Nonlinear Evidence on the Existence of Jobless Recoveries

Michael D. Bradley
Department of Economics
George Washington University
Washington, DC 20052
202-994-8089
mdbrad@gwu.edu

Dennis W. Jansen
Department of Economics
Texas A&M University
College Station, TX 77843
979-845-7375
dennisjansen@tamu.edu

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Abstract:
The sluggish growth in employment following the Great Recession has spurred research into investigating its cause. Economists are split as to whether it reflects the advent of "jobless recoveries" or just reflects "slow recoveries" in which both output and employment are slow to recover. We estimate a version of Friedman's plucking model to investigate this issue. We find evidence suggesting that employment does have its own dynamic response after a recession. Some of the slow growth in employment can be ascribed to the slow output growth, but there is a remaining portion which is consistent with the jobless recovery hypothesis. We then produce evidence relative to four different hypothesis of why jobless recoveries have occurred.

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Introduction

There is general agreement that one of the primary characteristics of the recovery from the Great Recession was the slow growth and weak recovery in employment. However, there is significant disagreement about the reasons behind that phenomenon and no consensus on why it has occurred. On one hand, there are economists who have identified that recovery, as well as the previous one (or two) as being "jobless" recoveries, in which it took employment an extraordinarily long time to return to its pre-recession peak. (Bernanke, (2003), Berger (2011), Calvo, Coricelli and Ottonello (2012)). In addition, employment growth, in this view, is thought to lag the general recovery in economic conditions.

Other economists dispute the characterization of a "jobless" recovery. They argue that the behavior of employment in the current, and immediately prior, recoveries was not atypical, and just a reflection of either the depth of the recession or the sluggishness in the overall economic recovery. (Gale, Smets and Wouters, (2012) and (Ball, Leigh, and Loungani (2012)).

Moreover, even among those economists who characterize recent recoveries as being jobless, there is no consensus on the reason for the weakness in employment response. The proposed explanations include the job polarization hypothesis (Jaimovich and Siu (2102)), the productivity hypothesis (Berger (2011)), the manufacturing restructuring hypothesis (Engemann and Owyag (2010)), and the flexible employment hypothesis (Schreft and Singh 2005)).

In this paper, we produce evidence relative to these differing views. We do so with a version of Friedman's famous plucking model which is particularly well suited to investigating this issue. Traditionally, output and employment have been subject to "bounce back" dynamics (Kim, Morley, and Piger (2005)) during recoveries, in which both output and employment growth are materially faster than they were during the mature phase of a recovery. This type of

dynamics requires an asymmetric model, like the plucking model. The model we employ allows for both lags in the response of employment or output to the state of the recession and for differential recovery dynamics due to the existence and magnitude of the recession. It thus permits empirical estimation of a possible bounce back effect for both output and employment, and supports direct investigation of possible changes in employment dynamics in recent recessions.[1]

A Parametric Version of Friedman's Plucking Model

We examine employment dynamics for U.S. recoveries through use of a parametric version of Friedman's (1969, 1993) plucking model of the business cycle. Friedman's plucking model of the business cycle suggests that output bumps along at or just below some theoretical maximum value, except for occasional events that pluck output downward – recessions – and from which output then recovers. Friedman (1969) wrote that a "large contraction in output tends to be followed on the average by a large business expansion; a mild contraction by a mild expansion" (p. 273). We use this model to examine the issue of jobless recoveries and employment dynamics at an aggregate level.

To model asymmetry in the growth of employment during recoveries, we employ an empirical model suited to capture the behavior described by Friedman in his plucking model. We include a variable to capture asymmetries in the growth of employment following recessions. This asymmetry allows employment to grow more rapidly after a recession, and the magnitude of this increased growth rate is a function of the magnitude of the recession. Deeper recessions

[1] In addition, the plucking model allows for examination of employment dynamics from peak to recovery. Calvo, Coricelli and Ottonello (2012) argue that this approach is essential and that looking at average unemployment or employment performance after a recession can lead to misleading inferences.

lead to higher growth rates of employment during the recovery. See Beaudry and Koop (1993) for their original application of this type of model to real GDP.

Our empirical model of employment growth is an AR model augmented with a term that captures the boost in employment growth that occurs when the level of employment (E_t) has fallen below its previous peak level. This nonlinear model is written as:

$$\Theta(L)_t \, \Delta E_t \;\; = \;\; \delta + \; [\Omega(L) \; - \; 1] \Gamma_t + \; \varepsilon_t, \qquad (1)$$

where the asymmetry variable is defined as :

$$\Gamma_t \;\; = \;\; max\{E_{t-j}\}_{j \geq 0} \; - \;\; E_t \;\; . \qquad (2)$$

Here *Θ(L)* and *Ω(L)* represent polynomials in the lag operator L, a convenient way to represent that there are lags of *ΔE* and lags of the asymmetric term in the equation. We assume *Ω(0)* = 1 so that only lags of Γ_t appear on the right hand side of (9). If the coefficient on the asymmetric term is positive, then *ΔE* grows faster when the asymmetric term increases, that is, when the recession is deeper. As the economy recovers, the asymmetry variable declines in value and the impact on *ΔE* is reduced. Finally, when the economy grows so that employment exceeds its previous peak size, the asymmetry variable is zero and the extra growth in employment is eliminated.

A positive coefficient on the asymmetry variable in equation (1) is consistent with Friedman's plucking model. The impulse response function will depend on the state of the economy, measured by the asymmetry variable. The growth rate, *ΔE* ,will be augmented after a recession, and the deeper the recession the larger the extra growth during the recession and subsequent recovery.

Initial Evidence on the Existence of Jobless Recoveries

We first use the plucking model to investigate the main question: whether there is evidence supporting the assertion that recent recoveries in the US have been "jobless." Recall that the controversy is between those economists who have argued that employment dynamics have changed in recent recoveries and those economists who have argued that employment dynamics have stayed the same, and the extraordinarily slow growth in employment simply reflects the deep recession and extraordinarily slow growth in output.

To produce evidence on this controversy, we first estimate the plucking model for real GDP growth, in order to compare our results to previous findings[2] and to examine if there have been changes real GDP growth dynamics during the last several recoveries. This will provide the baseline for a later examination of employment dynamics, and will permit comparison of the results for employment with the results for real GDP. To investigate whether or not there have jobless recoveries we must investigate whether similar dynamics hold for employment and output.

The plucking model for real GDP includes an asymmetry variable for real GDP, and two interaction terms, an indicator for the period following the 2001 recession (2001-2007) interacted with the asymmetry variable, and an indicator for the 2008 recession (2008 forward) interacted with the asymmetry variable. It is thus specified as:

$$\Upsilon(L)_t \Delta Y_t = \delta + [\Psi(L) - 1]\Phi_t + D_{01}[\Psi(L) - 1]\Phi_t + D_{08}[\Psi(L) - 1]\Phi_t + \varepsilon_t \quad (3)$$

where: $\Phi_t = max\{Y_{t-j}\}_{j\geq 0} - Y_t$

[2] Previous research has identified asymmetric dynamics for real GDP over the business cycle (Friedman (1969), Beaudry & Koop (1993) , Bradley & Jansen (2000), Jansen & Oh(1999)).

The interaction terms allow us to test whether the asymmetric response of real GDP growth during recoveries has changed following the two most recent recessions.

Table 1 provides our estimate of this model for real GDP. The specification of two lags for real GDP and one lag for the asymmetry term was determined by the Schwarz criterion. We find that the coefficient on the asymmetry variable for real GDP was large and significant prior to the 2001 recession, indicating a relatively large asymmetry, with a 3% decline in real GDP below peak leading to almost a 1% addition to GDP growth. Given that GDP growth averaged about 3% annually, this is a large effect.

Table 1. Model for Real GDP Growth

Variable	Coefficient	t-Statistic
C	0.0022	2.037
DY_{t-1}	0.4217	6.053
DY_{t-2}	0.1649	2.333
Φ_{t-1}	0.3230	3.007
$D_{01}*\Phi_{t-1}$	0.2816	0.104
$D_{08}*\Phi_{t-1}$	-0.2769	-2.236
# of observations	242	
R-squared	0.1757	
S.E. of regression	0.0083	
Schwarz criterion	-6.6245	

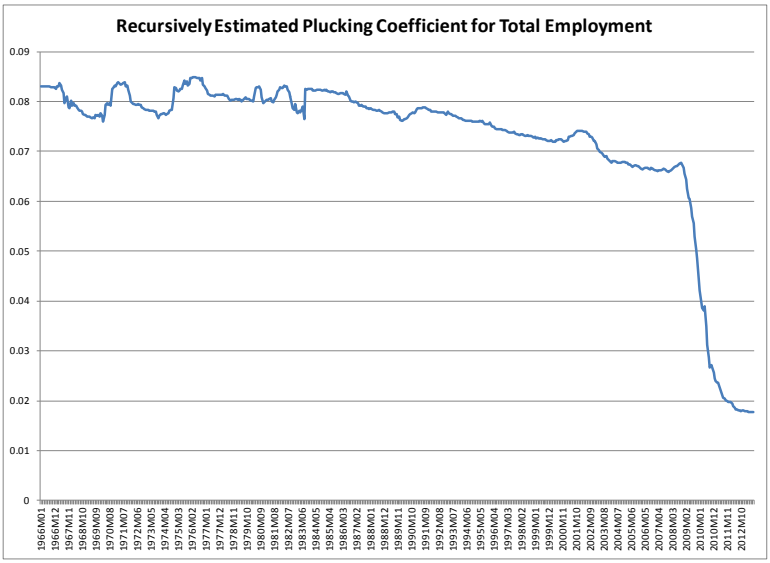
These results also indicate that there was a statistically significant reduction in the asymmetric effect after the 2008 recession but not after the 2001 recession. In fact, the GDP recovery after the 2001 recession appears stronger than after the previous recessions, although the estimated magnitude is far from statistically significant. For the 2008 recession, our point estimate of the asymmetric effect declines from .32 to .05, a substantial reduction. In fact, the asymmetric effect is not statistically different from zero in this later period. This result is

consistent with those who argue that the last recovery in GDP was atypical, and is partial support for the "slow recovery" hypothesis.

To focus more directly on the jobless recovery hypothesis, we estimate a plucking model for employment. We are interested in possible structural change in the employment relationship, especially if the employment response changed in recent recessions. In particular, we are looking for evidence that tests the existence of recent jobless recoveries.

We first estimate the model recursively in order to see if there has been any change in the impact of the asymmetry variable on employment growth. Figure 1 shows that the recursively estimated coefficient experienced a modest decline in for employment growth. It shows a modest decline in the 1990's, continuing in the 2000's, but a very sharp decline starting with the recession of 2008. In fact, the recursive estimate falls from .08 in the first part of our sample to .065 by 2007, but then declines dramatically to .02 during and after the Great Recession.

Figure 1. Recursive Estimates of the Coefficients on the Asymmetric Variable.



In Table 2 we report results for an employment plucking model in which we include dummy variables interacted with the asymmetry terms for the periods following 1990 recession (1990 – 2000), the 2001 recession (2001-2007), and the Great Recession (2008 forward).

Table 2. Model for Employment Allowing Structural Change.

Variable	Coefficient	t-Statistic
C	-0.0001	-0.9014
DE_{t-1}	0.2383	6.8565
DE_{t-2}	0.2831	8.0165
DE_{t-3}	0.1665	4.8688
DE_{t-4}	0.2020	5.8705
Γ_{t-1}	0.0741	6.3841
$D_{90}*\Gamma_{t-1}$	-0.0392	-1.0311
$D_{01}*\Gamma_{t-1}$	-0.0539	-2.2150
$D_{08}*\Gamma_{t-1}$	-0.0658	-5.5800
# of observations	764	
R-squared	0.400307	
S.E. of regression	0.0022	
Schwarz criterion	-9.3582	

These results indicate that there was a relatively large asymmetry -- a coefficient of 0.074 -- prior to the 2001 recession. A 3% reduction in employment below previous peak would lead to a 0.2 percent increase in the monthly growth rate of employment. This is not a trivial impact when compared to the mean monthly growth rate of employment in our sample, 0.15 percent. There was a statistically insignificant change in the "bounce back" coefficient in 1990 – though the point estimate is large – followed by a larger reduction in the asymmetry coefficient for employment, to about 0.02, beginning in the 2001 recession, and an even larger reduction beginning with the 2008 recession, to about 0.008. As in the case of real GDP, the asymmetric effect is statistically insignificant by the end of our sample. These results are supportive of the portion of the jobless recovery hypothesis that argues that employment dynamics have changed

in recent recoveries. The plucking model shows a strong asymmetry for earlier recoveries but a dissipation of that additional employment growth following the 2001 recession and its disappearance following the 2007-08 recession. This suggests that employment growth has indeed been slower in the last two recoveries.

Our initial investigations provided mixed results on the question of whether recent recoveries have been "jobless" or merely "slow." For the most recent recovery, we find evidence indicating a slowdown in growth in both employment and output. This result raises the question of whether the observed reductions in the estimated asymmetric dynamics mean that employment acts differently than GDP in recoveries, or whether employment simply reflects changes in economy-wide dynamics as demonstrated by the reduction in GDP growth. In contrast, our results suggest that the behavior of employment was distinct from the behavior of real GDP in the recovery from the 2001 recession. In sum, we find that the changes in employment dynamics are similar to but do not exactly mimic the changes in output dynamics.

Estimating an Employment Plucking Model Including a GDP Growth Asymmetry

A jobless recovery requires employment to have business cycle dynamics different from those for real GDP. If the employment growth simply reflects output growth in recent recoveries than the slow recovery hypothesis is correct. To investigate this question, we estimate an employment plucking model with two asymmetry terms, one for employment and one for real GDP. By simultaneously estimating these two terms we can test whether employment growth has a separate business cycle dynamic. The model is given by:

$$\Theta(L)_t\,\Delta E_t \;=\; \delta \;+\; [\Psi(L) \;-\; 1]\Phi_t \;+\; +\, D_{01}[\Psi(L) \;-\; 1]\Phi_t \;+\; D_{08}[\Psi(L) \;-\; 1]\Phi_t \;+$$
$$[\Omega(L) \;-\; 1]\Gamma_t \;+\; +\, D_{01}[\Omega(L) \;-\; 1]\Gamma_t \;+\; D_{08}[\Omega(L) \;-\; 1]\Gamma_t + \varepsilon_t, \qquad (4)$$

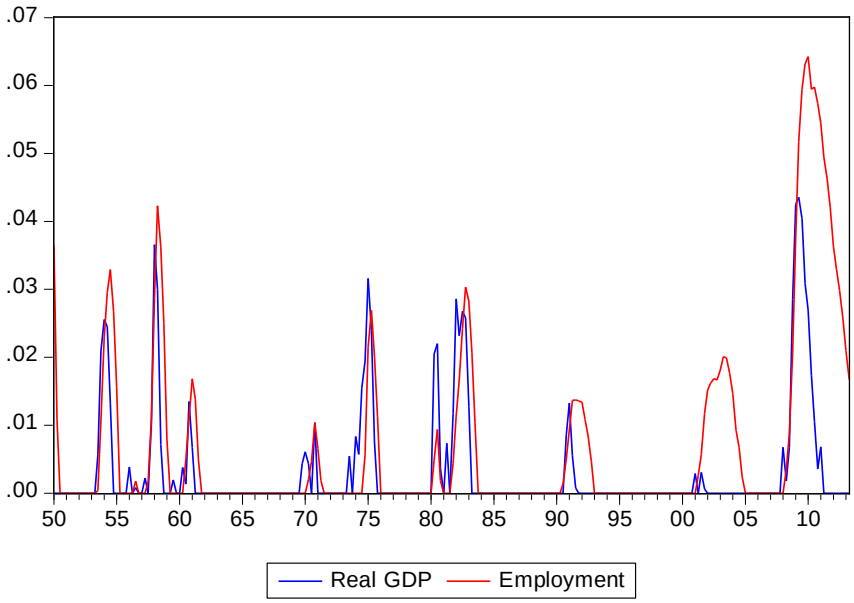
Before this model can be estimated, the disparate frequencies of employment and real GDP must be reconciled. We do this by converting employment to a quarterly frequency, using the average value for the three monthly employment levels. Also, before we estimate the extended model we check whether time aggregation affects the results of the original employment plucking model. Table 3 presents the results of estimating the employment plucking model on our constructed quarterly data. It shows that the same qualitative results hold, a positive coefficient on the asymmetric term for the period from 1950 through 2000, a significant reduction in that coefficient for the 2001 recession, and an even larger reduction for the 2008 recession. The size of the estimated coefficient on the asymmetric term is larger in the quarterly data.

Table 3. Model of Employment Growth at a Quarterly Frequency

Variable	Coefficient	t-Statistic
C	-0.0011	-1.8391
DE_{t-1}	0.9946	16.8549
DE_{t-2}	-0.1651	-1.9263
DE_{t-3}	0.2286	2.7349
DE_{t-4}	-0.1580	-1.9018
DE_{t-5}	-0.0476	-0.5882
DE_{t-6}	0.1462	2.5056
Γ_{t-1}	0.2804	6.3822
$D_{01}*\Gamma_{t-1}$	-0.1614	-2.2242
$D_{08}*\Gamma_{t-1}$	-0.2301	-5.9742
# of observations	254	
R-squared	0.7029	
S.E. of regression	0.0036	
Schwarz criterion	-8.2268	

Figure 2 presents the behavior of real GDP and employment during recessionary period by graphing the difference between the maximum value and the current value. A positive value for this measure means the current real GDP and/or employment is below its previous peak.

Figure 2. Graph of Asymmetry Term for Real GDP and for Employment.



As expected, employment and real GDP have similar patterns, especially prior to the last three recessions, with the trough in employment slightly lagging the trough in real GDP. However, in last three recessions, the time that it takes employment to return to the previous peak is noticeably longer than the time it takes real GDP to return to its previous peak. Moreover, this difference becomes larger with the two most recent recessions. In fact, the 2000 recession shows almost no decline in real GDP, but a long a sustained decline in employment, with a full recovery in employment requiring several years. The 2007 recession has a large decline in real GDP, with recovery after a few years, but an even larger decline in employment that did not return to its previous peak until late in the second quarter of 2014. This pattern suggests the possibility that employment dynamics may differ from output dynamics during recoveries and

appear to support the existence of jobless recoveries. To further investigate this issue we estimate the extended plucking model.

Table 4 presents the two-variable employment plucking model. As with the single-variable model, the coefficient on the employment asymmetry term is positive and significant. It is also bit larger in size than in the single variable model. In contrast, the coefficient on the real GDP term is negative and significant. This means that the asymmetric employment effect is smaller when both real GDP and employment are below their previous peaks. Given the pattern of recessions in the US, this outcome occurs early during the recession and recovery period. The above graph of distance from peak for output and employment shows that real GDP is quicker to recover to is previous peak. Once that occurs, the asymmetric employment effect becomes larger and, at least in the past, pushed employment back to its previous peak. This result indicates that there is a plucking model in employment apart from the asymmetric change in GDP. The employment plucking effect continues, and gets larger, even after GDP returns to its previous peak.

Table 4. Model of Employment Growth with Dynamics from Employment and Real GDP

Variable	Coefficient	t-Statistic
C	-0.0007	-1.0868
DE_{t-1}	0.9000	13.4724
DE_{t-2}	-0.1513	-1.7789
DE_{t-3}	0.2404	2.9051
DE_{t-4}	-0.1276	-1.5478
DE_{t-5}	-0.0420	-0.5266
DE_{t-6}	0.1358	2.3532
Γ_{t-1}	0.3711	6.8356
$D_{01}*\Gamma_{t-1}$	-0.2639	-3.2763
$D_{08}*\Gamma_{t-1}$	-0.3258	-5.8931
Φ_{t-1}	-0.1831	-3.0931
$D_{01}*\Phi_{t-1}$	-1.1024	-0.9416
$D_{08}*\Phi_{t-1}$	0.1787	2.2510
# of observations	254	
R-squared	0.7153	
S.E. of regression	0.0036	
Schwarz criterion	-8.2042	

The coefficients on the dummy variables for employment are both negative and significant, with the absolute size of the coefficient on the 2008 dummy being larger. This is consistent with an amelioration, and then complete disappearance, of asymmetric employment growth in the two most recent recoveries, even when controlling for GDP dynamics. Also, the coefficient on the dummy variable for an asymmetric real GDP effect in recovery from the 2001 recession is large in absolute value, but not significantly different from zero. This is consistent with the extremely shallow and brief nature of that recession. Figure 2 shows that asymmetry term for real GDP for that recession is much smaller and narrower than the corresponding asymmetry term for employment. Finally, the coefficient on the real GDP dummy variable for

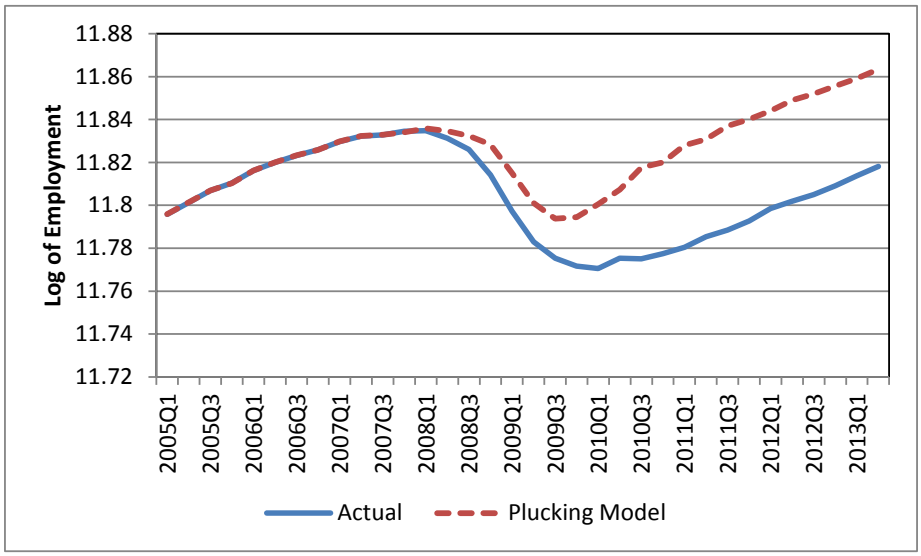
the recovery starting in 2008 is significant and virtually equal, in absolute terms, to the size of the overall GDP coefficient. This indicates that asymmetric impact of real GDP on employment has also dissipated.

In sum, we find evidence of employment dynamics apart from the effect of GDP dynamics. The employment plucking effect continues, and gets larger, even after GDP returns to its previous peak. This is evidence supporting the existence of jobless recoveries. In other words, the dissipation in the traditional "bounce back" effect of GDP during recoveries explains part, but not all, of the slowdown in employment growth in recent recoveries. For the recovery following the 2001 recession, we find no change in GDP bounce back effect, but a material reduction in the employment one. This result supports an inference that the 2001 recovery was indeed jobless. For the recovery from the great recession, the GDP effect dissipates but without an elimination of the separate employment bounce back effect, employment growth would have been more like traditional recoveries. This result supports an inference that the most recent recovery was also jobless, at least to a certain degree,

To get a sense the implications of the impact on the levels of employment, we plot the log of actual employment against the log of employment predicted by the plucking model in Figure 3. This representation shows the sharp employment declines that occurred early in the recession but more generally illustrates the nature of the moderating effect provided by the asymmetric growth term. The trough in employment occurs just a couple of quarters earlier in the plucking model but the ascent out of the recession is much sharper. We see that the difference between the two employment paths is defined primarily by the 2010-2011 period. Without the acceleration in employment provided by the plucking effect, the level of employment remains

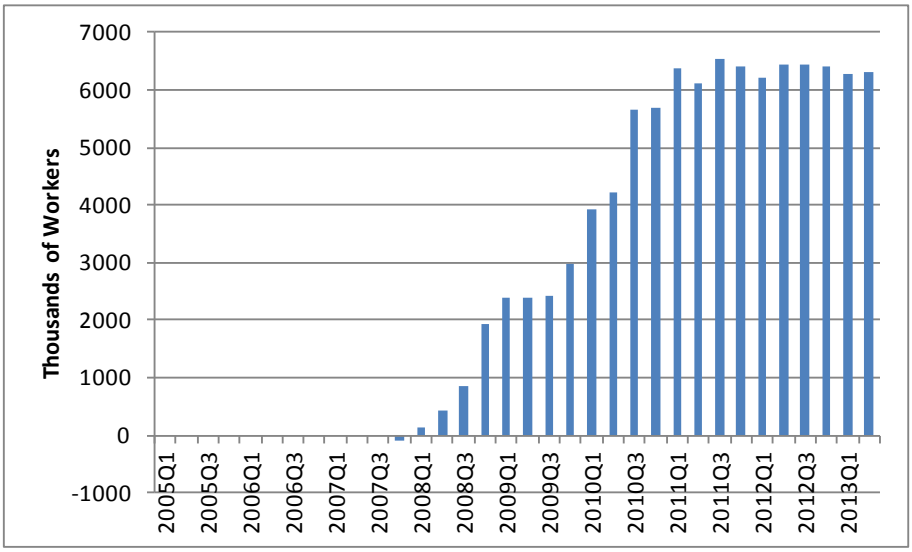
lower even when employment growth returns to more normal levels. Note that if the plucking model were still in force, employment would have returned to its previous peak by 2012.

Figure 3. Employment Levels, Actual and Simulated from the Plucking Model



Finally, we calculate the difference in employment implied by the dissipation of the plucking model. Figure 4 shows the difference, in thousands of workers, between the amount of employment predicted by the plucking model and the actual employment that occurred. The difference grows in two steps, with the first taking place early in the recession and the second taking place around 2010. On net, actual employment ended up being about 6 million workers less than what would have taken place if the plucking model were still in force.

Figure 4. Employment Shortfall from Loss of Bounce Back Effect



Evidence on Different Jobless Recovery Hypotheses

Given that our empirical evidence favors the existence of a jobless recovery, we now use the plucking model to investigate different hypotheses attempting to explain the existence of jobless recoveries. We look at four different hypotheses that have appeared in the literature: the productivity hypothesis, the job polarization hypothesis, the manufacturing restructuring hypothesis, and the flexible employment hypothesis. We produce evidence relevant to each.

1. The Productivity Hypothesis

Berger (2011), among others, has argued that rising productivity in recoveries allows output to increase without the traditionally associated job growth. This productivity growth occurs because firms invest in technological capital during expansions, but do not replace their labor with this capital to the extent possible during the expansions, because high (and rising) profits allow them to avoid difficult labor terminations. When the recession hits, firms are forced to lay off workers. Then, when the recovery takes place, firms make better use of their capital in

this view, to expand output through higher labor productivity. Hence employment does not expand. From the perspective of our plucking model, this hypothesis would mean that productivity growth during recoveries should be stronger for the most recent two recoveries in order to explain the lack of job growth..

Evidence in support of this productivity hypothesis would be of the form of a positive and significant coefficient on the structural dummy in a plucking model for productivity. We estimated such a model for productivity (specifically the Non-Farm Business Labor Productivity Index, 2009=100) using quarterly data from 1947-2013. The estimated model is presented below, and the asymmetry term, while positive, is not statistically significant. The interactions of the asymmetry term with indicators for the 2001 and 2008 recessions are also positive, indicating a higher response of productivity during the last two recessions, but the coefficient estimates are statistically insignificant.

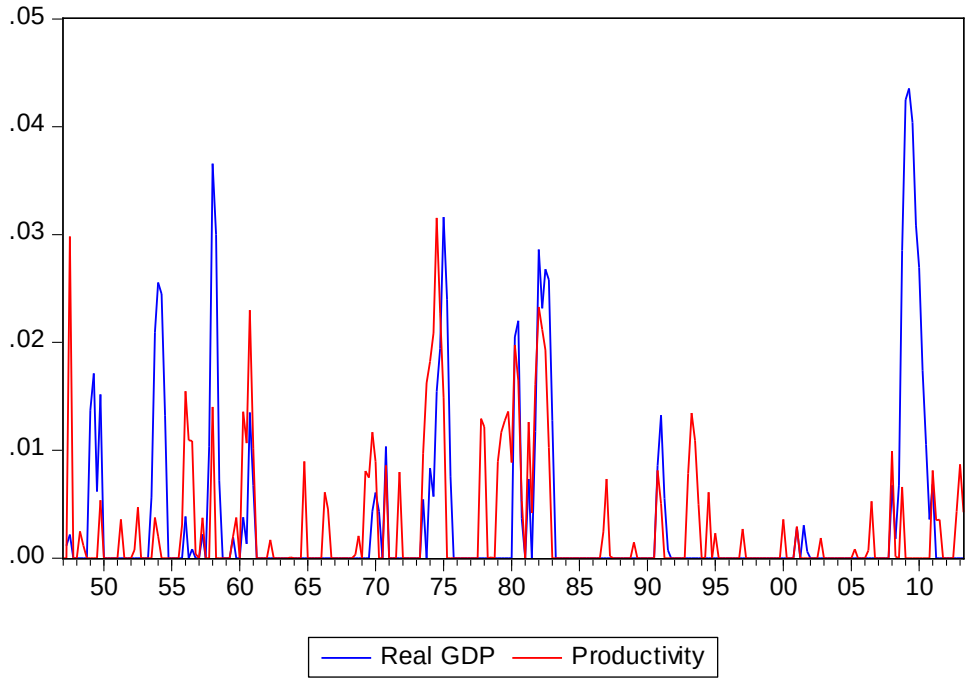
Table 5. Model of Productivity Growth

Variable	Coefficient	t-Statistic
C	0.0044	3.7430
$DPROD_{t-1}$	0.0689	0.9127
$DPROD_{t-2}$	0.0905	1.3855
$DPROD_{t-3}$	-0.0272	-0.4439
Γ_{t-1}	0.1144	0.8827
$D_{01}*\Gamma_{t-1}$	0.6720	0.4450
$D_{08}*\Gamma_{t-1}$	0.0502	0.1032
# of observations	262	
R-squared	0.0113	
S.E. of regression	0.0085	
Schwarz criterion	-6.5775	

The above regression casts doubt on the productivity explanation of the jobless recovery. In Figure 5, we graph the asymmetry term for productivity, along with the asymmetry variable for

real GDP. This graph indicates that productivity has a high degree of small fluctuations and is often below its previous peak even during expansions, so that the asymmetry variable for productivity does not always correspond to a recession.

Figure 5. Asymmetry term for Productivity and for Real GDP



To more closely tie productivity changes to recessions, we re-estimate the productivity model using as an explanatory variable the asymmetry term for real GDP. This is intended to correct for any issue caused by the more frequent departure of productivity levels from their previous peak relative to real GDP's departures from its previous peak. The results are in Table 6. This regression finds a positive asymmetry term, indicating the productivity grows faster the deeper is the recession as measured by real GDP falling below its previous peak. However, there is no statistically significant evidence that this relationship changed in the 2001 or 2008 recessions, and in fact the point estimate for the 2008 recession suggests that the productivity

response was lower in 2008 instead of higher, as would be expected from this productivity hypothesis. Thus this regression does not provide any statistically significant evidence to support the notion that the recent recessions/recoveries had a larger-than-normal productivity response that discouraged employment growth.

Table 6. Model of Productivity Growth With GDP Asymmetry Term

Variable	Coefficient	t-Statistic
C	0.0036	4.3060
DPRODt-1	0.0529	0.8977
DPRODt-2	0.0982	1.7036
DPRODt-3	0.0030	0.0513
Γ_{t-1}	0.3449	4.1905
$D_{01}*\Gamma_{t-1}$	2.7963	1.0553
$D_{08}*\Gamma_{t-1}$	-0.1890	-1.5828
# of observations	262	
R-squared	0.0828	
S.E. of regression	0.0082	
Schwarz criterion	-6.6526	

2. Job Polarization Hypothesis

Autor, Katz and Kearney (2006), Goos and Manning (2007), Goos, Manning and Salomons (2009, 2011), and Jaimovich and Siu (2102), argue that jobless recoveries are due to the relative lack of jobs in the middle of the skills distribution, a phenomenon known as job polarization. It occurs through technological progress causing substitution of various technologies for human efforts in the performance of middle-skill routine tasks. Because middle-skill jobs are lost during a recession and not regenerated during recoveries, this hypothesis proposes that job polarization is the main cause of slow employment growth.

In order to test this hypothesis, we need to have employment data by skill groups (low, moderate, high) for a sample that includes several recessions prior to the 2001 recession. Tuzeman and Willis (2013) provide such data by skill level but it starts in 1982, which only provides data on the 1991 recession in addition to the 2001 and 2008 recessions. We thus construct our own measure of employment by skill level. We use the Current Employment Survey (also called the CES or "establishment survey") to classify workers by skill level starting in 1964. We organize the CES categories into high, middle, and low skill employment groups as indicated in the following table. We exclude government employment, and apparently Tuzeman and Willis did so as well.[3]

Low Skill	Middle Skill	High Skill
Leisure and Hospitality Other Services	Mining and logging Construction Manufacturing Wholesale Trade Retail Trade Transportation & warehousing Utilities	Information services Financial activities Professional and business services Education and health services

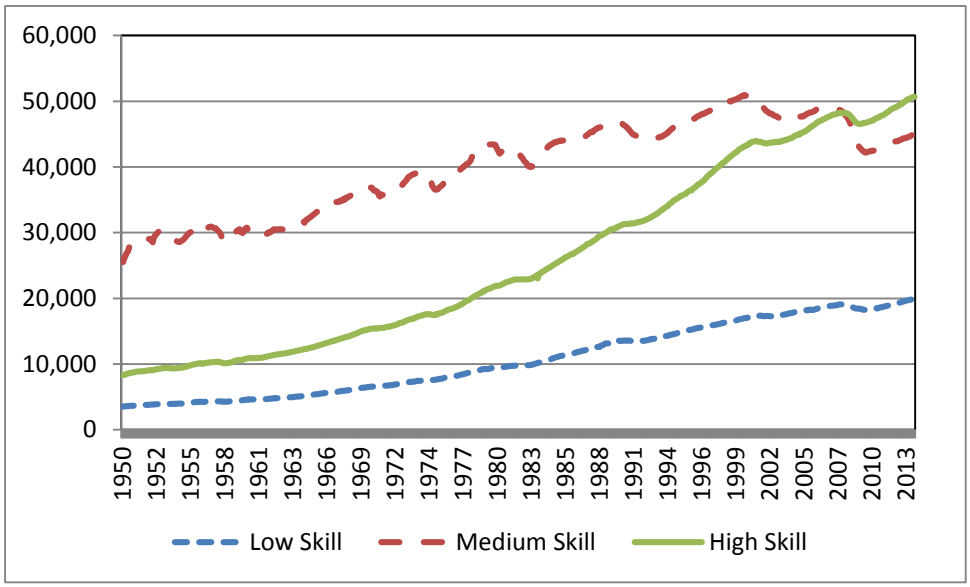
Figure 6 shows the employment levels and proportions we get using the CES data. The levels of high skilled employment have risen steadily perhaps with a bit of acceleration in the later part of the period. In addition, there has been modest but steady growth in low skill employment. Most striking is the decline in middle skill employment which peaked in mid-1999. Since then middle skill employment was initially in moderate decline, and since the 2007-2008 recession, rapid decline. In fact, high skill employment now exceeds middle skill employment. The proportion

[3] We compare our employment classifications to the TW classifications in the appendix (available upon request.) We find that our classification yields data that moves qualitatively similar to the data movements of the TW classification, while providing us with the needed longer sample period.

of employment in the middle skill category has fallen from about 70 percent in 1950 to just 40 percent in 2013. This decline in middle skill employment is a necessary condition for the existence of the job polarization hypothesis.

We estimate plucking models for each skill level. If the job polarization hypothesis is correct, we expect to see changes in the dynamics of middle skill employment, so that middle skill jobs are no longer growing rapidly after a recession, while high and/or low skill jobs continue to grow more rapidly after a recession. The key is that we expect middle skill job dynamics to change relative to low and high skill job dynamics.

Figure 6. Employment by Skill Level



We next estimate our employment plucking models by skill level. We first estimate the model for low skill labor. This estimation shows a positive and significant asymmetry term for our early sample period, an insignificant decline in the term for the 2001 recession, and such a large decline that the asymmetry term turns negative for the recovery after the 2008 recession.

This negative asymmetry term indicates that employment growth of low skilled labor declined as a result of the recession, just the opposite of what the overall plucking model would suggest, and somewhat inconsistent with the polarization hypothesis' focus on the relative decline in moderate skill labor as labor migrates to low and high skill jobs.

Table 7. Model of Employment Growth for Low Skill Labor

Variable	Coefficient	t-Statistic
C	0.0009	4.5176
DE_{t-1}	0.0560	1.3940
DE_{t-2}	0.3082	8.6569
DE_{t-3}	0.2050	5.6459
Γ_{t-1}	0.1258	2.5881
$D_{01}*\Gamma_{t-1}$	-0.1362	-0.8994
$D_{08}*\Gamma_{t-1}$	-0.1452	-3.0940
# of observations	764	
R-squared	0.1647	
S.E. of regression	0.0025	
Schwarz criterion	-9.0634	

We next estimate a plucking model for middle skill employment.[4] According to the polarization hypothesis, this estimation should produce a zero (or very small value) for the asymmetry term for recent recessions/recoveries. This is what we find and this result is consistent with the polarization hypothesis. That is, middle skill employment growth no longer responds as strongly positively to the depth of a recession in the 2001 and 2008 recessions.

[4] Because middle skill employment peaks around 1999 and then declines, we have to construct the adjusted asymmetry variable. In the adjusted approach we calculate this term as the distance from the most recent peak, even if that most recent peak is below a prior global peak.

Table 8. Model of Employment Growth for Middle Skill Labor

Variable	Coefficient	t-Statistic
C	-0.0004	-2.5008
DE_{t-1}	0.2636	7.3453
DE_{t-2}	0.3020	8.1365
DE_{t-3}	0.0933	2.4146
DE_{t-4}	0.1055	2.7327
DE_{t-5}	0.0679	1.8250
DE_{t-6}	-0.0001	-0.0041
Γ_{t-1}	0.0345	5.0802
$D_{01}*\Gamma_{t-1}$	-0.0250	-3.0641
$D_{08}*\Gamma_{t-1}$	-0.0285	-4.2995
# of observations	764	
R-squared	0.3960	
S.E. of regression	0.0032	
Schwarz criterion	-8.6062	

Finally, we estimate a plucking model for high skill employment. Like the other two skill levels, high skill employment has a positive asymmetry term for our early sample periods. However, like the results for middle skill employment, the asymmetry term is close to zero for recent recessions/recoveries. This again is somewhat inconsistent with the polarization hypothesis. According to the polarization hypothesis, high skill job growth should have been faster, or at least not slower, in response to the recent recessions, as workers moved from middle skilled jobs to either low skilled or high skilled jobs.

Table 9. Model of Employment Growth for High Skilled Labor

Variable	Coefficient	t-Statistic
C	0.00001	0.0580
DE_{t-1}	0.0225	0.6210
DE_{t-2}	0.2905	8.2459
DE_{t-3}	0.2868	7.9080
DE_{t-4}	0.1410	3.8618
DE_{t-5}	0.1017	2.8428
DE_{t-6}	0.0795	2.2395
Γ_{t-1}	0.2928	7.6786
$D_{01}*\Gamma_{t-1}$	-0.2401	-3.0502
$D_{08}*\Gamma_{t-1}$	-0.2710	-7.2539
# of observations	764	
R-squared	0.3238	
S.E. of regression	0.0020	
Schwarz criterion	-9.5424	

In sum, we have, at best, mixed evidence on the polarization hypothesis. We expected to see a reduction in the impact on employment growth of the asymmetry term for moderate skill employment, and an increase – or at least no change – in the impact of the asymmetry term for low and high skill employment. Instead we find a reduction in the impact of the asymmetry term for all skill levels, leaving little differentiation in the changing dynamics.

3. Manufacturing Restructuring Hypothesis

This hypothesis argues that jobless recoveries come from a decline in the cyclicality of the manufacturing sector in which there has been a movement from adjusting labor on the extensive margin to adjusting labor on the intensive margin (Engemann and Owyag (2010)). We examine this hypothesis by estimating separate plucking models for employment in the goods sector, the services sector, and the government sector. Support for the manufacturing

restructuring hypothesis requires the elimination of the bounce back effect in goods-sector employment for the recent recoveries and a limited or zero reduction in the effect for services and government employment.

First, we estimate the plucking model for the goods sector and find a material bounce back effect. The asymmetric term is positive and significant. A 3% decline from peak in this sector's employment results in almost an additional 0.1% increase in monthly employment growth. While this is small in absolute size, the sample average growth in employment in this sector is 0.015%, so the additional growth following a recession can be large relative to average growth. We also find that this effect has dissipated in recent recession, a result which supports the manufacturing restructuring hypothesis. To check this result, we next estimate the plucking model for services.

Table 10. Model of Employment Growth for the Goods Sector

Variable	Coefficient	t-Statistic
C	-0.0008	-3.4153
DE_{t-1}	0.2575	7.2689
DE_{t-2}	0.3181	9.2746
DE_{t-3}	0.1503	4.3279
Γ_{t-1}	0.0291	5.1566
$D_{01}*\Gamma_{t-1}$	-0.0212	-3.0292
$D_{08}*\Gamma_{t-1}$	-0.0252	-4.5097
# of observations	764	
R-squared	0.3623	
S.E. of regression	0.0045	
Schwarz criterion	-7.9108	

First, the asymmetric effect for the service sector is large. Before 2001 a 3% reduction in employment below peak would lead to almost a 1% additional growth in monthly service employment. This is large in absolute terms and particularly large relative to, the monthly average growth in service employment averages 0.2% in our sample. Second, these estimates show a substantial reduction in the asymmetric dynamics in services starting in 2001, and the asymmetric dynamics are essentially eliminated starting in 2008. These results contradict the manufacturing restructuring hypothesis because they suggest that there has also been a large reduction in the bounce back effect for services. This suggests that the reason(s) for jobless recoveries are not confined to the manufacturing sector.

Table 11. Model of Employment Growth for the Service Sector

Variable	Coefficient	t-Statistic
C	-0.00005	-0.3687
DE_{t-1}	0.0963	2.3805
DE_{t-2}	0.3693	9.5905
DE_{t-3}	0.3215	8.2493
DE_{t-4}	0.1691	4.1533
Γ_{t-1}	0.3264	5.7161
$D_{01}*\Gamma_{t-1}$	-0.2884	-4.7813
$D_{08}*\Gamma_{t-1}$	-0.3142	-5.6585
# of observations	597	
R-squared	0.4864	
S.E. of regression	0.0015	
Schwarz criterion	-10.1498	

Lastly, we look at the plucking model for government employment. We find no evidence of an asymmetric government employment response in any period. This may not be surprising, as

government employment is quite distinct from private sector employment in its usual dynamics as well as its response to the state of the business cycle.

In sum, find evidence of asymmetric dynamics in both the goods sector and the services sectors. We also find that that bounce back effect disappears in both sectors in the most recent two recessions. This evidence contradicts the restructuring hypothesis because the jobless recovery is not focused on just the manufacturing sector but also occurs in the services sector.

4. The Flexible Employment Hypothesis

This hypothesis starts with the idea that now firms can hire "just-in-time" employees (part-time and temporary workers) to replace permanent workers after a fall in labor demand caused by a recession. The addition of this flexibility in the labor market reduces employment growth and is hypothesized to be the source of sluggish employment growth in recoveries (Schreft and Sing (2003), Schreft, Singh, and Hodgson, (2005)).

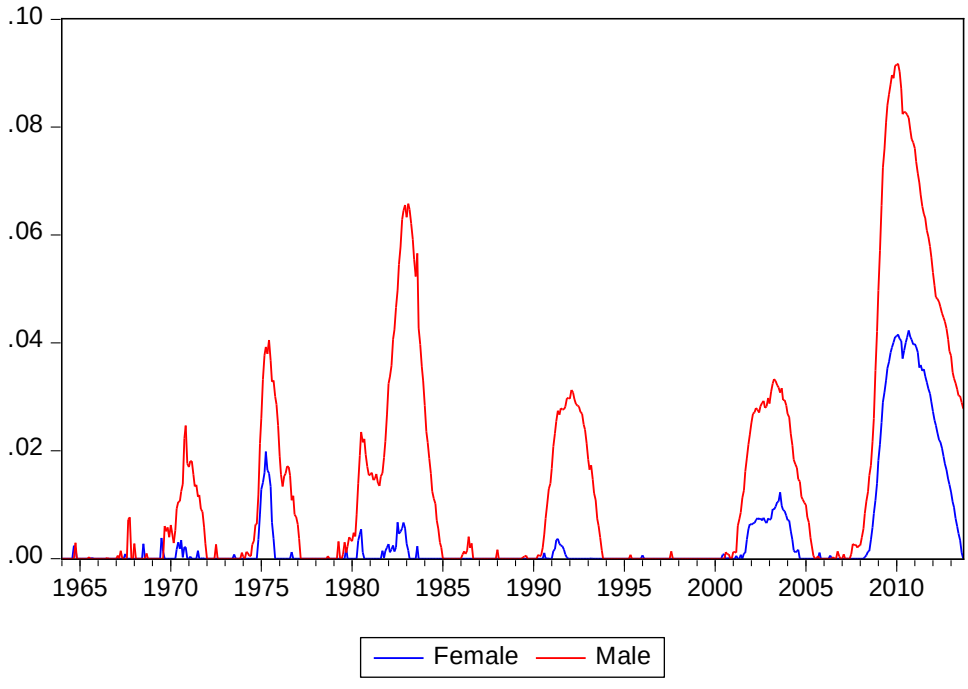
To examine this hypothesis, we note that women are much more likely to be just-in-time employees than men. For example, women are nearly twice as likely as men to work part time. In 2010, 26.6 percent of women worked part time as compared to just 13.4 percent of men. In 2013, the percentages were 25.8 and 13.0. If the flexible employment hypothesis is correct, then the jobless recovery effect should be more pronounced for female employment then for male employment. We investigate this hypothesis by estimating separate plucking models for female and male employment.

However, the BLS started the separate series for male and female employment 1964, which is a shorter series than our total employment series. In order to be sure the change in date did not color the results, so re-estimated our total employment model starting in 1964. These results mimic the results from the full data set, with the asymmetric term falling in absolute

magnitude and significance when the 2008-2013 subsample is included in the regression. This provides the basis for our gender comparison.

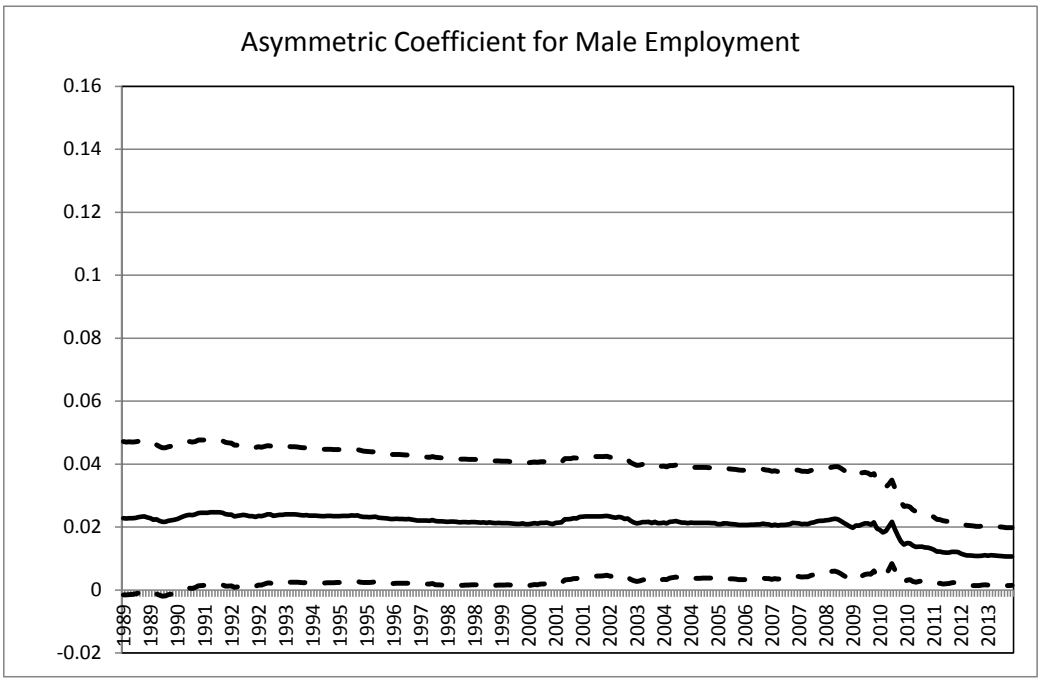
In Figure 7, we plot the asymmetric variable for female employment (blue) and for male employment (red). This variable measures the difference between (log) peak employment and (log) current employment. Generally, the female asymmetric variable is about half the size of the male variable, indicating that female employment during recessions falls less than male employment. There is also visual evidence that the female asymmetric variable, initially small and of short duration, started to increase in 2001, and increased in both duration and magnitude in 2008. In contrast, the male asymmetry shows a pattern similar to the pattern we discussed earlier for aggregate asymmetry, and it is apparent that prior to the 2000 recession most of the employment decline during recessions was a decline in male employment. Starting in 2000 male employment continued to decline and exhibited the 'jobless recovery' pattern we described earlier, but female employment also started exhibiting this same general pattern.

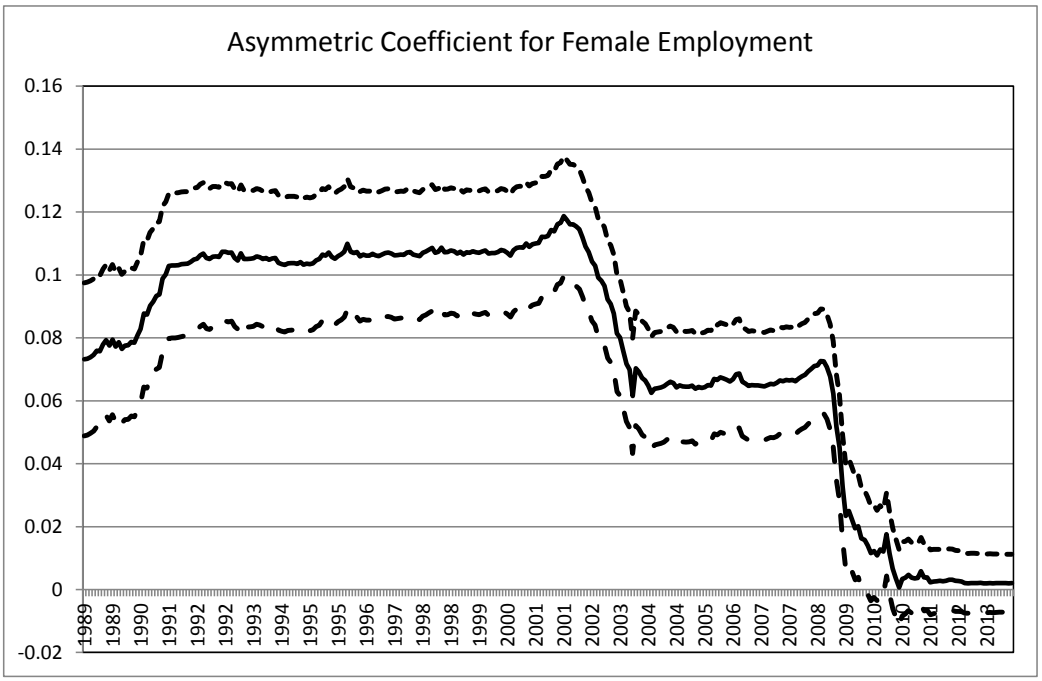
Figure 7. Asymmetric Terms for Female and Male Employment



We next investigate the differential employment dynamics for male and female employment by recursively estimating the plucking model separately for male and female employment. The recursive estimates of the coefficient on the bounce back term are presented in Figure 8. That figure implies very different patterns for male and female bounce back effect coefficient. The male employment coefficient shows a somewhat gradual decline in the until the Great Recession of 2008. Female employment shows two specific declines, one after the 2000 recession and another after the Great Recession of 2008. For female employment, the estimated coefficient on the asymmetric variable is essentially zero for samples that include the Great Recession, suggesting there is no positive asymmetric response to employment in a recovery.

Figure 8. Recursive Estimates of the Coefficient on Asymmetric Term, Male and Female Employment with Standard Error Bands





We next examine this issue by looking at tests for structural breaks. We introduce dummy variables for the 2001 and 2008 recessions, and interact those dummy variables with the asymmetry variable.

Table 12 Model of Employment Growth By Gender

	Males		**Females**	
Variable	Coefficient	t-Statistic	Coefficient	t-Statistic
C	-0.00013	-0.9348	0.00016	0.9878
DE_{t-1}	0.2028	4.9311	0.2382	5.8148
DE_{t-2}	0.2063	4.9140	0.1443	3.4525
DE_{t-3}	0.2360	5.5621	0.1894	4.5589
DE_{t-4}	0.1741	4.0685	0.1937	4.6718
DE_{t-5}	0.0260	0.6049	0.0529	1.2663
DE_{t-6}	0.0397	0.9329	0.0656	1.6042
Γ_{t-1}	0.0263	3.3163	0.1419	3.1971
$D_{01}*\Gamma_{t-1}$	-0.0106	-0.7716	-0.1308	-2.2310
$D_{08}*\Gamma_{t-1}$	-0.0187	-2.4206	-0.1390	-3.2332
# of observations	590		590	
R-squared	0.4090		0.4469	
S.E. of regression	0.0020		0.0019	
Schwarz criterion	-9.4709		-9.6231	

We find that the asymmetric effect in the female employment equation is initially substantially larger than in the male employment equation. We find that the reduction in size of this asymmetric effect occurred first in female employment, and has essentially eliminated any asymmetry due to recessions, or to declines in female employment below its previous peak. This is interesting because there is no evidence of a decline in the asymmetric effect for GDP following the 2001 recession. In contrast, the decline in the asymmetric effect for male employment in 2008 might just reflect the decline in overall cyclical response as indicated by the

results for real GDP. In sum, our results show a complete elimination of the bounce back effect for women and decline in the effect for men. This could be interpreted as indicating, indirectly, that the job flexibility hypothesis may explain part of the decline in employment response during recoveries, because this decline is more severe for women, who have much high levels of flexible employment.

Conclusion

The sluggish growth in employment following the Great Recession has spurred research into investigating its cause. Economists are split as to whether it reflects the advent of "jobless recoveries" in which employment growth lags the overall economic recovery or just reflects "slow recoveries" in which both output and employment are slow to recover.

We estimate a version of Friedman's plucking model to produce evidence on this difference of opinion. While we find that both employment and output have experienced a smaller "bounce back" effect in recent recoveries, there is evidence suggesting that employment does have its own dynamic response after a recession. We find that some of the slow growth in employment can be ascribed to the slow output growth but there is a remaining portion which is consistent with the jobless recovery hypothesis.

We then produce evidence relative to four different hypothesis of why jobless recoveries have occurred. Our evidence contradicts the productivity and manufacturing restructuring hypothesis but provides some support for the job polarization and flexible employment hypotheses.

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