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Presentation: Did the Housing Price Bubble Clobber Local Labor Market Job and Worker Flows When It Burst?

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Abstract

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Keywords

Housing prices, local labor markets, Quarterly Workforce Indicators, gross flows, MSA

Disciplines

Labor Economics

Comments

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

By JOHN M. ABOWD AND LARS VILHUBER*

We integrate local labor market data on worker flows, job flows, employment levels, and earnings with Metropolitan Statistical Area (MSA)-level data on housing prices and local area unemployment, to study the local labor market dynamics associated with the U.S. housing price bubble of the late 2000s. We proceed to study the magnitude and timing of the relation between the changes in local housing prices and local worker and job flows, and local labor market earnings. In addition to the unique contribution of using both local labor and housing market data, the paper also considers the contributions of the aggregate movements in the worker and job flows to the heterogeneous local labor market outcomes.

I. Data sources

The U.S. Census Bureau’s local labor market indicators, known as the Quarterly Workforce Indicators (QWI) cover about 92 percent of the private non-agricultural workforce. 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 MSAs). For most of these areas, the data are available from the mid-1990s onwards (Abowd and Vilhuber, 2011). For this article, 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, thus excluding very short jobs.¹ The average monthly full-quarter earnings zw_3 associated with full-quarter jobs f are a good approximation of a wage rate. We also use average monthly full-quarter earnings zwf_s associated with separations from full-quarter jobs f_s , and equivalently, average monthly full-quarter earnings zwf_a associated with accessions to full-quarter jobs f_a . Finally, the associated job creation and destruction rates $fjcr$ and $fjdr$ are also part of the QWI.

The Federal Housing Finance Agency (FHFA) publishes house price indices (HPI) for single-family, detached properties using data on repeat sales and refinancings obtained from the Federal Home Loan Mortgage Corporation (Freddie Mac) and the Federal National Mortgage Association (Fannie Mae) based on a modified version of the Case and Shiller (1987) weighted-repeat sales (WRS) methodology (Calhoun, 1996). Coverage excludes mortgage transactions on attached and multi-unit properties, properties financed by government insured loans, and properties financed by mortgages exceeding the conforming loan limits determining eligibility for purchase by Freddie Mac or Fannie Mae. We use available House Price Index (HPI) for 366 MSAs. All housing price indices are normalized to 100 in 1995:1 and divided by the Consumer Price Index (All Urban Consumers) (CPI-U).

We also use additional information on national and local labor market unemployment rates as estimated by the Bureau of

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¹Abowd et al. (2009) contains the precise definitions of the QWI-related concepts used in this article, which are based on integrated flow concepts from Abowd, Corbel and Kramarz (1999) and job flow concepts from Davis, Haltiwanger and Schuh (1996).

Labor Statistics (BLS).

The merged data have information on 354 MSAs, which are home to about 81 percent of the 2009 U.S. population, and in which 84 percent of all individuals worked in 2006. These data are ideal for studying the local labor market dynamics associated with the U.S. housing price bubble that burst nationally between April and December 2006 (authors' private calculations from Case-Shiller and national HPI data).

II. Model

The basic national equation relating housing price to labor market flows can be expressed as $y_{ot} = x_{ot}\bar{\beta} + \epsilon_{ot}$ for any variable y_{ot} under study and any vector x_{ot} of housing price and aggregate labor market conditions (including an intercept and lags, in our case for 5 quarters without restriction). The local labor market variable can be modeled as a composite of national and local effects which we represent as $y_{jt} = x_{ot}\bar{\beta} + (x_{jt} - x_{ot})\beta_j + \epsilon_{ot} + \epsilon_{jt}$. The purely local equation can be written as

$$(1) \quad y_{jt} - y_{ot} = (x_{jt} - x_{ot})\beta_j + \epsilon_{jt}$$

where the MSA-specific effect β_j is modeled as a mixed effect. Relaxing the specification to eliminate the implicit assumption that the relevant MSA-level equation is a strict deviation from the national equation gives

$$(2) \quad y_{jt} = \beta_{1j}y_{ot} + \beta_{2j}x_{ot} + \beta_{3j}x_{jt} + \epsilon_{jt},$$

where $\beta_{1j} = 1$ with no MSA-level variation, and $-\beta_{2j} = \beta_{3j}$ if the correct model is equation 1. We then restate the equation 2 as a mixed-effects linear model:

$$(3) \quad y_{jt} = \bar{\beta}_1 y_{ot} + \bar{\beta}_2 x_{ot} + \bar{\beta}_3 x_{jt} \\ + \tilde{v}_{1j} y_{ot} + \tilde{v}_{2j} x_{ot} + \tilde{v}_{3j} x_{jt} \\ + \epsilon_{jt},$$

where $\bar{\beta}_1$, $\bar{\beta}_2$ and $\bar{\beta}_3$ are the fixed national average coefficients, and \tilde{v}_{1j} , \tilde{v}_{2j} and \tilde{v}_{3j} are the random deviations of MSA-specific coefficients from the national average. The fitted marginal predictor captures the effects of the overall market conditions and MSA variation in the housing market and

local labor market conditions:

$$(4) \quad \hat{y}_{jt} = \hat{\beta}_1 y_{ot} + \hat{\beta}_2 x_{ot} + \hat{\beta}_3 x_{jt}.$$

The linear predictor inclusive of the estimated random effects captures the incremental contribution of the MSA-specific variation in the coefficients:

$$(5) \quad \hat{\tilde{y}}_{jt} = \hat{y}_{jt} + \hat{v}_{1j} y_{ot} + \hat{v}_{2j} x_{ot} + \hat{v}_{3j} x_{jt}.$$

The model is fit for full-quarter employment, worker flows, job flows, log full-quarter monthly earnings, log full-quarter monthly earnings of accessions (hires plus recalls) and log full-quarter earnings of separations (voluntary plus involuntary) by restricted maximum likelihood assuming that the residuals and the random effects have independent normal distributions with zero means and constant variances.

III. Results

The housing price bubble reached a peak in 2006:4. In that quarter, we identify the top decile of MSAs, which we call "top group" in our analysis. The 35 MSAs in the top group 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, but also experienced the most rapid housing price deflation. We compare them to the middle eight deciles, called "middle group." Well before the official onset of the recession, 2007:4, the top group MSAs experienced price decreases substantially greater (in absolute value) than the national average. 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.²

The differential incidence of the housing price bubble is working its way through the labor market. Consider Figure 1 (Panel A), which shows the level of full-quarter employment nationally from 1993:1 to 2010:2

²These data are illustrated in the figures in the Online Appendix.

with the two official recessions shaded gray. Full-quarter employment fell during both recessions. In the most recent recession, it did not level off until after the recession had been over for several quarters, and it has still not begun to grow again. Overall, the economy lost 4.8 million private full-quarter jobs from 2007:4 to 2009:4. The loss of stable jobs represents 76 percent of the 6.3 million such jobs that were gained from 2002:4 to 2007:4 (trough to peak) following the 2001 recession. Exploiting the flow identities, we note that the loss of full-quarter jobs during the most recent recession was accomplished by a precipitous decline in accessions to full-quarter employment accompanied by a very mild decline in full-quarter separations, which generated substantial net full-quarter employment declines. Using the job creation/destruction identity, we note that the same period saw a mild decline in gross full-quarter job creations and a substantial increase in full-quarter gross job destructions. Nationally, then, the 4.8 million net full-quarter jobs loss was accomplished by slashing the accession rate and allowing jobs to be destroyed through separations.

Figure 1 (Panel B) shows the level of full-quarter employment and the associated worker and job flow rates for the top group MSAs. These 35 MSAs, which accounted for 17 percent (16.6 million) of the 97.8 million full-quarter jobs at the peak of the housing price boom (2006:4), lost 1.1 million full-quarter jobs from 2007:4 to 2009:4.³ The massive loss of full-quarter jobs in the top group MSAs was accomplished through worker flows in which full-quarter accessions fell off the cliff, only beginning to recover in 2010:2, while full-quarter separations fell only very gently over the same period. From the gross job flow side of the identities, full-quarter job creations fell strongly, while full-quarter job destructions increased mildly. The top

group local labor markets experienced a more extreme form of the adjustment process that occurred nationally—destroying stable jobs by massively reducing hiring while separations only fell slightly.

To attempt to capture the differentially strong effect of the housing price bubble on the top group MSAs, we report the results of the MSA-level estimates of the responsiveness of gross worker and job flows to the local housing price index. By controlling for the national level of the labor market flow variable, national housing price movements, local and national labor market conditions, we can isolate the marginal contribution of the local HPI on the predicted flows. By allowing the effect to be heterogeneous across MSAs, we allow for the possibility that high-HPI MSAs had differential responses to all of the control variables. The results are partially summarized in Table 1. For all four MSA-specific gross flow rates, the coefficient on the equivalent national gross flow is essentially unity on average, but with a substantial standard deviation for the MSA-specific random component. In the case of gross worker flows, the random component has a standard deviation of about 14 percentage points while for gross job flows the standard deviation of the random component is about 25 percentage points. Both of these estimates imply very substantial MSA-specific deviation in the gross flows. Online Appendix figures C2 and C3 show that for all four gross flows, the estimated variation in the MSA-specific deviation from the national average is greatest for the top HPI group. That is, the most volatile local labor markets were those in which the housing price bubble was greatest.

[Table 1 about here]

Table 1 also shows the responsiveness of the flows to the local HPI, holding constant the national HPI, local and national labor market conditions. These effects are all positive on average (the estimated long-run effect is zero in all cases, not shown). Except for the full-quarter job creation rate, the standard deviation of the effect is about half

³There is a break in the comparability of the MSA data between 2005:1 and 2005:2 which accounts for the apparent large increase in the stock of full-quarter workers in the top HPI decile in the mid-2000s. From 2005:2 through 2010:2, there are no composition changes in the MSA data.

the effect magnitude, indicating that heterogeneity in the response to the housing price changes also contributed to differential local labor market outcomes.

A full explanation for why the local labor markets in the top group MSAs were more volatile and experienced a more severe recession than the national average awaits further modeling. There are some clues, however, in the wage rate movements. Spatial equilibrium models predict that local housing prices and local wage rates move in the same direction Moretti (2011). Figure 2 (Panel A) shows what happened to log real full-quarter monthly earnings over the course of the recession. For the middle group of MSAs, the real earnings fell very gently. For the top group, those earnings fell more strongly; however, the predicted fall in the log real monthly earnings of full-quarter workers, according to equation 4, shown as the “average marginal prediction (top group)” in the figure, is much greater. If wages had responded in the 35 top group MSAs in a manner consistent with the national average response, those wages would have fallen much more strongly. Hence, the movement towards a new spatial equilibrium in these local markets has been much slower than predicted. Online Appendix figures C4 and C4 show that the same phenomenon occurred for the log real monthly earnings of full-quarter accessions, which exacerbated the adjustments, and full-quarter separations, which mitigated the effects of the full-quarter accession wage rate stability.

Figure 2 (Panel B) shows the equivalent comparison between the “average marginal prediction (top group)” and the actual full-quarter employment for the top group and the middle group. The national model predicts an even more severe decline in employment in these MSAs than actually occurred.

IV. Discussion

The housing price bubble was most extreme in 35 Metropolitan Statistical Areas identified as occupying the top decile of the housing price index in the quarter

of its peak in real terms (2006:4). These 35 MSAs experienced a precipitous drop in full-quarter (stable) employment that was much steeper than the drop in the overall economy. The decline in the levels resulted from gross worker flows in which the full-quarter accession rate fell off a cliff while the full-quarter separation rate declined very slowly. In terms of gross job flows, the full-quarter job creation rate fell sharply while the full-quarter job destruction rate rose only modestly. In the economy as a whole, MSA-specific log real full-quarter monthly earnings fell over the course of the recession, which helped to restore the spatial equilibrium. However, in the 35 MSAs in the top decile of the housing price bubble, this did not happen, which probably exacerbated the local labor market adjustments as evidenced by sustained above-prediction earnings for full-quarter employment and accessions. The log real earnings of full-quarter separations in these labor markets also fell more slowly than predicted, which may have offset the exacerbating effect of the accession earnings.

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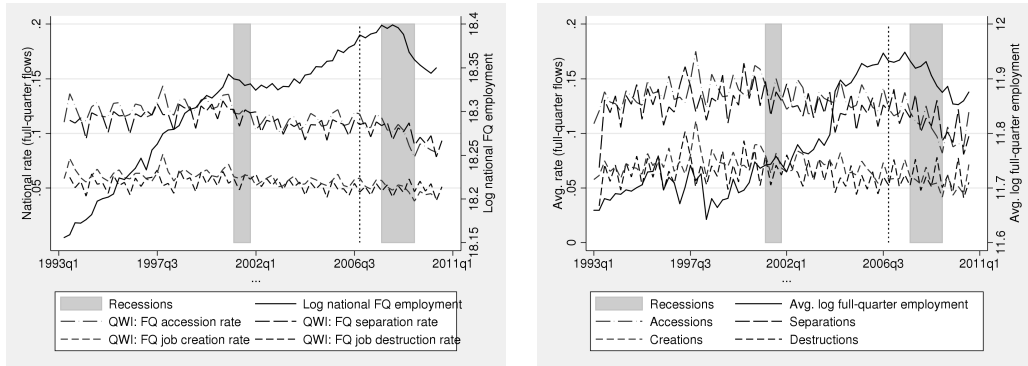
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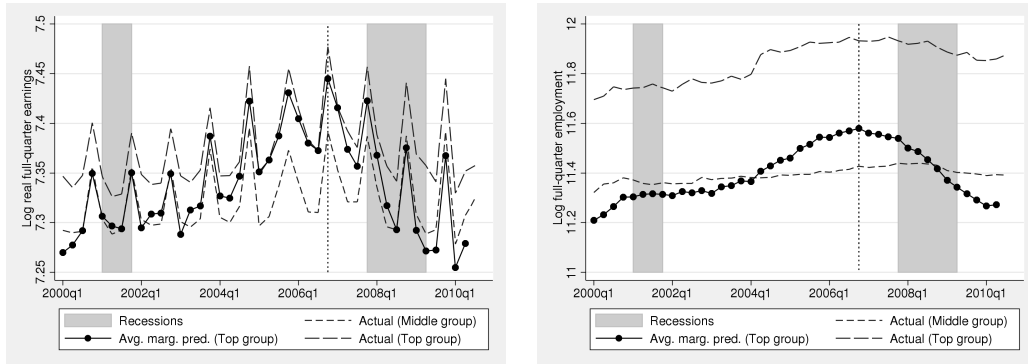
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PANEL A: NATIONAL

PANEL B: TOP DECILE MSAs BY HPI

FIGURE 1. FULL-QUARTER EMPLOYMENT AND FLOWS, 1993-2010



PANEL A: LOG FULL-QUARTER MONTHLY EARNINGS

PANEL B: LOG FULL-QUARTER EMPLOYMENT

FIGURE 2. ACTUAL AND PREDICTED VALUES, TOP AND MIDDLE GROUPS BY HPI, 2000-2010

TABLE 1—SELECTED RESULTS

Dependent Variable	National Variable Coeff.	RE Standard Deviation	Log Local HPI Coeff.	HPI RE Standard Deviation
FQ AR	0.9649 (0.0307)	0.1364	0.0267 (0.0072)	0.011
FQ SR	1.0318 (0.0407)	0.1519	0.0222 (0.0084)	0.0146
FQ JCR	0.9748 (0.0399)	0.2485	0.0133 (0.0069)	-
FQ JDR	1.0236 (0.0491)	0.2693	0.0101 (0.0079)	0.0128

Standard errors are in parentheses. RE=Random effect. AR=Accession rate. SR=Separation rate. JCR = Job creation rate. JDR = Job destruction rate.

DATA APPENDIX

A1. QWI data

The U.S. Census Bureau has published its local labor market indicators, known as the 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 MSAs). 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 $zwfs$ associated with separations from full-quarter jobs fs , 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](#)⁴. 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 2010Q4⁵. 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 are downloadable from the VirtualRDC as well⁶. The specific version of the data used in this article was created on 2012-01-02 (r2254).⁷

A2. HPI data

HPI data used in this paper were downloaded from the Federal Housing Finance Agency (FHFA).⁸ 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

⁴<http://vrdc.cornell.edu/qwipu>

⁵<http://vrdc.cornell.edu/qwipu/R2011Q3>

⁶<http://vrdc.cornell.edu/news/data/qwi-national-data/>

⁷<http://vrdc.cornell.edu/qwipu.national/older/r2254>

⁸<http://www.fhfa.gov/Default.aspx?Page=87>

national HPI numbers for the same time period. All indices were rebaselined to 1995Q1 = 100.

A3. Unemployment data

The 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.

A4. Deflators

QWI earnings data are deflated by the 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.

A5. 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

DISCUSSION OF HOUSING PRICES, AND CHOICE OF THE SAMPLE OF MSAs

Panel A of Appendix Figure C1 shows the national index as the solid dark line.⁹ 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.

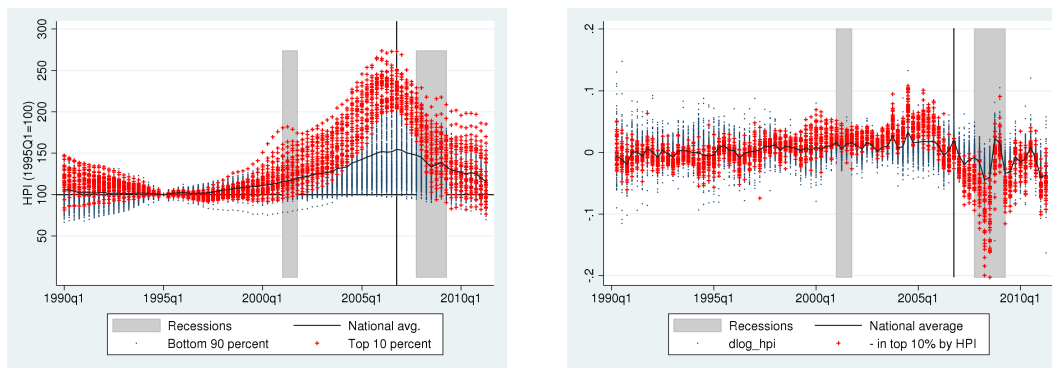
⁹For the graph, the deflated HPI data have been re-baselined to 100 in 1995:1. The analysis uses unnormalized deflated HPI data

These MSAs are also the local areas that experienced the most rapid housing price deflation, as illustrated in Panel B of Figure C1. 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 C1.

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.

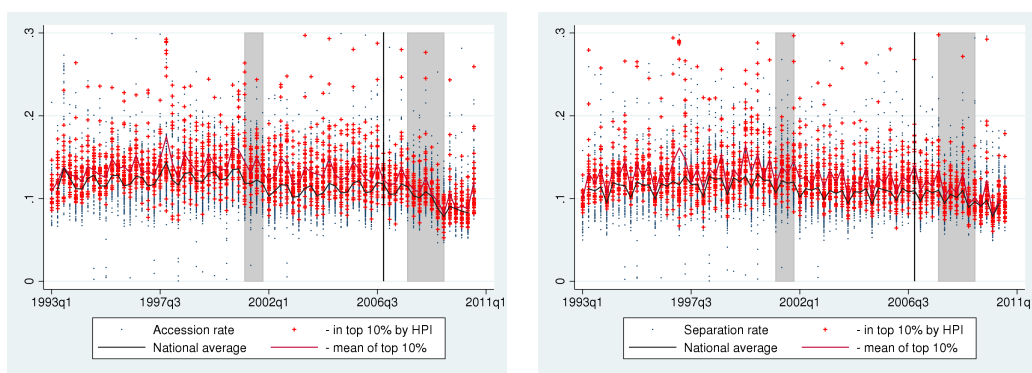
The complete result files for all estimated variables, including EBLUPs, are provided as individual data sets, one per dependent variable (see Appendix Table C2).



Panel A: HPI, top 10 percent as of 2006Q4

Panel B: Log change in HPI

FIGURE C1. EVOLUTION OF HPI OVER THE SAMPLE PERIOD



A: Accession Rates

B: Separation Rates

FIGURE C2. FULL-QUARTER WORKER FLOWS

Table C1—: MSAs in the top group by HPI

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

Table C2—: List of complete result data files

<i>FAR</i>	re_09_far.sas7bdat
<i>FSR</i>	re_09_fsr.sas7bdat
<i>FJCR</i>	re_09_fjcr.sas7bdat
<i>FJDR</i>	re_09_fjdr.sas7bdat
<i>F</i>	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

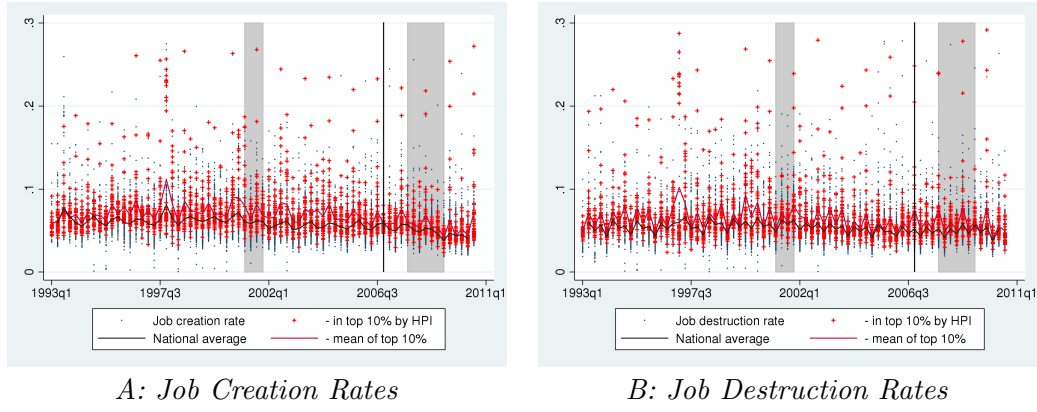


FIGURE C3. FULL-QUARTER JOB FLOWS

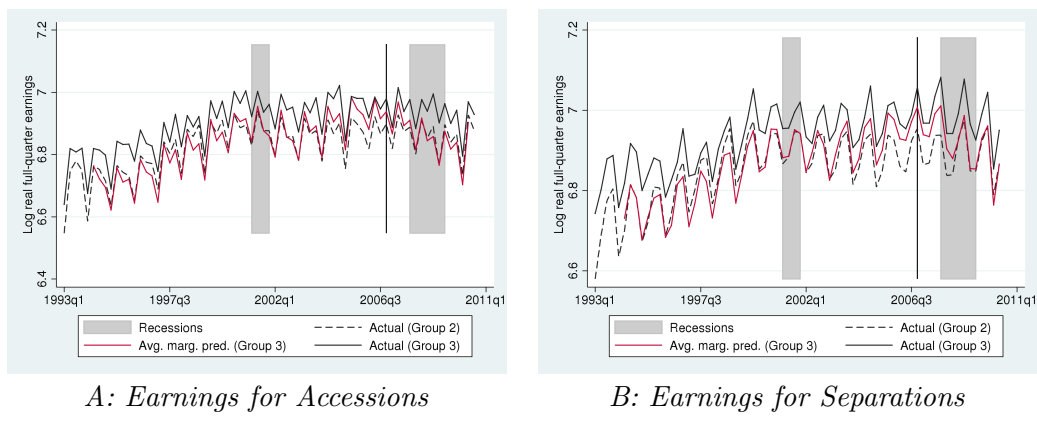


FIGURE C4. LOG FULL-QUARTER MONTHLY EARNINGS FOR WORKER FLOWS, ACTUAL AND PREDICTED, TOP AND MIDDLE GROUPS BY HPI

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_laus_qtr_unemprat
        lag2_laus_qtr_unemprat
        lag3_laus_qtr_unemprat
        lag4_laus_qtr_unemprat
        lag5_laus_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_laус_qtr_unemprat
geocode*lag2_laус_qtr_unemprat
geocode*lag3_laус_qtr_unemprat
geocode*lag4_laус_qtr_unemprat
geocode*lag5_laус_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).

E1. 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.

E2. 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.

E3. 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.

E4. 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).

E5. 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.

E6. 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.

E7. Overview and basic data processing conventions

E8. 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

$$(E1) \quad m_{ijt} = \begin{cases} 1, & \text{if } i \text{ has positive earnings at establishment } j \text{ during quarter } t \\ 0, & \text{otherwise.} \end{cases}$$

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 $t - 1$),

$$(E2) \quad b_{ijt} = \begin{cases} 1, & \text{if } m_{ijt-1} = m_{ijt} = 1 \\ 0, & \text{otherwise.} \end{cases}$$

END OF QUARTER EMPLOYMENT

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

$$(E3) \quad e_{ijt} = \begin{cases} 1, & \text{if } m_{ijt} = m_{ijt+1} = 1 \\ 0, & \text{otherwise.} \end{cases}$$

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)

$$(E4) \quad f_{ijt} = \begin{cases} 1, & \text{if } m_{ijt-1} = 1 \ \& \ m_{ijt} = 1 \ \& \ m_{ijt+1} = 1 \\ 0, & \text{otherwise.} \end{cases}$$

ACCESSIONS TO CONSECUTIVE QUARTER STATUS

(*a*₂): for $qfirst < t < qlast$, individual i transitioned 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)

$$(E5) \quad a_{2ijt} = \begin{cases} 1, & \text{if } a_{1ijt} = 1 \ \& \ m_{ijt+1} = 1 \\ 0, & \text{otherwise.} \end{cases}$$

ACCESSIONS TO FULL QUARTER STATUS

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

$$(E6) \quad a_{3ijt} = \begin{cases} 1, & \text{if } a_{2ijt-1} = 1 \ \& \ m_{ijt+1} = 1 \\ 0, & \text{otherwise.} \end{cases}$$

SEPARATIONS FROM FULL-QUARTER STATUS

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

$$(E7) \quad s_{3ijt} = \begin{cases} 1, & \text{if } s_{2ijt} = 1 \ \& \ m_{ijt-2} = 1 \\ 0, & \text{otherwise.} \end{cases}$$

TOTAL EARNINGS DURING THE QUARTER

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

$$(E8) \quad w_{1ijt} = \sum \text{all } UI\text{-covered earnings by } i \text{ at } j \text{ during } t$$

EARNINGS OF FULL-QUARTER INDIVIDUAL

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

$$(E9) \quad w_{3ijt} = \begin{cases} w_{1ijt}, & \text{if } f_{ijt} = 1 \\ \text{undefined,} & \text{otherwise} \end{cases}$$

EARNINGS OF FULL-QUARTER ACCESSIONS

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

$$(E10) \quad wa_{3ijt} = \begin{cases} w_{1ijt}, & \text{if } a_{3ijt} = 1 \\ \text{undefined,} & \text{otherwise} \end{cases}$$

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

$$(E11) \quad ws_{3ijt} = \begin{cases} w_{1ijt}, & \text{if } s_{3ijt+1} = 1 \\ \text{undefined,} & \text{otherwise} \end{cases}$$

E9. 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:

$$(E12) \quad B_{jt} = b_{.jt} = \sum_i b_{ijt}$$

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)

$$(E13) \quad B_{jt} = b_{.jt}$$

END-OF-PERIOD EMPLOYMENT

(number of jobs)

$$(E14) \quad E_{jt} = e_{.jt}$$

FULL-QUARTER EMPLOYMENT

$$(E15) \quad F_{jt} = f_{.jt}$$

AVERAGE EMPLOYMENT

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

$$(E16) \quad \bar{E}_{jt} = \frac{(B_{jt} + E_{jt})}{2}$$

AVERAGE FULL-QUARTER EMPLOYMENT

for establishment j during period t

$$(E17) \quad \bar{F}_{jt} = \frac{F_{jt-1} + F_{jt}}{2}$$

FLOW INTO FULL-QUARTER EMPLOYMENT

for establishment j during t

$$(E18) \quad FA_{jt} = a_{3.jt}$$

AVERAGE RATE OF FLOW INTO FULL-QUARTER EMPLOYMENT

for establishment j during t

$$(E19) \quad FAR_{jt} = FA_{jt} / \bar{F}_{jt}$$

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

$$(E20) \quad JF_{jt} = E_{jt} - B_{jt}$$

NET CHANGE IN FULL-QUARTER EMPLOYMENT

for establishment j during period t

$$(E21) \quad FJF_{jt} = F_{jt} - F_{jt-1}$$

AVERAGE FULL-QUARTER EMPLOYMENT GROWTH RATE

for establishment j between $t - 1$ and t

$$(E22) \quad FG_{jt} = \frac{FJF_{jt}}{\bar{F}_{jt}}$$

FULL-QUARTER JOB CREATIONS

for establishment j between $t - 1$ and t

$$(E23) \quad FJC_{jt} = \bar{F}_{jt} \max(0, FG_{jt})$$

AVERAGE FULL-QUARTER JOB CREATION RATE

for establishment j between $t - 1$ and t

$$(E24) \quad FJCR_{jt} = FJC_{jt} / \bar{F}_{jt}$$

FULL-QUARTER JOB DESTRUCTION

for establishment j between $t - 1$ and t

$$(E25) \quad FJD_{jt} = \bar{F}_{jt} \text{abs}(\min(0, FG_{jt}))$$

AVERAGE FULL-QUARTER JOB DESTRUCTION RATE

for establishment j between $t - 1$ and t

$$(E26) \quad FJDR_{jt} = FJD_{jt} / \bar{F}_{jt}$$

AVERAGE EARNINGS OF FULL-QUARTER EMPLOYEES

$$(E27) \quad ZW_{3jt} = W_{3jt} / F_{jt}$$

AVERAGE EARNINGS OF TRANSITS TO FULL-QUARTER STATUS

$$(E28) \quad ZWFA_{jt} = WFA_{jt} / FA_{jt}$$

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

$$(E29) \quad ZWFS_{jt-1} = WFS_{jt-1} / FS_{jt}$$

E10. 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*

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

E11. 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:

$$(E30) \quad G_{jt} = \frac{JF_{jt}}{\bar{E}_{jt}}$$

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

$$(E31) \quad G_{kt} = \frac{\sum_{j \in \{K(j)=k\}} \bar{E}_{jt} \times G_{jt}}{\bar{E}_{kt}}$$

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

$$(E32) \quad JF_{kt} = \sum_{j \in \{K(j)=k\}} JF_{jt}.$$

Substitution yields

$$(E33) \quad JF_{kt} = \sum_j (\bar{E}_{jt} \times G_{jt}) = G_{kt} \times \bar{E}_{kt},$$

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