 2010Q4<sup>2</sup>. Historical data availability varies by state, with some states only providing data from 2004Q1 (AZ) onwards, and other providing data from as early as 1990Q1 (MD). Data for NH and MA were not available. For MSAs spanning state borders, the QWI report each state's section separately. These have been aggregated up to the full MSA level, however, in years when data for only some, but not all of the states in the multi-state MSAs are available, this aggregation may not be complete.

We also use data from the prototype National QWI first developed in Abowd and Vilhuber (2011), updated to cover data through 2010Q3. In contrast to the data described in Abowd and Vilhuber (2011), this is the first documented use of the full-quarter variables. The National QWI

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<sup>1</sup><http://vrdc.cornell.edu/qwipu>

<sup>2</sup><http://vrdc.cornell.edu/qwipu/R2011Q3>

are downloadable from the [VirtualRDC](#) as well<sup>3</sup>. The specific version of the data used in this article was created on 2012-01-02 (r2254).<sup>4</sup>

#### B. HPI data

House Price Index (HPI) data used in this paper were downloaded from the [Federal Housing Finance Agency \(FHFA\)](#).<sup>5</sup> We use the data files through 2011Q2, accessed on Sept 15, 2011. HPI are available for 355 MSAs and 29 Metropolitan Statistical Division (MSD)s. We aggregate the MSD components up to their corresponding MSA, yielding 366 MSAs. We also use national HPI numbers for the same time period. All indices were rebaselined to 1995Q1 = 100.

#### C. Unemployment data

The Bureau of Labor Statistics (BLS) provides [data on national unemployment](#). For this paper, we used series LNU04000000Q, accessed on December 20, 2011. [Local Area Unemployment Statistics \(LAUS\)](#) are provided by the BLS (see [Bureau of Labor Statistics \(1997\)](#) and [Brown \(2005\)](#)), and were accessed on November 24, 2011. Data on New England City and Town Area (NECTA)s were excluded, data on MSDs were aggregated to their corresponding MSA, and then further aggregated to quarterly values by taking the simple 3-month average for each calendar quarter.

#### D. Deflators

QWI earnings data are deflated by the Consumer Price Index (All Urban Consumers) (CPI-U) (series CUSR0000SA0), aggregated to quarterly indices by averaging monthly indices. HPI data are deflated by the housing component of the CPI-U (U.S. city average series CUSR0000SAH), again obtaining quarterly indices by simple averaging of monthly indices.

<sup>3</sup><http://vrdc.cornell.edu/news/data/qwi-national-data/>

<sup>4</sup><http://vrdc.cornell.edu/qwipu.national/older/r2254>

<sup>5</sup><http://www.fhfa.gov/Default.aspx?Page=87>

#### E. MSA definitions

MSA definitions vary over time, and different statistical programs use different definitions. The QWI use MSA definitions that were last updated in 2008. The HPI data uses definitions that seem current as of 2009. In the case of the LAUS data, definitions seem current as of 2009, but not all MSAs have tabulated data - in some instances, NECTA definitions are used instead. For the purpose of this paper, we merged only MSAs that had not changed over time, leading to the exclusion of seven MSAs:

##### MSAs excluded from analysis

MSA code	Name of MSA
17180	City of The Dalles, OR
23020	Fort Walton Beach-Crestview-Destin, FL
42260	Sarasota-Bradenton-Venice, FL
47860	Washington, OH
48260	Weirton-Steubenville, WV-OH
48340	West Helena, AR

## II. Discussion of housing prices, and choice of the sample of MSAs

Panel A of Appendix Figure 1 shows the national index as the solid dark line.<sup>6</sup> It peaks in 2006:4, slightly later than the available Case-Shiller Index data. In that quarter, we identify the top decile of MSAs. The historical pattern for the MSAs in this top group are shown with a cross-hatch throughout the displayed history of the HPI. The 35 MSAs highlighted in this chart are the most important ones for understanding local variability in the response to the housing price bubble. Collectively, these 35 MSAs spent at least four years above the national average HPI.

These MSAs are also the local areas that experienced the most rapid housing price deflation, as illustrated in Panel B of Figure

<sup>6</sup>For the graph, the deflated HPI data have been re-baselined to 100 in 1995:1. The analysis uses unnormalized deflated HPI data

1. In the decade leading up to the housing price peak, shown as the solid vertical line on the graph, the MSAs in the top decile consistently experienced the fastest price increases. But the bubble started to deflate before the peak for this group, as shown by the cross-hatches signifying the same MSAs as in Panel A. Well before the official onset of the recession, 2007:4, these MSAs were experiencing price decreases substantially greater (in absolute value) than the national average (solid line), and in the depths of the recession, these MSAs displayed the largest price reductions of all, accounting for the lower tail of distribution even after housing prices started to recover. The MSAs selected by this algorithm are listed in Appendix Table 1.

### III. Analysis data

After data cleaning, standardization, and merging of the different data sources, the analysis files are ready for analysis. For the purposes of this article, a file called “analysis\_09.sas7bdat” was used.

The complete result files for all estimated variables, including EBLUPs, are provided as individual data sets, one per dependent variable (see Appendix Table 2).

### REFERENCES

- Abowd, John M., and Lars Vilhuber.** 2011. “National Estimates of Gross Employment and Job Flows from the Quarterly Workforce Indicators with Demographic and Industry Detail.” *Journal of Econometrics*, 161: 82–99.
- Abowd, John M., Bryce E. Stephens, Lars Vilhuber, Fredrik Andersson, Kevin L. McKinney, Marc Roemer, and Simon Woodcock.** 2009. “The LEHD Infrastructure Files and the Creation of the Quarterly Workforce Indicators.” *Producer Dynamics: New Evidence from Micro Data*, ed. Timothy Dunne, J. Bradford Jensen and Mark J. Roberts Vol. 68 of *Studies in Income and Wealth*, 149–230. University of Chicago Press for the NBER.
- Abowd, John M., Patrick Corbel, and Francis Kramarz.** 1999. “The Entry and Exit of Workers and the Growth of Employment: An Analysis of French Establishments.” *Review of Economics and Statistics*, 81(2): 170–187.
- Brown, Sharon P.** 2005. “Improving estimation and benchmarking of State labor force statistics.” *Monthly Labor Review*, 128(5): 23–31. .
- Bureau of Labor Statistics.** 1997. *BLS Handbook of Methods*. Washington DC:U.S. Bureau of Labor Statistics, Division of Information Services. <http://www.bls.gov/opub/hom/>.
- Davis, Steven J., John C. Haltiwanger, and Scott Schuh.** 1996. *Job creation and destruction*. Cambridge, MA:MIT Press.

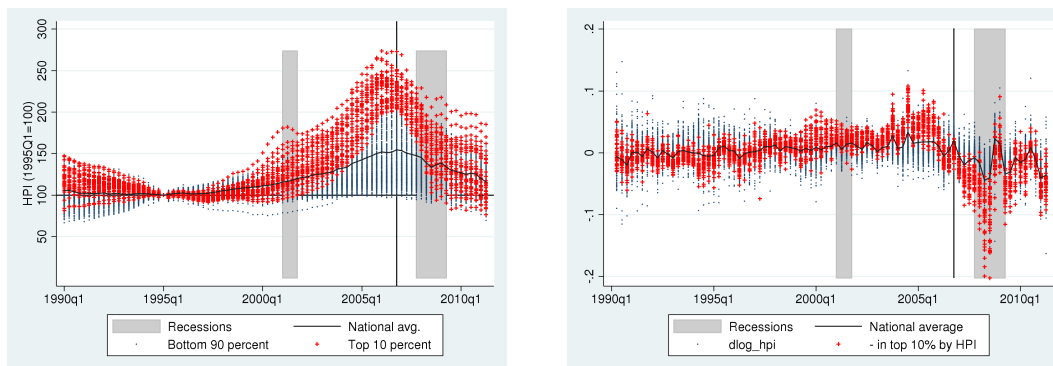


FIGURE 1. EVOLUTION OF HPI OVER THE SAMPLE PERIOD

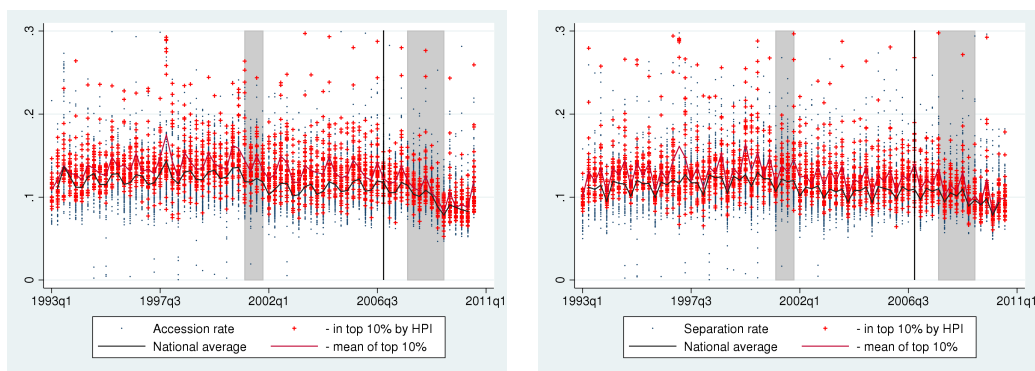


FIGURE 2. FULL-QUARTER WORKER FLOWS

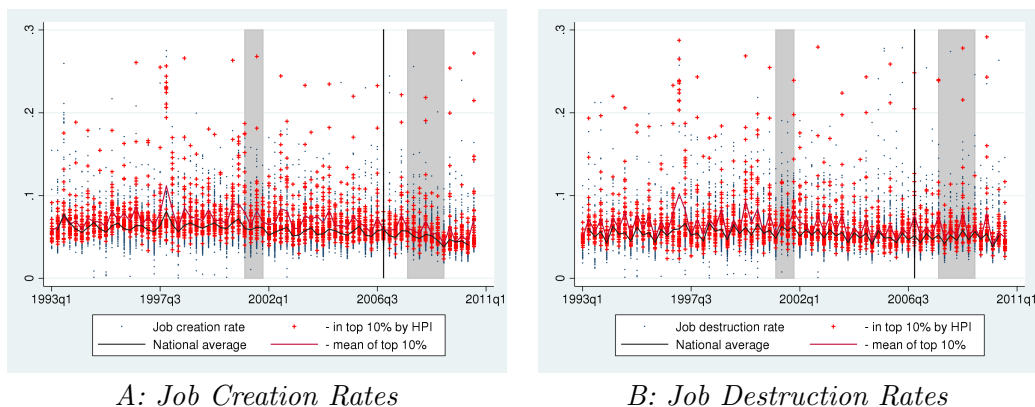


FIGURE 3. FULL-QUARTER JOB FLOWS

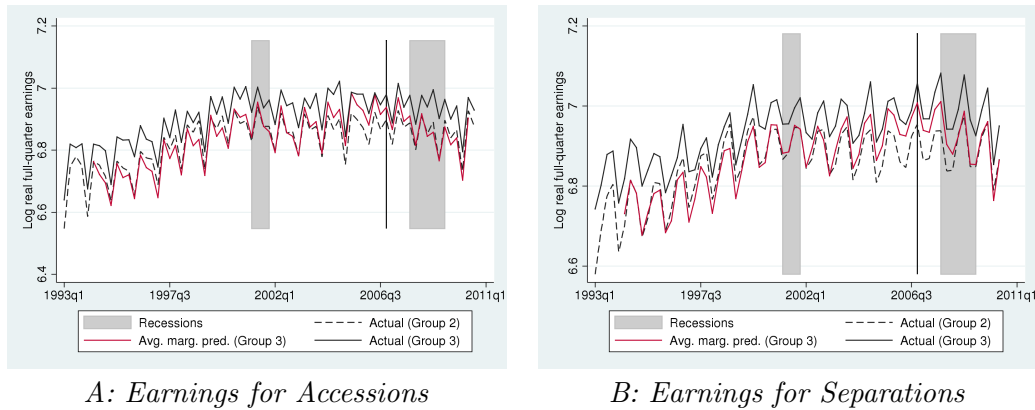


FIGURE 4. LOG FULL-QUARTER MONTHLY EARNINGS FOR WORKER FLOWS, ACTUAL AND PREDICTED, TOP AND MIDDLE GROUPS BY HPI

Table 1—: MSAs in the top group by HPI

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12100	Atlantic City-Hammonton, NJ Metropolitan Statistical Area
12540	Bakersfield-Delano, CA Metropolitan Statistical Area
13460	Bend, OR Metropolitan Statistical Area
15980	Cape Coral-Fort Myers, FL Metropolitan Statistical Area
19660	Deltona-Daytona Beach-Ormond Beach, FL Metropolitan Statistical Area
23420	Fresno, CA Metropolitan Statistical Area
25980	Hinesville-Fort Stewart, GA Metropolitan Statistical Area
27780	Johnstown, PA Metropolitan Statistical Area
31100	Los Angeles-Long Beach-Santa Ana, CA Metropolitan Statistical Area
31460	Madera-Chowchilla, CA Metropolitan Statistical Area
32780	Medford, OR Metropolitan Statistical Area
32900	Merced, CA Metropolitan Statistical Area
33100	Miami-Fort Lauderdale-Pompano Beach, FL Metropolitan Statistical Area
33700	Modesto, CA Metropolitan Statistical Area
34900	Napa, CA Metropolitan Statistical Area
34940	Naples-Marco Island, FL Metropolitan Statistical Area
35840	North Port-Bradenton-Sarasota, FL Metropolitan Statistical Area
36140	Ocean City, NJ Metropolitan Statistical Area
36740	Orlando-Kissimmee-Sanford, FL Metropolitan Statistical Area
37100	Oxnard-Thousand Oaks-Ventura, CA Metropolitan Statistical Area
37340	Palm Bay-Melbourne-Titusville, FL Metropolitan Statistical Area
37380	Palm Coast, FL Metropolitan Statistical Area
38060	Phoenix-Mesa-Glendale, AZ Metropolitan Statistical Area
38940	Port St. Lucie, FL Metropolitan Statistical Area
39460	Punta Gorda, FL Metropolitan Statistical Area
40140	Riverside-San Bernardino-Ontario, CA Metropolitan Statistical Area
40900	Sacramento-Arden-Arcade-Roseville, CA Metropolitan Statistical Area
41500	Salinas, CA Metropolitan Statistical Area
41740	San Diego-Carlsbad-San Marcos, CA Metropolitan Statistical Area
41860	San Francisco-Oakland-Fremont, CA Metropolitan Statistical Area
41940	San Jose-Sunnyvale-Santa Clara, CA Metropolitan Statistical Area
42020	San Luis Obispo-Paso Robles, CA Metropolitan Statistical Area
42060	Santa Barbara-Santa Maria-Goleta, CA Metropolitan Statistical Area
42100	Santa Cruz-Watsonville, CA Metropolitan Statistical Area
42220	Santa Rosa-Petaluma, CA Metropolitan Statistical Area
44700	Stockton, CA Metropolitan Statistical Area
45300	Tampa-St. Petersburg-Clearwater, FL Metropolitan Statistical Area
46700	Vallejo-Fairfield, CA Metropolitan Statistical Area

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Table 2—: List of complete result data files

$FAR$	re_09_far.sas7bdat
$FSR$	re_09_fsr.sas7bdat
$FJCR$	re_09_fjcr.sas7bdat
$FJDR$	re_09_fjdr.sas7bdat
$F$	re_09_log_f.sas7bdat
$\log(ZW_3)$	re_09_log_z_w3_deflated.sas7bdat
$\log(ZWFA)$	re_09_log_z_wfa_deflated.sas7bdat
$\log(ZWFS)$	re_09_log_z_wfs_deflated.sas7bdat

## PROGRAMS

The following generic program was used to estimate the mixed-effect equations for the paper:

```

/* $Id: generic_program_09.sas 2264 2012-01-17 03:33:12Z vilhu001
   $ */

/* defines the dependent variable */
%let depvar=fjdr;
/* defines the corresponding RHS variable at the national level*/
%let indvar=nqwi.&depvar.;

proc hpmixed data=OUTPUTS.analysis_09;
id &depvar. &indvar. geocode qtime year quarter;
class geocode;
model &depvar. =

    &indvar.
    log_hpi_00
        lag1_log_hpi_00 lag2_log_hpi_00
        lag3_log_hpi_00 lag4_log_hpi_00
        lag5_log_hpi_00
    qtr_unemprat_00
        lag1_qtr_unemprat_00 lag2_qtr_unemprat_00
        lag3_qtr_unemprat_00 lag4_qtr_unemprat_00
        lag5_qtr_unemprat_00
    log_hpi
        lag1_log_hpi lag2_log_hpi
        lag3_log_hpi lag4_log_hpi
        lag5_log_hpi
    laus_qtr_unemprat
        lag1_laust_qtr_unemprat
        lag2_laust_qtr_unemprat
        lag3_laust_qtr_unemprat
        lag4_laust_qtr_unemprat
        lag5_laust_qtr_unemprat

    /solution;
/* various random variables from the full interaction are
   commented out after an initial run
   to improve convergence. This varies by variable. */
random geocode*&indvar.
    geocode*log_hpi_00
    geocode*lag1_log_hpi_00
    geocode*lag2_log_hpi_00
    geocode*lag3_log_hpi_00
    geocode*lag4_log_hpi_00
    geocode*lag5_log_hpi_00
    geocode*qtr_unemprat_00
    geocode*lag1_qtr_unemprat_00
    geocode*lag2_qtr_unemprat_00

```



```
geocode*lag3_qtr_unemprat_00
geocode*lag4_qtr_unemprat_00
geocode*lag5_qtr_unemprat_00
geocode*log_hpi
geocode*lag1_log_hpi
geocode*lag2_log_hpi
geocode*lag3_log_hpi
geocode*lag4_log_hpi
geocode*lag5_log_hpi
geocode*laus_qtr_unemprat
geocode*lag1_laus_qtr_unemprat
geocode*lag2_laus_qtr_unemprat
geocode*lag3_laus_qtr_unemprat
geocode*lag4_laus_qtr_unemprat
geocode*lag5_laus_qtr_unemprat
    /solution nofullz type=vc;
ods output SolutionR=OUTPUTS.re_09_&depvar._eblup;
ods output ParameterEstimates=OUTPUTS.re_09_&depvar._fixed;
ods output CovParms=OUTPUTS.re_09_&depvar._cov;
output out=OUTPUTS.re_09_&depvar.
    predicted(noblup)=&depvar._marg_pred
    predicted(blup)=&depvar._pred
    stderr(blup)=&depvar._stderr
    stderr(noblup)=&depvar._marg_stderr
    residual(blup)=&depvar._resid;
run;

/* compute the EBLUPs directly */
data OUTPUTS.re_09_&depvar.;
    set OUTPUTS.re_09_&depvar.;
    &depvar._eblup = &depvar._pred - &depvar._marg_pred;
run;

/* for graphing purposes, we use the data files
    OUTPUTS.re_09_&depvar. directly*/
```

## QWI CONCEPTS AND DEFINITIONS

This section provides a summary of the concepts and definitions underlying the QWI. For a more comprehensive discussion of this, the reader is referred to [Abowd et al. \(2009\)](#).

*B1. Employment for a full quarter*

The concept of full-quarter employment estimates individuals who are likely to have been continuously employed throughout the quarter at a given employer. An individual is defined as full-quarter-employed if that individual has valid UI-wage records in the current quarter, the preceding quarter, and the subsequent quarter at the same employer (SEIN). That is, in terms of the point-in-time definitions, if the individual is employed at the same employer at both the beginning and end of the quarter, then the individual is considered full-quarter employed in the QWI system.

*B2. Accession and separation from full-quarter employment*

Full-quarter employment is not a point-in-time concept. Full-quarter accession refers to the quarter in which an individual first attains full-quarter employment status at a given employer. Full-quarter separation occurs in the last full-quarter that an individual worked for a given employer.

As noted above, full-quarter employment refers to an estimate of the number of employees who were employed at a given employer during the entire quarter. An accession to full-quarter employment, then, involves two additional conditions that are not relevant for ordinary accessions. First, the individual (PIK) must still be employed at the end of the quarter at the same employer (SEIN) for which the ordinary accession is defined. At this point (the end of the quarter where the accession occurred and the beginning of the next quarter) the individual has acceded to continuing-quarter status. An accession to continuing-quarter status means that the individual acceded in the current quarter and is end-of-quarter employed. Next the QWI system must check for the possibility that the individual becomes a full-quarter employee in the subsequent quarter. An accession to full-quarter status occurs if the individual acceded in the previous quarter, and is employed at both the beginning and end of the current quarter.

Full-quarter separation works much the same way. One must be careful about the timing, however. If an individual separates in the current quarter, then the QWI system looks at the preceding quarter to determine if the individual was employed at the beginning of the current quarter. An individual who separates in a quarter in which that person was employed at the beginning of the quarter is a separation from continuing-quarter status in the current quarter. Finally, the QWI system checks to see if the individual was a full-quarter employee in the preceding quarter. An individual who was a full quarter employee in the previous quarter is treated as a full-quarter separation in the quarter in which that person actually separates. Note, therefore, that the definition of full-quarter separation preserves the timing of the actual separation (current quarter) but restricts the estimate to those individuals who were full-quarter status in the preceding quarter.

*B3. Full-quarter job creations, job destructions and net job flows*

The QWI system applies the same job flow concepts to full-quarter employment to generate estimates of full-quarter job creations, full-quarter job destructions, and full-quarter net job flows. Full-quarter employment in the current quarter is compared to full-quarter employment in the preceding quarter. If full-quarter employment has increased between the preceding quarter and the current quarter, then full-quarter job creations are equal to full-quarter employment in the current quarter less full-quarter employment in the preceding

quarter. In this case full-quarter job destructions are zero. If full-quarter employment has decreased between the previous and current quarters, then full-quarter job destructions are equal to full-quarter employment in the preceding quarter minus full-quarter employment in the current quarter. In this case, full-quarter job destructions are zero. Full-quarter net job flows equal full-quarter job creations minus full-quarter job destructions.

*B4. Average earnings of full-quarter employees*

Measuring earnings using UI wage records in the QWI system presents some interesting challenges. The earnings of end-of-quarter employees who are not present at the beginning of the quarter are the earnings of accessions during the quarter. The QWI system does not provide any information about how much of the quarter such individuals worked. The range of possibilities goes from 1 day to every day of the quarter. Hence, estimates of the average earnings of such individuals may not be comparable from quarter to quarter unless one assumes that the average accession works the same number of quarters regardless of other conditions in the economy. Similarly, the earnings of beginning-of-quarter workers who are not present at the end of the quarter represent the earnings of separations. These present the same comparison problems as the average earnings of accessions; namely, it is difficult to model the number of weeks worked during the quarter. If we consider only those individuals employed at the employer in a given quarter who were neither accessions nor separations during that quarter, we are left, exactly, with the full-quarter employees, as discussed above.

The QWI system measures the average earnings of full-quarter employees by summing the earnings on the UI wage records of all individuals at a given employer who have full-quarter status in a given quarter then dividing by the number of full-quarter employees. For example, suppose that in 2000:2 employer *A* has 10 full-quarter employees and that their total earnings are \$300,000. Then, the average earnings of the full-quarter employees at *A* in 2000:2 is \$30,000. Suppose, further that 6 of these employees are men and that their total earnings are \$150,000. So, the average earnings of full-quarter male employees is \$25,000 in 2000:2 and the average earnings of female full-quarter employees is \$37,500 ( $= \$150,000/4$ ).

*B5. Average earnings of full-quarter accessions*

As discussed above, a full-quarter accession is an individual who acceded in the preceding quarter and achieved full-quarter status in the current quarter. The QWI system measures the average earnings of full-quarter accessions in a given quarter by summing the UI wage record earnings of all full-quarter accessions during the quarter and dividing by the number of full-quarter accessions in that quarter.

*B6. Average earnings of full-quarter separations*

Full-quarter separations are individuals who separate during the current quarter who were full-quarter employees in the previous quarter. The QWI system measures the average earnings of full-quarter separations by summing the earnings for all individuals who are full-quarter status in the current quarter and who separate in the subsequent quarter. This total is then divided by full-quarter separations in the subsequent quarter. The average earnings of full-quarter separations is, thus, the average earnings of full-quarter employees in the current quarter who separated in the next quarter. Note the dating of this variable.

## B7. Overview and basic data processing conventions

## B8. Individual concepts

## FLOW EMPLOYMENT

(*m*): for  $qfirst \leq t \leq qlast$ , individual  $i$  employed (matched to a job) at some time during period  $t$  at establishment  $j$

$$(B1) \quad m_{ijt} = \begin{cases} 1, & \text{if } i \text{ has positive earnings at establishment } j \text{ during quarter } t \\ 0, & \text{otherwise.} \end{cases}$$

Flow employment corresponds to the presence of a UI wage record in the system.

## BEGINNING OF QUARTER EMPLOYMENT

(*b*): for  $qfirst < t$ , individual  $i$  employed at the beginning of  $t$  (and the end of  $t - 1$ ),

$$(B2) \quad b_{ijt} = \begin{cases} 1, & \text{if } m_{ijt-1} = m_{ijt} = 1 \\ 0, & \text{otherwise.} \end{cases}$$

## END OF QUARTER EMPLOYMENT

(*e*): for  $t < qlast$ , individual  $i$  employed at  $j$  at the end of  $t$  (and the beginning of  $t + 1$ ),

$$(B3) \quad e_{ijt} = \begin{cases} 1, & \text{if } m_{ijt} = m_{ijt+1} = 1 \\ 0, & \text{otherwise.} \end{cases}$$

## FULL QUARTER EMPLOYMENT

(*f*): for  $qfirst < t < qlast$ , individual  $i$  was employed at  $j$  at the beginning and end of quarter  $t$  (full-quarter job)

$$(B4) \quad f_{ijt} = \begin{cases} 1, & \text{if } m_{ijt-1} = 1 \ \& \ m_{ijt} = 1 \ \& \ m_{ijt+1} = 1 \\ 0, & \text{otherwise.} \end{cases}$$

## ACCESSIONS TO CONSECUTIVE QUARTER STATUS

(*a*<sub>2</sub>): for  $qfirst < t < qlast$ , individual  $i$  transited from accession to consecutive-quarter status at  $j$  at the end of  $t$  and the beginning of  $t + 1$  (accession in  $t$  and still employed at the end of the quarter)

$$(B5) \quad a_{2ijt} = \begin{cases} 1, & \text{if } a_{1ijt} = 1 \ \& \ m_{ijt+1} = 1 \\ 0, & \text{otherwise.} \end{cases}$$

## ACCESSIONS TO FULL QUARTER STATUS

(*a*<sub>3</sub>): for  $qfirst + 1 < t < qlast$ , individual  $i$  transited from consecutive-quarter to full-quarter status at  $j$  during period  $t$  (accession in  $t - 1$  and employed for the full quarter in  $t$ )

$$(B6) \quad a_{3ijt} = \begin{cases} 1, & \text{if } a_{2ijt-1} = 1 \ \& \ m_{ijt+1} = 1 \\ 0, & \text{otherwise.} \end{cases}$$

## SEPARATIONS FROM FULL-QUARTER STATUS

( $s_3$ ): for  $qfirst + 1 < t < qlast$ , individual  $i$  separated from  $j$  during  $t$  with full-quarter status during  $t - 1$

$$(B7) \quad s_{3ijt} = \begin{cases} 1, & \text{if } s_{2ijt} = 1 \ \& \ m_{ijt-2} = 1 \\ 0, & \text{otherwise.} \end{cases}$$

## TOTAL EARNINGS DURING THE QUARTER

( $w_1$ ): for  $qfirst \leq t \leq qlast$ , earnings of individual  $i$  at establishment  $j$  during period  $t$

$$(B8) \quad w_{1ijt} = \sum \text{all } UI\text{-covered earnings by } i \text{ at } j \text{ during } t$$

## EARNINGS OF FULL-QUARTER INDIVIDUAL

( $w_3$ ): for  $qfirst < t < qlast$ , earnings of individual  $i$  at establishment  $j$  during period  $t$

$$(B9) \quad w_{3ijt} = \begin{cases} w_{1ijt}, & \text{if } f_{ijt} = 1 \\ \text{undefined,} & \text{otherwise} \end{cases}$$

## EARNINGS OF FULL-QUARTER ACCESSIONS

( $wa_3$ ): for  $qfirst + 1 < t < qlast$ , earnings of individual  $i$  at employer  $j$  during period  $t$

$$(B10) \quad wa_{3ijt} = \begin{cases} w_{1ijt}, & \text{if } a_{3ijt} = 1 \\ \text{undefined,} & \text{otherwise} \end{cases}$$

## EARNINGS OF FULL-QUARTER SEPARATIONS

( $ws_3$ ): for  $qfirst + 1 < t < qlast$ , individual  $i$  separated from  $j$  during  $t + 1$  with full-quarter status during  $t$

$$(B11) \quad ws_{3ijt} = \begin{cases} w_{1ijt}, & \text{if } s_{3ijt+1} = 1 \\ \text{undefined,} & \text{otherwise} \end{cases}$$

## B9. Establishment concepts

For statistic  $x_{cijt}$  denote the sum over  $i$  during period  $t$  as  $x_{c.jt}$ . For example, beginning of period employment for firm  $j$  is written as:

$$(B12) \quad B_{jt} = b_{.jt} = \sum_i b_{ijt}$$

All individual statistics generate establishment totals according to the formula above. For reference, only a few are listed here.

## BEGINNING-OF-PERIOD EMPLOYMENT

(number of jobs)

$$(B13) \quad B_{jt} = b_{.jt}$$

## END-OF-PERIOD EMPLOYMENT

(number of jobs)

$$(B14) \quad E_{jt} = e_{.jt}$$

## FULL-QUARTER EMPLOYMENT

$$(B15) \quad F_{jt} = f_{.jt}$$

## AVERAGE EMPLOYMENT

for establishment  $j$  between periods  $t - 1$  and  $t$

$$(B16) \quad \bar{E}_{jt} = \frac{(B_{jt} + E_{jt})}{2}$$

## AVERAGE FULL-QUARTER EMPLOYMENT

for establishment  $j$  during period  $t$

$$(B17) \quad \bar{F}_{jt} = \frac{F_{jt-1} + F_{jt}}{2}$$

## FLOW INTO FULL-QUARTER EMPLOYMENT

for establishment  $j$  during  $t$

$$(B18) \quad FA_{jt} = a_{3.jt}$$

## AVERAGE RATE OF FLOW INTO FULL-QUARTER EMPLOYMENT

for establishment  $j$  during  $t$

$$(B19) \quad FAR_{jt} = FA_{jt} / \bar{F}_{jt}$$

with equivalent definitions for the flow out of full-quarter employment ( $FS_{jt}$ ,  $FSR_{jt}$ ).  
Job flow concepts are only defined for the establishment, and are described here.

## NET JOB FLOWS

(change in employment) for establishment  $j$  during period  $t$

$$(B20) \quad JF_{jt} = E_{jt} - B_{jt}$$

## NET CHANGE IN FULL-QUARTER EMPLOYMENT

for establishment  $j$  during period  $t$

$$(B21) \quad FJF_{jt} = F_{jt} - F_{jt-1}$$

## AVERAGE FULL-QUARTER EMPLOYMENT GROWTH RATE

for establishment  $j$  between  $t - 1$  and  $t$

$$(B22) \quad FG_{jt} = \frac{FJF_{jt}}{\bar{F}_{jt}}$$

## FULL-QUARTER JOB CREATIONS

for establishment  $j$  between  $t - 1$  and  $t$

$$(B23) \quad FJC_{jt} = \bar{F}_{jt} \max(0, FG_{jt})$$

## AVERAGE FULL-QUARTER JOB CREATION RATE

for establishment  $j$  between  $t - 1$  and  $t$

$$(B24) \quad FJCR_{jt} = FJC_{jt} / \bar{F}_{jt}$$

## FULL-QUARTER JOB DESTRUCTION

for establishment  $j$  between  $t - 1$  and  $t$

$$(B25) \quad FJD_{jt} = \bar{F}_{jt} \text{abs}(\min(0, FG_{jt}))$$

## AVERAGE FULL-QUARTER JOB DESTRUCTION RATE

for establishment  $j$  between  $t - 1$  and  $t$

$$(B26) \quad FJDR_{jt} = FJD_{jt} / \bar{F}_{jt}$$

## AVERAGE EARNINGS OF FULL-QUARTER EMPLOYEES

$$(B27) \quad ZW_{3jt} = W_{3jt} / F_{jt}$$

## AVERAGE EARNINGS OF TRANSITS TO FULL-QUARTER STATUS

$$(B28) \quad ZWFA_{jt} = WFA_{jt} / FA_{jt}$$

## AVERAGE EARNINGS OF SEPARATIONS FROM FULL-QUARTER STATUS (MOST RECENT FULL QUARTER)

$$(B29) \quad ZWFS_{jt-1} = WFS_{jt-1} / FS_{jt}$$

*B10. Identities*

The identities stated below hold at the establishment level for every subcategory. These identities may not hold in the published data exactly, due to the application of disclosure avoidance protocols.

DEFINITION 1: *Employment at beginning of period  $t$  equals end of period  $t - 1$*

$$B_{jt} = E_{jt-1}$$

DEFINITION 2: *Evolution of end of period employment*

$$E_{jt} = B_{jt} + A_{jt} - S_{jt}$$

DEFINITION 3: *Evolution of average employment*

$$\bar{E}_{jt} = B_{jt} + (A_{jt} - S_{jt})/2$$

DEFINITION 4: *Evolution of full-quarter employment*

$$F_{jt} = F_{jt-1} + FA_{jt} - FS_{jt}$$

DEFINITION 5: *Full-quarter creation-destruction identity*

$$F_{jt} = F_{jt-1} + FJC_{jt} - FJD_{jt}$$

DEFINITION 6: *Full-quarter job flow identity*

$$FJF_{jt} = FJC_{jt} - FJD_{jt}$$

DEFINITION 7: *Full-quarter creation-destruction/accession-separation identity*

$$FA_{jt} - FS_{jt} = FJC_{jt} - FJD_{jt}$$

DEFINITION 8: *Full quarter employment growth rate identity*

$$FG_{jt} = FJCR_{jt} - FJDR_{jt}$$

DEFINITION 9: *Full quarter creation-destruction/accession-separation rate identity*

$$FJCR_{jt} - FJDR_{jt} = FAR_{jt} - FSR_{jt}$$

DEFINITION 10: *Full-quarter payroll identity*

$$W_{3jt} = W_{2jt} - WCA_{jt}$$

#### B11. Aggregation of job flows

The aggregation of job flows is performed using growth rates to facilitate confidentiality protection. The rate of growth  $JF$  for establishment  $j$  during period  $t$  is estimated by:

$$(B30) \quad G_{jt} = \frac{JF_{jt}}{\bar{E}_{jt}}$$

For an arbitrary aggregate  $k = (\text{ownership} \times \text{state} \times \text{substate-geography} \times \text{industry} \times \text{demographic})$  cell, we have:

$$(B31) \quad G_{kt} = \frac{\sum_{j \in \{K(j)=k\}} \bar{E}_{jt} \times G_{jt}}{\bar{E}_{kt}}$$



where the function  $K(j)$  indicates the classification associated with firm  $j$ . We calculate the aggregate net job flow as

$$(B32) \quad JF_{kt} = \sum_{j \in \{K(j)=k\}} JF_{jt}.$$

Substitution yields

$$(B33) \quad JF_{kt} = \sum_j (\bar{E}_{jt} \times G_{jt}) = G_{kt} \times \bar{E}_{kt},$$

so the aggregate job flow, as computed, is equivalent to the aggregate growth rate times aggregate employment. Gross job creation/destruction aggregates are formed from the job creation and destruction rates by analogous formulas substituting  $JC$  or  $JD$ , as appropriate, for  $JF$  (Davis, Haltiwanger and Schuh, 1996, p. 189 for details). Aggregates for the gross worker flows ( $AR$  and  $SR$ ) follow the definitions in Abowd, Corbel and Kramarz (1999).

## ABBREVIATIONS

- BLS** Bureau of Labor Statistics
- CBSA** Core-Based Statistical Area
- CPI-U** Consumer Price Index (All Urban Consumers)
- FHFA** Federal Housing Finance Agency
- HPI** House Price Index
- LAUS** Local Area Unemployment Statistics
- MSA** Metropolitan Statistical Area
- MSD** Metropolitan Statistical Division
- NECTA** New England City and Town Area
- QWI** Quarterly Workforce Indicators
- WIB** Workforce Investment Board

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