Erratum: The Aggregate Implications of Regional Business Cycles*

Martin Beraja Erik Hurst Juan Ospina

January 30, 2025

*E-mail: maberaja@mit.edu, erik.hurst@chicagobooth.edu, and jospinte@banrep.gov.co.

1 Overview

We thank Man Chon Iao – a Ph.D. student at NYU – for bringing to our attention that we had a mistake in our code that generated the results in the published version of our paper. In this erratum, we: (1) discuss the mistake, (2) highlight the changes we made to our code in response to the mistake, and (3) reproduce all the relevant tables and figures of the paper after correcting the mistake. In particular, Section 2 of this erratum discusses the mistake, Section 3 updates the paper's core tables and figures and Section 4 updates all remaining motivating and robustness tables and figures. Any table or figure we did not reproduce means the table/figure was unchanged compared to the original.

In summary, the magnitudes of the reported estimates change, although the qualitative results remain.

2 The Mistake

At the heart of the empirical component of our paper is the creation of state level wage measures during the period surrounding the Great Recession. When we initially made our composition adjusted state level wage measures, we summed over the wages for those working in each of our detailed demographic groups within each state for each year using repeated cross sectional data from the American Community Survey. We then divided the total wages paid in each state-demographic group-year cell by the *total number of individuals* within each state-demographic group-year cell. This step produced a measure of the average wage for each demographic group in each state in each year. We then aggregated the state level demographic groups in each year - holding the group weights fixed at some initial time period level - to make our measure of demographically adjusted state wages in each year. Our mistake stems from the fact that we should have divided by the *total number of "working" individuals* within each group instead of the total number of individuals (unconditional on work status) within each group.

3 Main results

The main empirical result in the paper is the estimation of a state level New Keynesian Wage Phillips Curve (Table 5, Section 5). The main quantitative results are the implications for aggregate business cycles of incorporating regional data when estimating a DSGE model (Figures 4 and 5, Section 7). We update these results below.

3.1 New Keynesian Wage Phillips Curve (Section 5)

We introduce two changes in our estimation. The first change simply corrects the original mistake in the code. We refer to results associated with this change as "Corrected Model 1" in what follows. The second change adds one more year of data in the estimation of the New Keynesian Wage Phillips Curve. We refer to the results incorporating both changes as "Corrected Model 2." In each case, the updated estimate of ξ_w — the fraction of nominal wages that do not adjust in a year — remains much smaller when using regional data than the estimate found when using aggregate data alone. This was our key empirical finding in the paper.

In the original paper, we estimated that the slope of the New Keynesian Wage Phillips Curve κ_w was 0.35 (0.16), implying that the fraction of nominal wages that do not adjust ξ_w was 24% during a given year. The corresponding estimate for ξ_w when using aggregate data was 50%. Table 5 (column 2) below shows that the slope κ_w is now 0.15 (0.09) under Corrected Model 1, implying a ξ_w of 37%. However, the estimate of κ_w is no longer statistically significant at standard levels.[1] To mitigate the increased importance of sampling error to potentially bias our estimates, we next added one more year of data (2012) to our estimation (Corrected Model 2). The additional data was already in the file so we are not bringing in new data. Column 4 shows that the slope κ_w is 0.25 (0.12) in this case and becomes statistically significant at standard levels, implying a fraction ξ_w of 29% during a given year.[2]

Specific Changes to the Code: First, we add two lines of additional code to the file from our original replication package entitled "acs_wage_file_econometrica_final.do". In particular, we now define our wage measure by dividing total wages for a given demographic group in a given state by the total number of *working* individuals in that state-demographic group cell.

[1] There is some inherent noise in our state level wage measures (regardless of our unintentional mistake in the code) due to the fact that we make our wage measures using micro data from the American Community Survey which has relatively small samples at the state-demographic cell level. Such sampling error in the wage series seemed to have been less important in the original version of the paper (see footnote 3).

[2] We could have used an additional year of data in our original estimation, but we did not think to do so. We originally just created a data set using the period spanning the Great Recession. As part of this erratum, we also further explored the robustness of our results to different sample periods (either further expanding or shrinking it). This is a sensitivity analysis that we should have done in the original paper. The estimate of the slope κ_w moves around when we use different time periods (results available upon request). All of the estimates – regardless of the sample period – fall within the standard error band reported in the original paper. Additionally, it is worth noting that our estimate of κ_w using the original data (with the error) would have been even higher if we added the 2012 data to our original estimation sample; this would have implied even more wage flexibility from the regional data than what was reported in the original paper if we included the 2012 data. Both with the error and without, adding the 2012 data strengthens our estimates of wage flexibility using the regional data.

The added lines to the code can be found in lines 199 and 207 of the revised file entitled "acs_wage_file_econometrica_final_erratum.do"; these added lines define the total number of workers in each year. We also changed lined 239, 245, and 250 (where we now divide the wage bill by the number of working households instead of total households). This corrects the original mistake (Corrected Model 1). Second, we add the additional year of data and computed relevant statistics for estimating the New Keynesian Wage Phillips Curve with the additional year of data (Corrected Model 2). The added code can be found in lines 718-778 of the new file "acs_state_price_wage_econometrica_final_erratum.do".

3.2 Quantitative Results (Section 7)

The main quantitative results in the paper use the estimates of the New Keynesian Wage Phillips Curve from regional data, together with aggregate data, in order to estimate our DSGE model. In all, our main findings are unchanged: incorporating regional data matters for our understanding of aggregate business cycles.

In Section 7.2.1, we compared the employment response at several horizons to household demand shocks that occurred between 2007 and 2010 (Figure 4). The updated 'Model, Benchmark' line is somewhat different than in the original. In particular, the decline up to 2010 is more pronounced under both Corrected Models 1 and 2, so that the back-of-the-envelope and model-implied responses differ even more than in the original; the fact that there are differences across the lines in these figures is one of the main points of the paper.

In Section 7.2.2, we quantified which shocks can account for the employment decline between 2007 and 2010 as well as the slow recovery afterward (Figure 5). The updated Figure 5 under both Corrected Models 1 and 2 are almost indistinguishable from the original. The only noticeable difference is a somewhat smaller contribution of shocks to 'Aggregate Demand + Policy' in our benchmarks. The broad conclusion of this exercise thus remains the same: the results when using regional data in estimation differ from the results when using aggregate data alone.

Specific Changes to the Code: All the codes remain identical to the ones in the original replication package, except that we replace the estimate for $\kappa_w = 0.35$ in the original paper for $\kappa_w = 0.15$ and $\kappa_w = 0.25$ corresponding to Corrected Models 1 and 2 (Table 5).

4 Other results

4.1 Empirical

Section 3 of the paper showed some simple scatter plots and correlations between state level employment changes between 2007 and 2010 and state level demographically adjusted wage changes between 2007 and 2010. We used these reduced form estimates to motivate how regional wage dynamics during the Great Recession were different than the aggregate wage dynamics. This section was purely illustrative and none of the main results in our paper actually hinged on it. Still, for completeness, we reproduce them below.

We show the updated results under both Corrected Models 1 and 2. Since these results compute long differences during the period around the Great Recession, we now deal with the issue of the increased importance of sampling error by pooling together state level wage and employment changes between 2006 and 2007 (for our pre-recession period) and then again between 2010 and 2011 (for our post-recession period).[3]

The scatter plots (Figure 1) are not visibly different from those in the original paper, although the slopes are somewhat attenuated. Under Corrected Model 2, the real wage elasticity with respect to changes in employment in the regional data (Table 1) is larger than the same elasticity computed using time series data (Table 2).[4] The regional elasticity is marginally significant under Corrected Model 1, again likely due to the increased importance of sampling error we have discussed.

Specific Changes to the Code: For Corrected Model 2, we now define state level nominal wages, real wages and employment rates at the pooled 2006/2007 level and again at the pooled 2010/2011 level. Those changes can be found in lines 114-127 and in lines 228-232 of the revised file.

4.2 Quantitative

In Table 7 in Section 6.1, the log-marginal likelihood and mean squared error are only slightly different than the original under either Corrected Model 1 or 2. The conclusions of Section 6.1 remain unchanged.

[3] In the original paper, pooling together years for our initial and end period had no effect on our results in Section 3 even though the state level wage data was wrongly computed. This is what we mean when we say that sampling error was less important in footnote 1. We believe that the mistake in the code masked the inherent noise in our wage series by mechanically increasing the correlation between employment and wage changes across states.

[4] For symmetry with Table 1, we also pool between 2006/2007 and again 2010/2011 when using the time series data in Table 2.

In Section 6.2, we explored why using aggregate data alone could be problematic when trying to distinguish models with high versus low wage stickiness, as well as why the regional data may help with identification. The updated Figures 3 shows that the bottom line of the analysis remains the same using both Corrected Model 1 and 2: it becomes hard to distinguish across models with high versus low wage stickiness in aggregate data whenever labor supply shocks are important relative to demand shocks (e.g., discount rate shocks) and whenever the time series data have a relatively short sample.

In the original Section 7.1.1, we regressed the log-change in real wages between 2007 and 2010 on the log-change in employment during this time period, where we instrument the latter with the log-change in house prices between 2007 and 2010. We obtained a 3-year elasticity of 0.78 (0.30). Similarly, we computed the impulse responses of real wages and employment over a 3-year horizon, and found an aggregate wage elasticity $\frac{dlog(w^{agg})}{dlog(n^{agg})}$ of 1.16 for our benchmark parameterization that combines regional and aggregate data in estimation. We now obtain a 3-year empirical elasticity of 0.32 (0.27) and a theoretical elasticity of 0.64 under Corrected Model 1, and an empirical elasticity of 0.37 (0.26) and a theoretical elasticity of 0.90 under Corrected Model 2. So the original conclusion of this subsection remains the same: "economic mechanisms that differentially operate between the aggregate and regional levels cannot alone explain the relative stickiness of aggregate wages that we observed during the Great Recession."

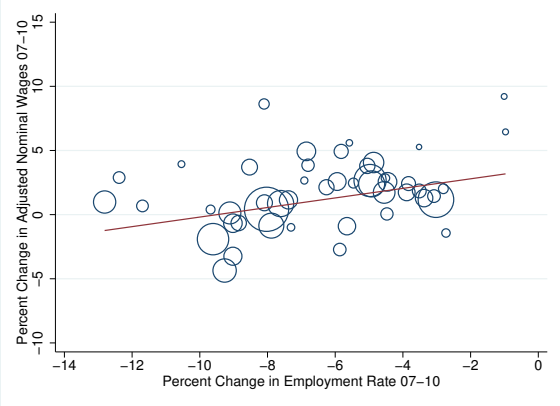
In Section 7.1.2, we computed the wage elasticities following different combinations of shocks (Table 8). The benchmark elasticities to the b shock and to b and μ combined are lower than in the original paper under both Corrected Models 1 and 2. However, they still remain much larger than the elasticities from the model estimated with aggregate data alone. In all, the conclusions from Section 7.1.2 remain unchanged too.

Specific Changes to the Code: Again, all the codes remain identical to the ones in the original replication package, except that we replace the estimate for $\kappa_w = 0.35$ in the original paper for $\kappa_w = 0.15$ and $\kappa_w = 0.25$ corresponding to Corrected Models 1 and 2 (Table 5).

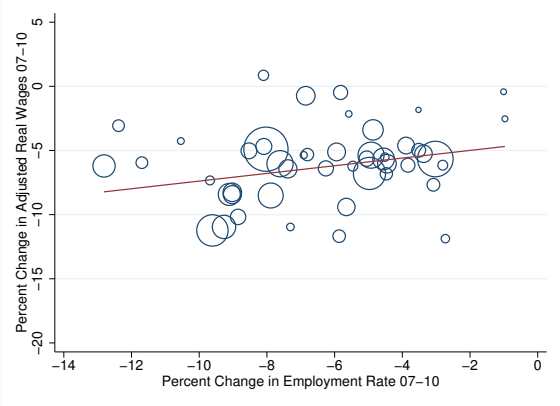
5 Updated Figures and Tables

Below we present the updated results for Figure 1, Figures 3-5, Appendix A5-A6, and Tables 1, 2, and 4-8 of the main paper. All other tables and figures are unaffected by our changes.

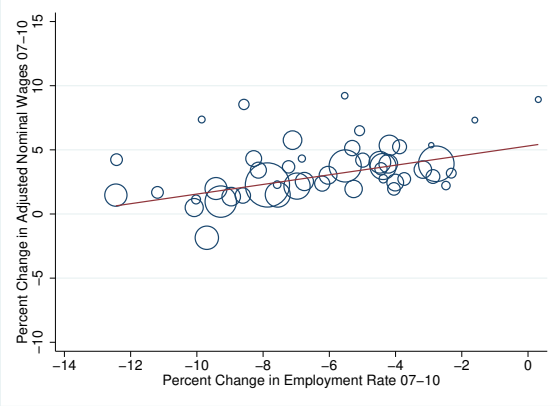
Figure 1: State Employment Growth vs. State Wage Growth, Corrected Data



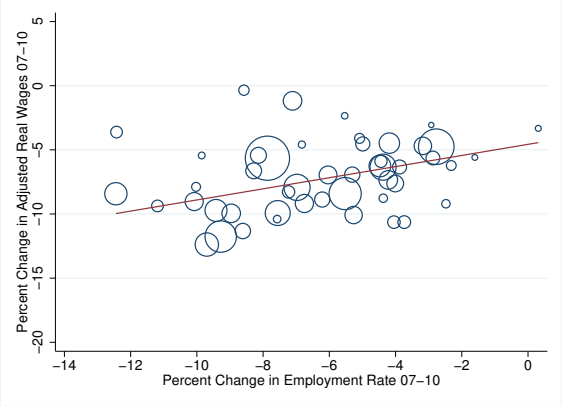
(a) Nominal Wage: Correction 1



(b) Real Wage: Correction 1



(c) Nominal Wage: Correction 2



(d) Real Wage: Correction 2

Note: This figure reproduces Figure 1 from the main paper with the corrected data. Panels (a) and (b) show the scatter plot between state employment growth and state nominal wage growth (panel (a)) and state real wage growth (panel (b)) between 2007 and 2010 correcting the mistake in our real wage measure (referred to as "Corrected Model 1"). Panels (c) and (d) show the same scatter plots between the 2006/2007 pooled data and 2010/2011 pooled data correcting the mistake in our real wage measure (referred to as "Corrected Model 2"). See original text for additional details.

Table 1: Cross-State Estimates of Wage Elasticities During the Great Recession

Wage Measure	Corrected Model 1 Estimated Elasticity	Corrected Model 2 Estimated Elasticity
Nominal Wages	0.37	0.37
	(0.14)	(0.08)
Real Wages	0.30	0.43
	(0.16)	(0.15)

Note: This table replicates Table 1 from the original text with the corrected wage measure. Table reports the simple bi-variate relationship between state employment growth between 2006/2007 pooled data and 2010/2011 pooled data and state demographically adjusted wage growth between the same periods. Column 1 shows the results from just correcting the mistake ("Corrected Model 1"). Column 2 shows the results from correcting the mistake and showing the trend pooling together the initial period data (2006/2007) and end period data (2010/2011) ("Corrected Model 2"). See original text for additional details.

Table 2: Time Series Estimates of Real Wage Elasticities During the Great Recession

Panel A: Corrected Model 1		
	CPS Data	ACS Data
De-Trended Nominal Wage Growth, 2007-2010	-3.8 percent	-4.0 percent
De-Trended Nominal Wage Elasticity, 2007-2010	0.50	0.52
De-Trended Real Wage Growth, 2007-2010	-2.5 percent	-2.7 percent
Real Wage Elasticity, 2007-2010	0.31	0.35
Panel B: Corrected Model 2		
	CPS Data	ACS Data
Nominal Wage Growth, 2007-2010	-5.6 percent	-5.3 percent
Nominal Wage Elasticity, 2007-2010	0.85	0.80
De-Trended Real Wage Growth, 2007-2010	-1.6 percent	-1.3 percent
Real Wage Elasticity, 2007-2010	0.25	0.19

Note: Panel A of the table replicates Table 2 from the main text correcting the mistake (Corrected Model 1). Panel B of the table replicates Table 2 correcting the mistake and also showing the time series trends pooling together 2006/2007 data as the starting point and then pooling together 2010/2011 data as the ending point. During the 2006/2007-2010/2011 period, the aggregate employment rate fell by 6.6 percent. See text of the main paper for additional details about the table construction.

Table 4: Model priors and posteriors

		Prior			Posterior Corrected Models			
					Model 1		Model 2	
		Dist	Mean	SD	Mean	SD	Mean	SD
	Wage Phillips Curve							
ξ_w	Calvo wages	B	N/A	N/A	0.37	N/A	0.29	N/A
h	habit parameter	B	0.50	0.10	0.56	0.07	0.51	0.07
	Others							
α	capital share	N	0.40	0.05	0.12	0.01	0.12	0.01
ι_p	price indexation	B	0.50	0.15	0.22	0.09	0.22	0.09
λ_p	SS price markup	N	1.20	0.10	1.05	0.07	1.04	0.07
ξ_p	Calvo prices	B	0.32	0.20	0.67	0.05	0.65	0.05
χ	capital util. cost	N	1.00	1.00	1.20	0.78	1.29	0.78
S''	capital adjust. cost	N	5.00	3.00	2.15	0.88	2.08	0.87
ϕ_π	reaction infation	N	1.50	0.25	1.51	0.13	1.54	0.13
ϕ_X	reaction GDP growth	N	0.25	0.10	0.47	0.08	0.47	0.08
ρ_R	int. rate smoothing	B	0.50	0.20	0.39	0.09	0.38	0.09
ρ_η	monetary policy	B	0.50	0.20	0.41	0.14	0.42	0.14
ρ_z	TFP growth	B	0.50	0.20	0.14	0.08	0.14	0.08
ρ_g	gov't spending	B	0.50	0.20	0.62	0.14	0.62	0.13
ρ_μ	investment	B	0.50	0.20	0.71	0.09	0.71	0.09
ρ_{λ_p}	price markup	B	0.50	0.20	0.63	0.13	0.67	0.13
ρ_φ	labor supply	B	0.50	0.20	0.65	0.10	0.70	0.10
ρ_b	discount factor	B	0.50	0.20	0.73	0.07	0.73	0.07
$100\sigma_\eta$	monetary policy	IG	2.33	3.31	1.11	0.14	1.13	0.15
$100\sigma_z$	TFP growth	IG	0.80	1.32	2.07	0.23	2.07	0.23
$100\sigma_g$	gov't spending	IG	0.80	1.32	0.47	0.06	0.47	0.06
$100\sigma_\mu$	investment	IG	0.80	1.32	10.43	3.47	10.44	3.49
$100\sigma_{\lambda_p}$	price markup	IG	0.80	1.32	0.74	0.16	0.76	0.16
$100\sigma_\varphi$	labor supply	IG	0.80	1.32	1.28	0.22	1.57	0.25
$100\sigma_b$	discount factor	IG	0.80	1.32	0.51	0.10	0.55	0.11
Log marginal likelihood					-589		-591	

Notes: N stands for Normal; B for Beta; IG for Inverse-Gamma distribution. Metropolis-Hastings: 2 chains with 120,000 draws, first 24,000 were discarded. Log marginal likelihood calculated as Modified Harmonic Mean. "Benchmark" corresponds to the fixed-point estimation with $\vartheta = 0$ which estimates ξ_w using only the regional data. "Aggregate data" corresponds to the estimation with $\vartheta = 2$ which effectively ignores regional data and is equivalent to estimating ξ_w solely from the aggregate data.

Table 5: Estimates of κ_w from Cross State Variation, Base Specification

	Corrected Model 1		Corrected Model 2	
	(1)	(2)	(3)	(4)
$\hat{\alpha}_2$	0.06	0.07	0.07	0.11
	(0.02)	(0.04)	(0.03)	(0.05)
$\hat{\alpha}_3$	0.47	0.47	0.47	0.45
	(0.01)	(0.02)	(0.01)	(0.02)
$\hat{\kappa}_w$	0.12	0.15	0.15	0.25
	(0.05)	(0.08)	(0.06)	(0.12)
$\hat{\xi}_w$	0.40	0.37	0.37	0.29
Instrument for $\tilde{w}_{kt+1}$	Yes	Yes	Yes	Yes
Instrument for $\tilde{MRS}_{kt}$	No	Yes	No	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Sample Size	240	240	240	240

Note: Note: This table replicates Table 5 from the original text with the corrected wage measure. Columns 1 and 2 show the results from just correcting the mistake ("Corrected Model 1"). Columns 3 and 4 show the results from correcting the mistake and adding in the 2012 data for estimation to increase ("Corrected Model 2"). See original text for additional details of the table layout.

Table 6: Estimates of κ_w and ξ_w from Cross State Variation, Robustness Specifications

	Corrected Model 1		Corrected Model 2	
	Estimate of κ_w	Estimate of ξ_w	Estimate of κ_w	Estimate of ξ_w
Base Estimates	0.15	0.37	0.25	0.29
	(0.09)		(0.12)	
Robustness 1: $h = 0.3$	0.16	0.36	0.25	0.29
	(0.09)		(0.12)	
Robustness 2: $h = 0.6$	0.14	0.38	0.24	0.30
	(0.08)		(0.12)	
Robustness 3: $\nu = 1.5$	0.09	0.46	0.14	0.33
	(0.06)		(0.07)	
Robustness 4: $\nu = 0.5$	0.28	0.27	0.48	0.19
	(0.16)		(0.36)	
Robustness 5: Estimate ι_w	0.14	0.37	0.24	0.30
	(0.09)		(0.12)	

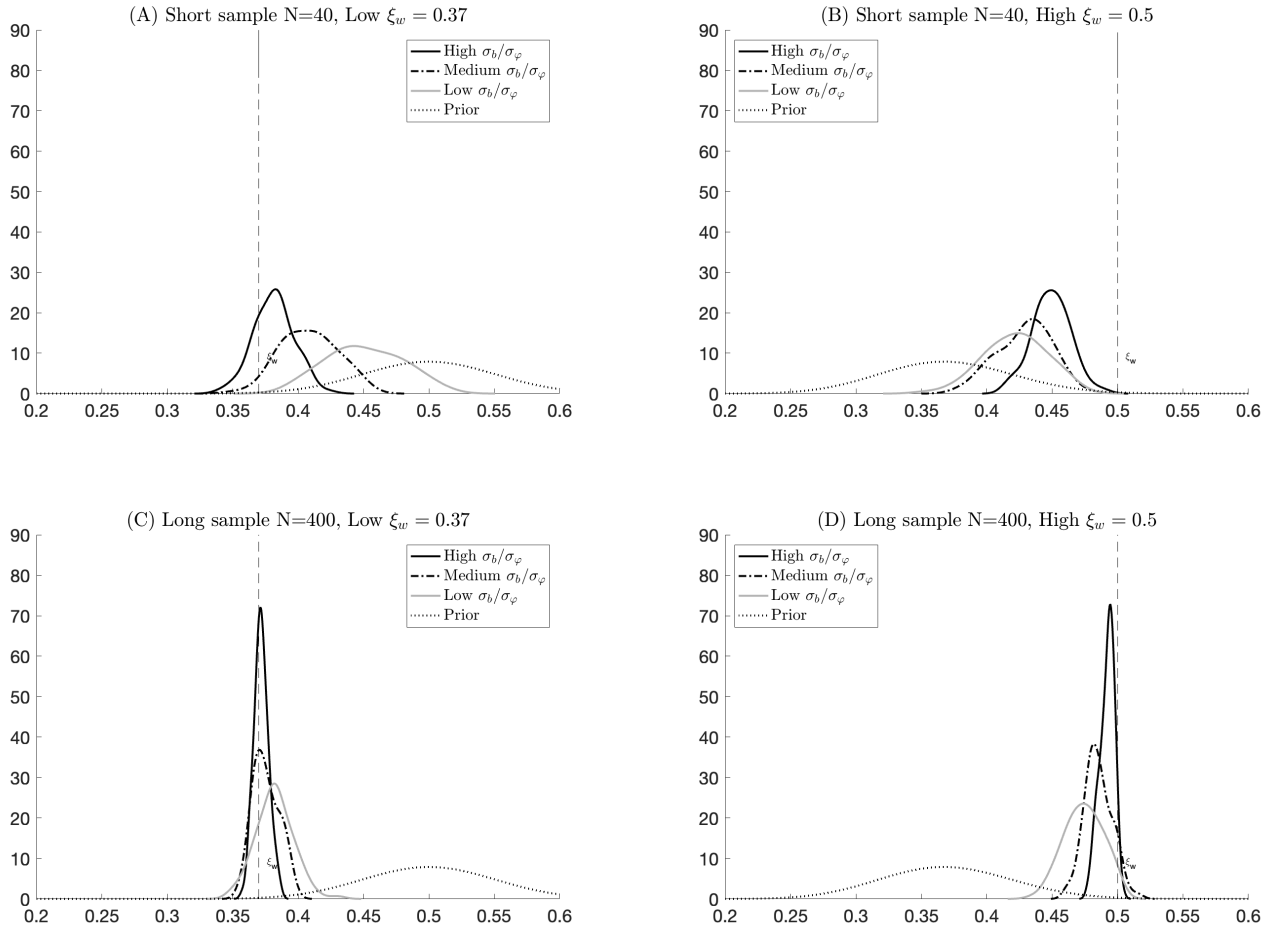
Note: This table replicates Table 6 from the original text with the corrected wage measure. Columns 1 and 2 show the results from just correcting the mistake ("Corrected Model 1"). Columns 3 and 4 show the results from correcting the mistake and adding in the 2012 data for estimation to increase power ("Corrected Model 2"). See original text for additional details of the table layout.

Table 7: Fit of Aggregate model and Regional NKWPC

Corrected Model 1	$\xi_w = 0.37$ $(\vartheta = 0)$	$\xi_w = 0.5$ $(\vartheta = 2)$
Aggregate model log-marginal likelihood	-589	-590
Mean-squared error of regional NKWPC	0.0002	0.0016
Corrected Model 2	$\xi_w = 0.29$ $(\vartheta = 0)$	$\xi_w = 0.5$ $(\vartheta = 2)$
Aggregate model log-marginal likelihood	-591	-590
Mean-squared error of regional NKWPC	0.0003	0.0017

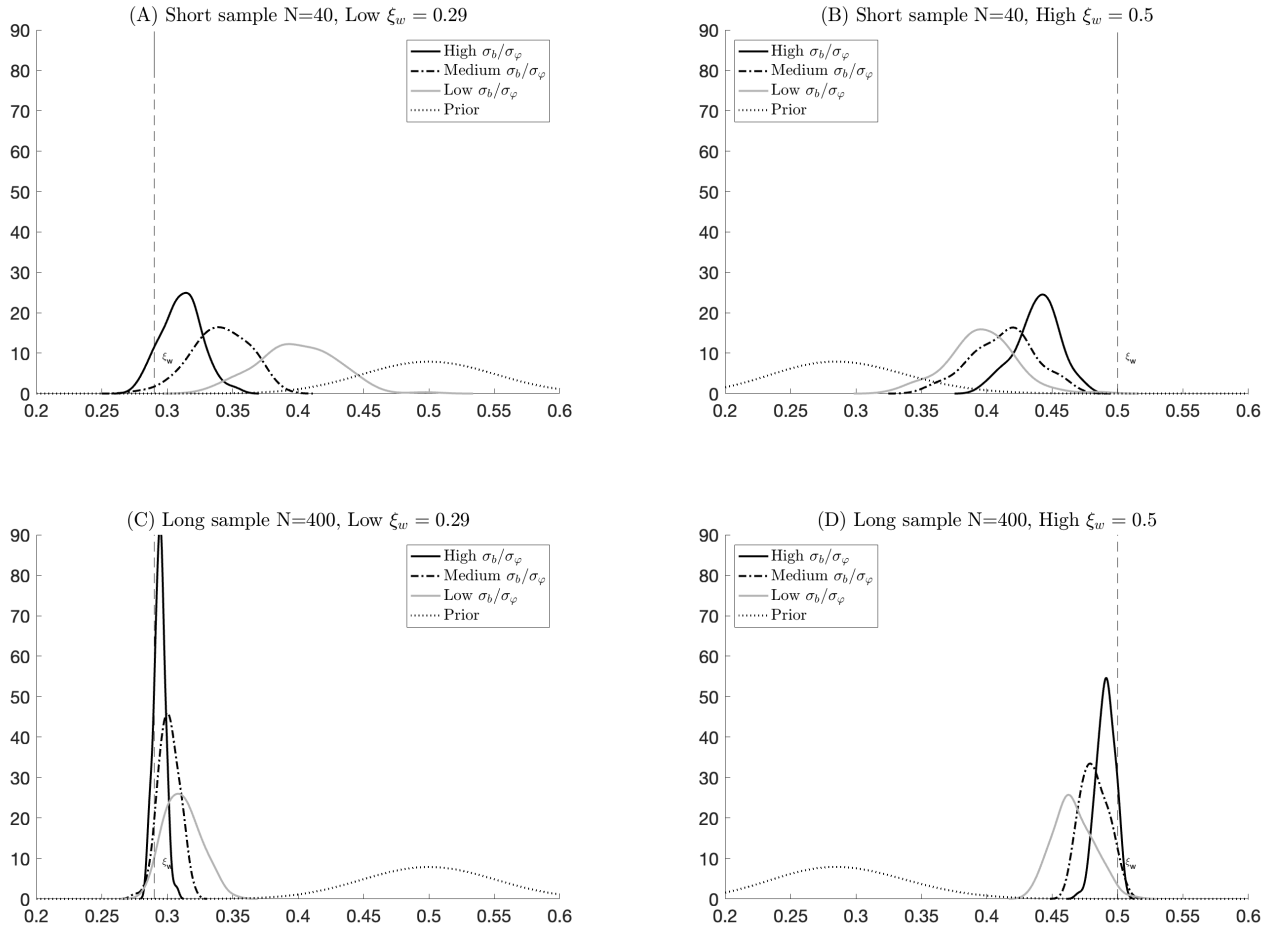
Note: The first line is the aggregate model fit to the aggregate time-series data, as measured by the log-marginal likelihood. The second line is the mean squared error of the regional NKWPC.

Figure 3 (Corrected Model 1): Posterior mode distribution of ξ_w under different thought experiments



Note: Figure shows how the posterior mode distribution of ξ_w changes under different data generating processes, priors, and sample length. See text for details.

Figure 3 (Corrected Model 2): Posterior mode distribution of ξ_w under different thought experiments



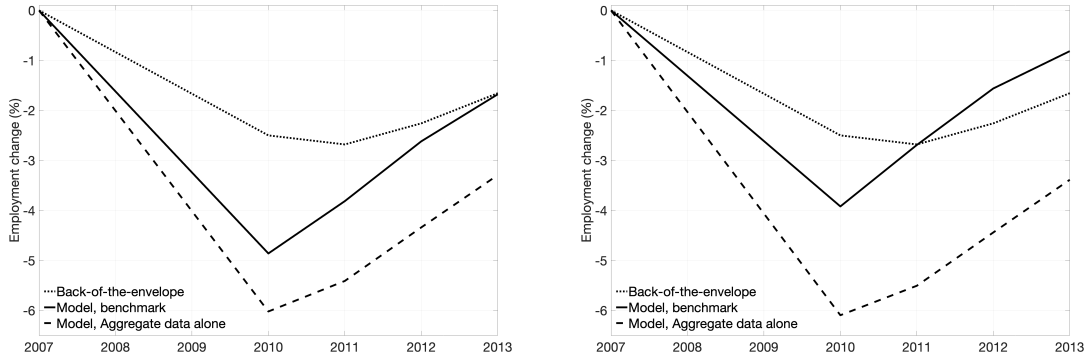
Note: Figure shows how the posterior mode distribution of ξ_w changes under different data generating processes, priors, and sample length. See text for details.

Table 8: Predicted $\frac{dlog(w^{agg})}{dlog(n^{agg})}$ during the Great Recession in Response to Various Shocks

	Shocks		
	b	b and μ	b, μ, and φ
Benchmark (Corrected Model 1)	0.61	0.58	0.29
Benchmark (Corrected Model 2)	0.80	0.72	0.31
Aggregate data alone	0.39	0.40	0.25

Note: The column first column corresponds to feeding the model with only the 2008, 2009, and 2010 realizations of the discount factor shock (b). The second column feeds the realizations of both the discount factor and investment efficiency shocks (b, μ). The final column feeds the realizations of the discount factor shock, the investment efficiency shock and the labor supply shock (b, μ, φ). The first row labeled "Benchmark" uses the parameterization and shocks when estimating the model with both regional and aggregate data. The second row labeled "Aggregate data only" uses the parameterization and shocks when only using aggregate data for estimation.

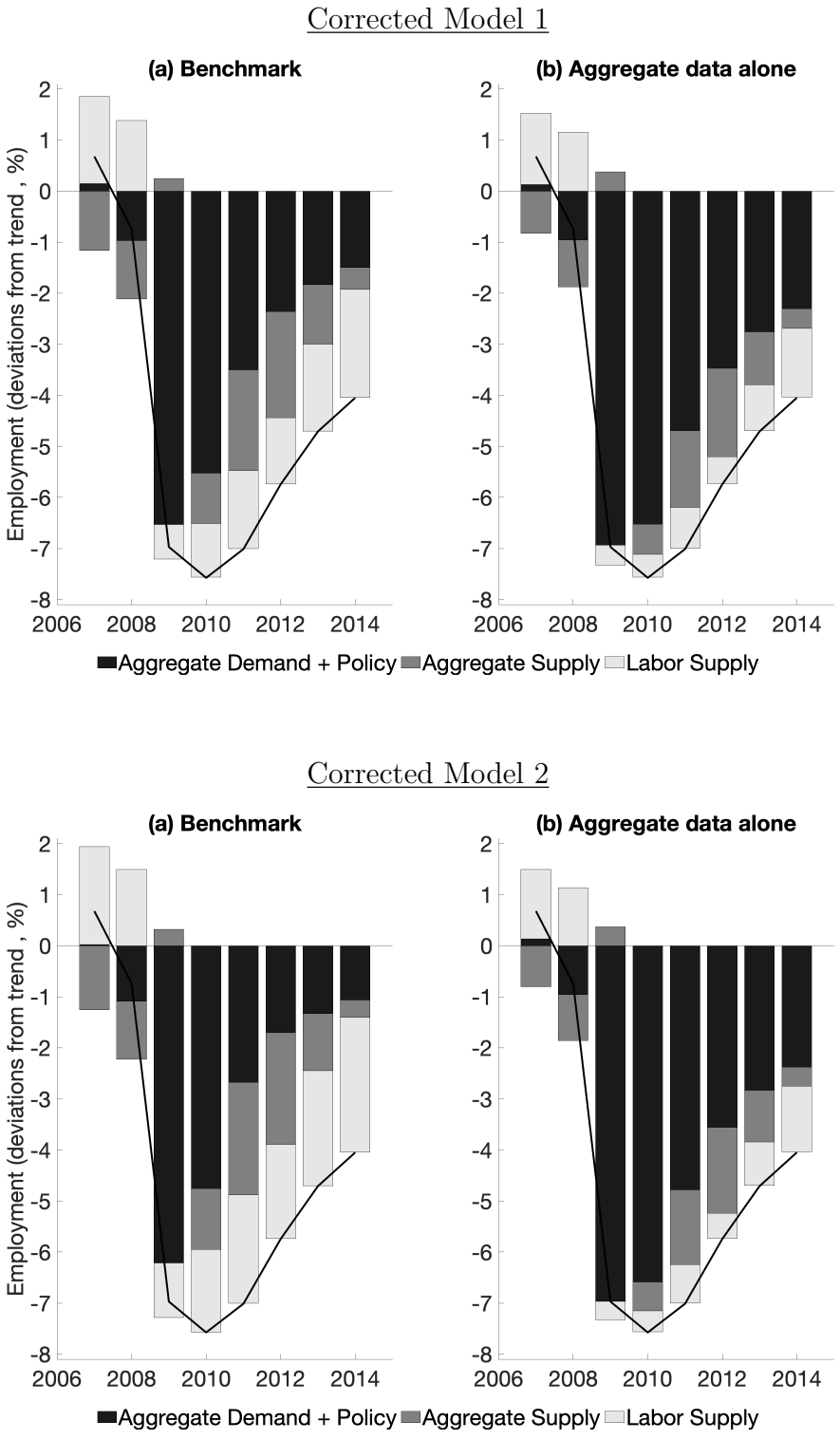
Figure 4: Employment Response to 2007-2010 Household Demand shocks



(a) Corrected Model 1 (b) Corrected Model 2

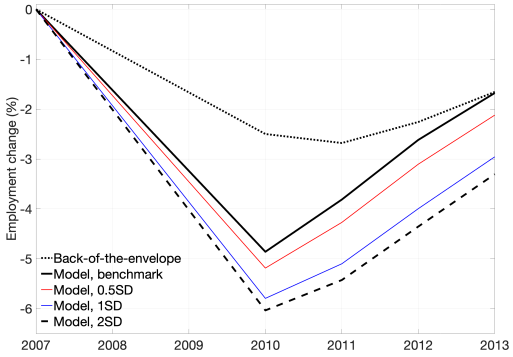
Note: "Model, benchmark" shows the employment response when feeding the model with the 2007-2010 discount factor shocks, under the benchmark parameterization that combines regional and aggregate data in estimation. "Model, aggregate data alone" uses the alternative parameterization when we estimate the model with aggregate data only. For "Back-of-the-envelope", we first compute the regional employment elasticity at different horizons to regional house price changes that occurred between 2007-2010. Then, we multiply these elasticities with the aggregate house price changes between 2007-2010.

Figure 5: Employment shock decomposition

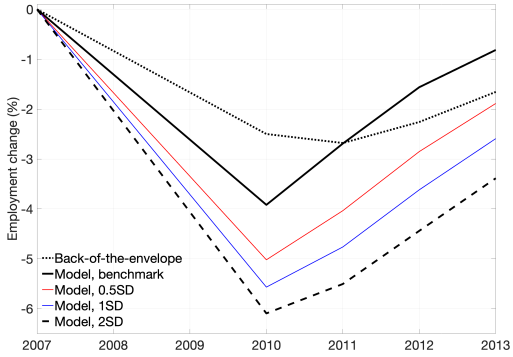


Note: Bars are computed by feeding the model with groups of shocks, one at a time. Combined, they add up to the data (i.e., the solid line). "Aggregate Demand + Policy" feeds the discount factor, the investment efficiency, monetary policy, and government spending shocks. "Aggregate Supply" feeds the price markup and productivity shocks. "Labor Supply" feeds the labor supply shocks alone. Panel (a) corresponds to our benchmark estimation that combines regional and aggregate data. Panel (b) uses aggregate data alone in estimation instead.

Figure A5: Employment Response to 2007-2010 Household Demand shocks



(a) Corrected Model 1



(b) Corrected Model 2

Figure A6: Employment shock decomposition