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

John M. Abowd
Cornell University, John.Abowd@cornell.edu

Lars Vilhuber
Cornell University, lv39@cornell.edu

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

Abstract
We integrate local labor market data on worker flows, job flows, employment levels, and earnings with 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.

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

Disciplines
Labor Economics

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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 Villhuber, 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. 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 $zwfs$ associated with separations from full-quarter jobs $fs$, and equivalently, average monthly full-quarter 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.

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 Labor Statistics. Financial support from the U.S. Census Bureau and the National Science Foundation (Grants: SES 0922005, SES 1042181 and SES 1131848) is gratefully acknowledged.

1 Abowd 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 SCHNUH (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 $y_{ot} = x_{ot} \beta + \epsilon_{ot}$ 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 $y_{jt} = x_{ot} \beta + (x_{jt} - x_{ot}) \beta_j + \epsilon_{ot} + \epsilon_{jt}$. The purely local equation can be written as

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

where the MSA-specific effect $\beta_j$ 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

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

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:

$$y_{jt} = \bar{\beta}_1 y_{ot} + \bar{\beta}_2 x_{ot} + \bar{\beta}_3 x_{jt} + \bar{\nu}_1 y_{ot} + \bar{\nu}_2 x_{ot} + \bar{\nu}_3 x_{jt} + \epsilon_{jt},$$

where $\bar{\beta}_1$, $\bar{\beta}_2$ and $\bar{\beta}_3$ are the fixed national average coefficients, and $\bar{\nu}_1$, $\bar{\nu}_2$ and $\bar{\nu}_3$ 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:

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

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

$$\tilde{y}_{jt} = \hat{y}_{jt} + \tilde{\nu}_1 y_{ot} + \tilde{\nu}_2 x_{ot} + \tilde{\nu}_3 x_{jt}.$$

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. 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 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
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.

REFERENCES


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

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

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 $w_{fz}^{3}$ associated with full-quarter jobs $f$ are a good approximation of a wage rate. We also use average earnings $w_{fz}s$ associated with separations from full-quarter jobs $fs$, and equivalently, average earnings $w_{fz}fa$ 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. 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. 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 Villhuber (2011), updated to cover data through 2010Q3. In contrast to the data described in Abowd and Villhuber (2011), this is the first documented use of the full-quarter variables. The National QWI are downloadable from the VirtualRDC as well. The specific version of the data used in this article was created on 2012-01-02 (r2254).

A2. HPI data

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

4http://vrdc.cornell.edu/qwipu
5http://vrdc.cornell.edu/qwipu/R2011Q3
6http://vrdc.cornell.edu/news/data/qwi-national-data/
7http://vrdc.cornell.edu/qwipu.national/older/r2254
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:

<table>
<thead>
<tr>
<th>MSA code</th>
<th>Name of MSA</th>
</tr>
</thead>
<tbody>
<tr>
<td>17180</td>
<td>City of The Dalles, OR</td>
</tr>
<tr>
<td>23020</td>
<td>Fort Walton Beach-Crestview-Destin, FL</td>
</tr>
<tr>
<td>42260</td>
<td>Sarasota-Bradenton-Venice, FL</td>
</tr>
<tr>
<td>47860</td>
<td>Washington, OH</td>
</tr>
<tr>
<td>48260</td>
<td>Weirton-Steubenville, WV-OH</td>
</tr>
<tr>
<td>48340</td>
<td>West Helena, AR</td>
</tr>
</tbody>
</table>

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. 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

Figure C2. Full-quarter worker flows

Table C1—: MSAs in the top group by HPI

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<th>Area Name</th>
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</tr>
<tr>
<td>12540</td>
<td>Bakersfield-Delano, CA Metropolitan Statistical Area</td>
</tr>
<tr>
<td>13460</td>
<td>Bend, OR Metropolitan Statistical Area</td>
</tr>
<tr>
<td>15980</td>
<td>Cape Coral-Fort Myers, FL Metropolitan Statistical Area</td>
</tr>
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<td>19660</td>
<td>Deltona-Daytona Beach-Ormond Beach, FL Metropolitan Statistical Area</td>
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<td>23420</td>
<td>Fresno, CA Metropolitan Statistical Area</td>
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<td>Hinesville-Fort Stewart, GA Metropolitan Statistical Area</td>
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<td>36140</td>
<td>Ocean City, NJ Metropolitan Statistical Area</td>
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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

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<td>FJCR</td>
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</tr>
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<tr>
<td>F</td>
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<td>log(ZWFS)</td>
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</tr>
</tbody>
</table>
Figure C3. Full-quarter Job Flows

A: Job Creation Rates

B: Job Destruction Rates

Figure C4. Log Full-quarter Monthly Earnings for Worker Flows, Actual and Predicted, Top and Middle Groups by HPI

A: Earnings for Accessions

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

```sas
/* $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.analyses_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_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).

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.
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 \( q_{first} \leq t \leq q_{last} \), individual \( i \) employed (matched to a job) at some time during period \( t \) at establishment \( j \)

\[
m_{ijt} = \begin{cases} 
1, & \text{if } i \text{ has positive earnings at establishment } j \text{ during quarter } t \\
0, & \text{otherwise.}
\end{cases}
\]

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

**Beginning of quarter employment**

\( (b) \): for \( q_{first} < t \), individual \( i \) employed at the beginning of \( t \) (and the end of \( t - 1 \))

\[
b_{ijt} = \begin{cases} 
1, & \text{if } m_{ijt-1} = m_{ijt} = 1 \\
0, & \text{otherwise.}
\end{cases}
\]

**End of quarter employment**

\( (c) \): for \( t < q_{last} \), individual \( i \) employed at \( j \) at the end of \( t \) (and the beginning of \( t + 1 \))

\[
e_{ijt} = \begin{cases} 
1, & \text{if } m_{ijt} = m_{ijt+1} = 1 \\
0, & \text{otherwise.}
\end{cases}
\]

**Full quarter employment**

\( (f) \): for \( q_{first} < t < q_{last} \), individual \( i \) was employed at \( j \) at the beginning and end of quarter \( t \) (full-quarter job)

\[
f_{ijt} = \begin{cases} 
1, & \text{if } m_{ijt-1} = m_{ijt} = m_{ijt+1} = 1 \\
0, & \text{otherwise.}
\end{cases}
\]

**Accessions to consecutive quarter status**

\( (a_2) \): for \( q_{first} < t < q_{last} \), 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)

\[
a_{2ijt} = \begin{cases} 
1, & \text{if } a_{1ijt} = 1 \land m_{ijt+1} = 1 \\
0, & \text{otherwise.}
\end{cases}
\]

**Accessions to full quarter status**

\( (a_3) \): for \( q_{first} + 1 < t < q_{last} \), 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 \( t \))

\[
a_{3ijt} = \begin{cases} 
1, & \text{if } a_{2ijt-1} = 1 \land m_{ijt+1} = 1 \\
0, & \text{otherwise.}
\end{cases}
\]
Separations from full-quarter status

\((s_3)\): for \(q_{first} + 1 < t < q_{last}\), individual \(i\) separated from \(j\) during \(t\) with full-quarter status during \(t - 1\)

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

Total earnings during the quarter

\((w_1)\): for \(q_{first} \leq t \leq q_{last}\), earnings of individual \(i\) at establishment \(j\) during period \(t\)

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

Earnings of full-quarter individual

\((w_3)\): for \(q_{first} < t < q_{last}\), earnings of individual \(i\) at establishment \(j\) during period \(t\)

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

Earnings of full-quarter accessions

\((w_a_3)\): for \(q_{first} + 1 < t < q_{last}\), earnings of individual \(i\) at employer \(j\) during period \(t\)

\[(E10)\]
\[w_{a3ijt} = \begin{cases} 
w_{1ijt}, & \text{if } a_{3ijt} = 1 \\
\text{undefined, otherwise} 
\end{cases}\]

Earnings of full-quarter separations

\((w_s_3)\): for \(q_{first} + 1 < t < q_{last}\), individual \(i\) separated from \(j\) during \(t + 1\) with full-quarter status during \(t\)

\[(E11)\]
\[w_{s3ijt} = \begin{cases} 
w_{1ijt}, & \text{if } s_{3ijt+1} = 1 \\
\text{undefined, otherwise} 
\end{cases}\]

\(E9.\) Establishment concepts

For statistic \(x_{cijt}\) denote the sum over \(i\) during period \(t\) as \(x_{cjt}\). For example, beginning of period employment for firm \(j\) is written as:

\[(E12)\]
\[B_{jt} = b_{jt} = \sum_i b_{ijt}\]

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

Beginning-of-period employment

\((\text{number of jobs})\)

\[(E13)\]
\[B_{jt} = b_{jt}\]
**End-of-period employment**

(number of jobs)

(E14) \[ E_{jt} = e_{jt} \]

**Full-quarter employment**

(E15) \[ F_{jt} = f_{jt} \]

**Average employment**

for establishment \( j \) between periods \( t - 1 \) and \( t \)

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

**Average full-quarter employment**

for establishment \( j \) during period \( t \)

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

**Flow into full-quarter employment**

for establishment \( j \) during \( t \)

(E18) \[ FA_{jt} = a_{3,jt} \]

**Average rate of flow into full-quarter employment**

for establishment \( j \) during \( t \)

(E19) \[ FAR_{jt} = FA_{jt} / \bar{F}_{jt} \]

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) \[ JF_{jt} = E_{jt} - B_{jt} \]

**Net change in full-quarter employment**

for establishment \( j \) during period \( t \)

(E21) \[ FJF_{jt} = F_{jt} - F_{jt-1} \]
Average full-quarter employment growth rate

for establishment \( j \) between \( t - 1 \) and \( t \)

(E22)  \[ FG_{jt} = \frac{FJF_{jt}}{\bar{F}_{jt}} \]

Full-quarter job creations

for establishment \( j \) between \( t - 1 \) and \( t \)

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

Average full-quarter job creation rate

for establishment \( j \) between \( t - 1 \) and \( t \)

(E24)  \[ FJCR_{jt} = \frac{FJC_{jt}}{\bar{F}_{jt}} \]

Full-quarter job destruction

for establishment \( j \) between \( t - 1 \) and \( t \)

(E25)  \[ FJD_{jt} = \bar{F}_{jt} \abs{\min(0, FG_{jt})} \]

Average full-quarter job destruction rate

for establishment \( j \) between \( t - 1 \) and \( t \)

(E26)  \[ FJDR_{jt} = \frac{FJD_{jt}}{\bar{F}_{jt}} \]

Average earnings of full-quarter employees

(E27)  \[ ZW_{3jt} = W_{3jt} / F_{jt} \]

Average earnings of transits to full-quarter status

(E28)  \[ ZWFA_{jt} = WFA_{jt} / FA_{jt} \]

Average earnings of separations from full-quarter status (most recent full quarter)

(E29)  \[ ZWFS_{jt-1} = WFS_{jt-1} / FS_{jt} \]

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:

$$(E30) \quad G_{jt} = \frac{JF_{jt}}{E_{jt}}$$

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

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