

Understanding the Jobless Recoveries After 1991 and 2001

Rüdiger Bachmann *

March 9, 2012

Abstract

The jobless recoveries in the aftermath of the 1991 and 2001 recessions have puzzled many. Most explanations have focused on structural change. In this paper, I investigate the quantitative contribution of a cyclical mechanism towards generating jobless recoveries. Extending the model by Hansen and Sargent (1988), I calibrate and compute a dynamic stochastic general equilibrium model of heterogeneous establishments that use two margins of labor services: an *intensive* margin, hours per worker, and an *extensive* margin, employment. When facing adjustment costs to the latter, aggregate employment at the end of a short and shallow recession is still relatively high and the need for new hires is weak. Moreover, establishments increase average hours per worker in the early phase of a weak recovery, before they start hiring anew later on. This pattern is consistent with U.S. data. I find that this mechanism can explain approximately half of the differential behavior of aggregate employment in the recoveries following the 1991 and 2001 recessions, compared to previous ones.

JEL Codes: E10, E24, E30, E32.

Keywords: Jobless recoveries, adjustment costs, generalized (S, s) model, DSGE model, extensive and intensive margin, aggregate hours and employment.

*RWTH Aachen University, University of Michigan, NBER, CESifo and IFO (e-mail: ruediger.bachmann@rwth-aachen.de). This is a revised version of the first chapter of my dissertation. I am grateful to Eduardo Engel, Giuseppe Moscarini, Tony Smith, Ying Fan, Thijs van Rens and seminar/meeting participants at Yale, the IHS-Vienna, Magdeburg University, Dortmund University, UC San Diego, UC Santa Cruz, University of Michigan, Harvard Business School, Princeton, Chicago Business School, University of Pennsylvania, University of Maryland, Wharton Business School, Penn State, Arizona State, LSE, UC London, ESSIM 2007, IAB, Cologne University and Bonn University for their comments.

1 Introduction

The jobless recoveries following the 1991 and 2001 recessions have puzzled many. They have triggered a lively debate among political pundits, business columnists and professional economists. The “Jobless Recoveries” speech by then governor Ben Bernanke at the Global Economic and Investment Outlook Conference in 2003, is but one of the many instances of this discussion.¹

This debate is far from having reached a consensus about the causes of jobless recoveries. While a minority views jobless recoveries as a mere downward bias in the official employment statistics and hence as an epiphenomenon (Melloan, 2003, Meltzer, 2003, and Kane, 2004), the majority attributes the occurrence of jobless recoveries to fundamental changes in the underlying economic structure: increased macro- and microeconomic uncertainty in the environment for most businesses after 2001, the availability of a more flexible labor force in the form of temporary workers and offshoring, a secular increase in health benefits and an increased speed of sectoral reallocation in the U.S. economy.²

In this paper, I explore a cyclical explanation for jobless recoveries - a tale of two margins: Consider a long boom followed by a short and shallow recession; assume that hiring and firing of workers is costly and takes time, so that firms still have many workers on their payroll at the end of the recession. Then business conditions improve, but in a lackluster way.³ Because of relatively high payroll employment, firms do not need to hire immediately, because of adjustment costs, they do not want to hire immediately. Moreover, firms lose continuously workers due to exogenous reasons. The result is a jobless recovery. Throughout the paper this will be called the *extensive* margin. Add that firms can make workers on their payroll work longer and harder (by paying them more), and the jobless recovery may be exacerbated. This will be called the *intensive* margin.

¹See Bernanke (2003). Other examples are: Gordon and Baily (1993), Groshen and Potter (2003), Melloan (2003), Meltzer (2003), Schreft and Singh (2003), Schweitzer (2003), Aaronson et al. (2004a, 2004b), Groshen et al. (2004), Kane (2004), Schultze (2004), Schweitzer and Venkatu (2004), Gomme (2005), Schreft et al. (2005), Dueker (2006), Gould (2006) as well as McConnell and Tracy (2006).

²Some authors have discussed cyclical explanations, such as negative labor supply shocks (see Aaronson et al., 2004a), or sluggish aggregate demand (see Bernanke, 2003). Gordon and Baily (1993) express a sceptical view about structural explanations for the jobless recovery in 1991. While I do not dismiss structural explanations, the empirical evidence for some of them is scant: increased speed of structural change (suggested by Groshen and Potter, 2003, as well as Groshen et al., 2004; see Andolfatto and MacDonald, 2004, for a model of jobless recoveries based on this mechanism) and offshoring. Aaronson et al. (2004a and 2004b) as well as McConnell and Tracy (2006) find little support for the structural change hypothesis. And Schultze (2004) shows that neither the mass layoff statistics by the Bureau of Labor Statistics (BLS), nor the import statistics corroborate the offshoring hypothesis. Schreft et al. (2005) suggest that the increased availability of flexible labor services such as part-time work and temporary work, as well as outsourcing of services towards the self-employed contributes to jobless recoveries. This per se cannot explain why aggregate employment, which includes the self-employed, declines as a whole.

³Recently, Engemann and Owyang (2007) as well as Faberman (2008) have connected the great moderation - short and shallow recessions with lackluster recoveries - to the incidence of jobless recoveries.

In order to investigate this cyclical mechanism quantitatively, I extend the equilibrium overtime premium model by Hansen and Sargent (1988) and calibrate a dynamic stochastic general equilibrium (DSGE) model with heterogeneous firms that use these two margins of labor services: hours per worker and employment. Adjustment of the latter is subject to fixed costs. Overtime work requires the payment of an overtime premium.⁴ The literature has found ample evidence for non-convexities in employment adjustment at the establishment level (for instance: Caballero et al. 1997, and, most recently, Bloom, 2009). I calibrate these fixed adjustment costs to the average job turnover rate observed in micro data. The model features just sufficient heterogeneity to use micro data for calibration. Its intensive margin - average hours per worker - is observable in the aggregate. These last two features impose empirical discipline on the model, a central element given the quantitative nature of the investigation. The equilibrium is computed using the algorithm proposed in Krusell and Smith (1997). I use this model to conduct case studies for the behavior of aggregate employment during post war recoveries in the U.S.⁵

The main findings are: (i) the model predicts approximately 50 and 75 per cent of the continued decline of the cyclical component of aggregate employment during the 1991 and 2001 recoveries, respectively; (ii) the model does not feature joblessness in the recoveries prior to 1991, when there are none; the difference is caused by short and shallow recessions with lackluster recoveries after 1991 versus brisk cyclical swings before; (iii) the baseline model explains approximately half of the differential behavior of aggregate employment in the last two recoveries compared to its average behavior in the previous ones; I, thus, show that cyclical mechanisms are important to explain jobless recoveries;⁶ (iv) allowing firms a greater flexibility in their hours choice than in the benchmark model, generates more realistic wage and hours-per-worker dynamics, leading to exacerbated jobless recoveries that match the data more closely.

I should note at the outset: this paper is not about the weak labor market in the aftermath of the so-called Great Recession, which many have characterized also as a jobless recovery (see, for instance, Shimer, 2010). Whether this anemic labor market is indeed comparable to the job-

⁴For a general equilibrium framework, this paper provides the first quantitative analysis of the interaction of a production factor that is subject to non-convex adjustment costs (employment), and a close substitute that can be smoothly adjusted (hours per worker). King and Rebelo (1999) suggest this as an important open research issue in the context of capital adjustment and capacity utilization. More broadly, this paper contributes to the literature on labor adjustment costs in heterogeneous firm models and its aggregate implications: Caballero and Engel (1993), Hopenhayn and Rogerson (1993), Caballero et al. (1997), Campbell and Fisher (2000, 2002), Veracierto (2003), Cooper et al. (2004, 2007), Bloom (2009), as well as King and Thomas (2006).

⁵van Rens (2004) as well as Koenders and Rogerson (2005) also propose models with a cyclical mechanism and a second margin, and attribute jobless recoveries to changes in within-firm re-organization over the cycle. The main differences to this paper are: the second margin there is essentially unobservable, and, secondly, this paper conducts model-based case studies for historically observed jobless recovery episodes.

⁶Recent work by Dueker (2006), who uses a Markov-switching approach to model cyclically changing expected output growth, also lends some statistical support for a cyclical explanation.

less recovery episodes after 1991 and 2001 is an open question; and one which cannot really be addressed yet, given the in part substantial data revisions about this episode that are still ongoing. It is also too early to tell what the cyclical situation of aggregate employment was in the second quarter of 2009, the official trough of the recession. We simply do not know the trend development of aggregate employment yet. Despite the unusual length of the Great Recession there could still have been an employment overhang at its official end. Finally, there is at least prime facie evidence that the Great Recession and its aftermath are different from any other recession and recovery episodes in U.S. post-war history: Beveridge curve shifts, financial disruption, deleveraging, policy uncertainty, etc., which cannot be invoked for the jobless recovery episodes after 1991 and 2001.

The remainder of this paper is organized as follows: in the next section, I briefly present the relevant data facts. The ensuing section develops the baseline DSGE model. A calibration section follows, before I discuss the main results of the paper. Then comes a section with extensions to the baseline model and a conclusion. A detailed description of the data, a brief exposition of the numerical procedures used in this paper and a robustness section are relegated to appendices.

2 The Facts

Jobless recoveries are usually defined as a continued decline of aggregate employment, accompanied by an increase in aggregate GDP after the NBER trough date of a cycle.⁷

Figure 1: Jobless Recoveries After 1991 and 2001 and Earlier Recoveries

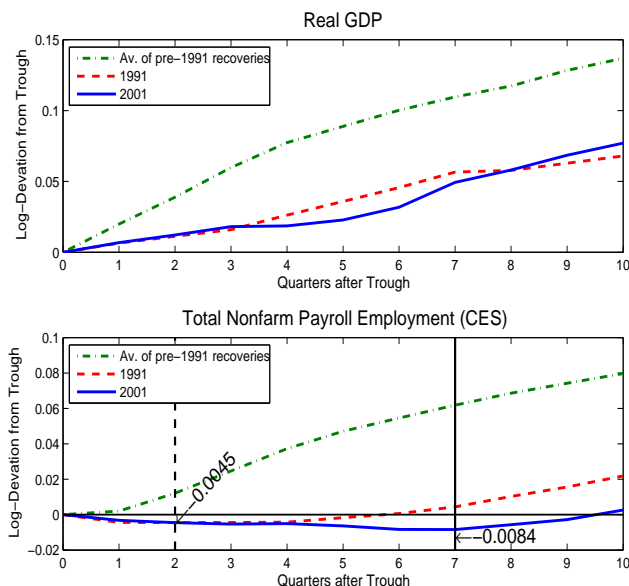


Figure 1 shows that the aftermath of the 1991 and 2001 recessions is very different from that of earlier recessions. While prior to 1991 aggregate employment, on average, picks up immediately after the trough,⁸ into the the recoveries of 1991 and 2001 employment continued falling many quarters during the recovery phase, increasing above its trough level only six and ten quarters after the end of the recession, for 1991 and 2001, respectively.⁹

Since this paper is about the quantitative contribution of a cyclical mechanism towards generating jobless recoveries, the next figure shows the cyclical analogue to the lower panel of Figure 1. It displays the cyclical component of total non-farm payroll employment after the troughs in 1991 and 2001, respectively.¹⁰ Because of an overall positive trend employment growth, the

⁷This is the definition most of the literature uses, for instance Aaronson et al. (2004), Groshen et al. (2003), Schreft et al. (2003, 2005). An exception is Koenders and Rogerson (2005), who use the first quarter of a recession to have aggregate output below trend, instead of the end of the recession, as the reference point from which to measure jobless recoveries.

⁸The pattern is similar for each pre-1991 recovery individually.

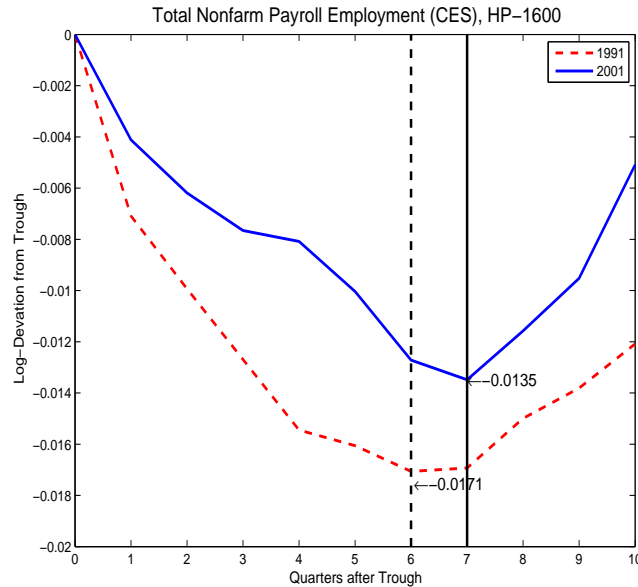
⁹Appendix A describes in detail the data used. There has been a debate in the literature about the right aggregate employment measure in the context of jobless recoveries. Appendix B discusses this issue in some detail, and concludes that the practice of most of the literature on jobless recoveries, for instance, Groshen, E. et al. (2003), Schreft, S. et al. (2003, 2005) and Schweitzer (2003), as well as Birkeland (2005) and Koenders and Rogerson (2005), including this paper, to use establishment-level data (CES) is justified.

The plot for the average pre-1991 recovery averages over the recoveries in the aftermath of the recessions from 1949 to 1982. I consider the double cycle at the beginning of the 1980's as one and take 1982 as the end of it.

¹⁰The cyclical component was computed as the log-deviation from an HP-filter with smoothing parameter 1600.

minima of the cyclical component of employment are much lower than in the raw data: -1.7% and -1.4% , for 1991 and 2001, respectively. Moreover, for 1991 the position of the minimum shifted to six quarters after the NBER trough. In neither case was the NBER trough level reached after ten quarters.

Figure 2: The Cyclical Employment Component in the Jobless Recoveries After 1991 and 2001



Another way of capturing the differential behavior of cyclical aggregate employment and output before and after the nineties, which is independent of the NBER dating procedure, is the substantial shift in the dynamic correlogram between both time series.

Figure 3: Rightward Shift in Dynamic Output-Employment Correlations

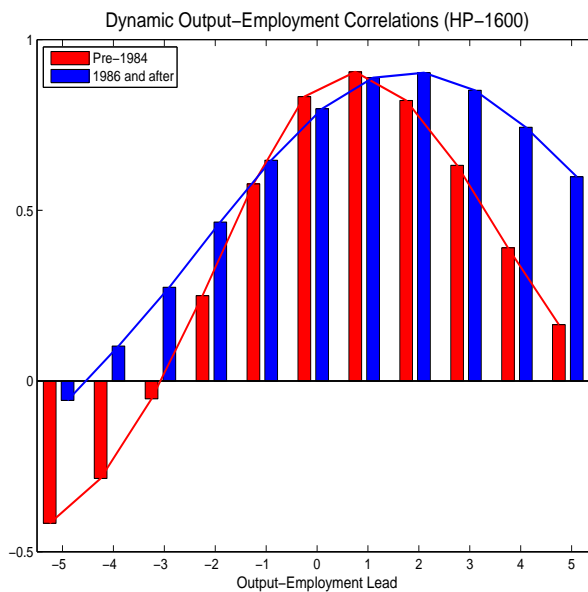


Figure 3 displays the lead/lag correlations of output and employment: output leads are to the right, lags to the left. The peak correlation before the nineties is at one quarter output lead, it shifts to two quarters for the last twenty years. The later correlogram declines much slower on the output lead side than before.¹¹

Figure 4: Jobless Recoveries are a Cyclical Phenomenon

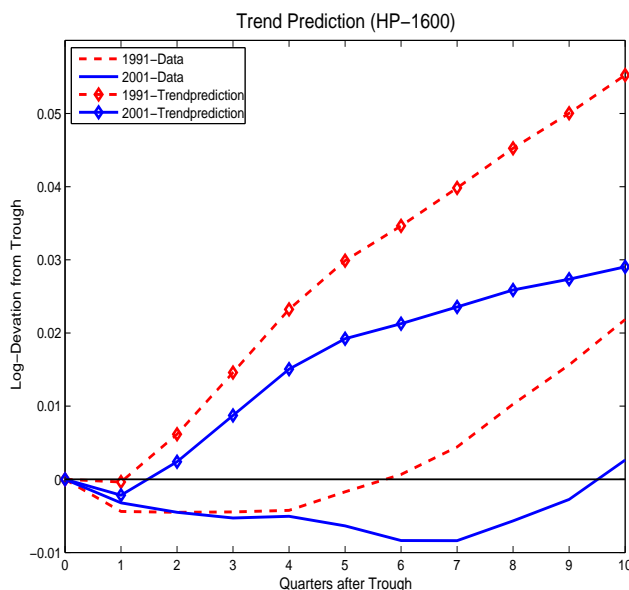


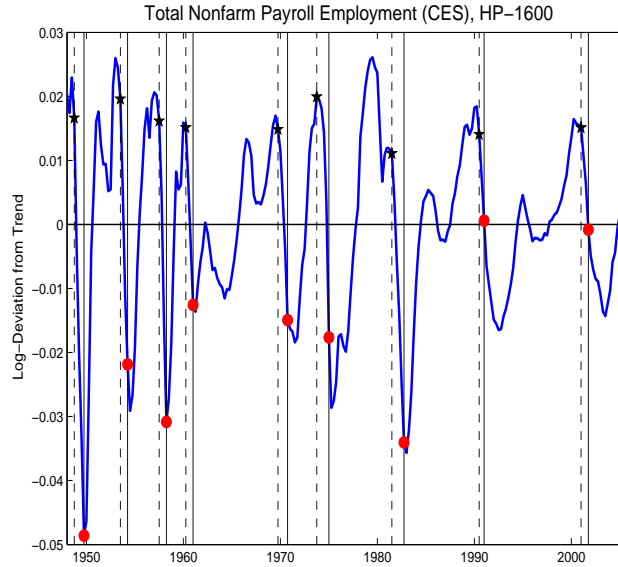
Figure 4 shows that a cyclical explanation is needed to fully understand jobless recoveries. The graph displays the actual aggregate employment behavior during the jobless recovery episodes 1991 and 2001, and the prediction for aggregate employment behavior, if the average cyclical component of aggregate employment over all post-war recoveries were added to the trend components for aggregate employment in 1991 and 2001 (the lines with markers). As can be seen, given that employment trend growth is positive even in 1991 and 2001, adding an on average expansive cyclical component would considerably over-predict employment growth in 1991 and 2001. Hence, a necessary condition for the jobless recoveries in 1991 and 2001 to occur, is the specific cyclical decline of aggregate employment as shown in figure 2.¹²

How does the cyclical behavior during the jobless recoveries in 1991 and 2001 compare to the total of the U.S. aggregate employment series? Figure 5 shows the time path of the cyclical component of aggregate employment in U.S. postwar history, together with the NBER peaks (dashed lines) and troughs (straight lines). Two related facts are important: the recessions in

¹¹I split the data in II/84, so that the 1982 recession lies in the first sample. I leave a window of two years and take the second sample from III/86 onwards.

¹²Notice that the HP-filter with a smoothing parameter of 1600 is a conservative estimate for a possible trend explanation. Using a smoothing parameter of 160000 (a value that is closer to the one recently used by Shimer, 2005), for instance, would leave considerably less room for a structural change explanation, a linear trend, by construction, none. The statement is robust to using a band pass filter (6,32) with a moving average of 8, and to taking out the first recovery episode in 1950, directly after the war.

Figure 5: The Cyclical Component of Aggregate Employment



1991 and 2001 have been unusually short and unusually shallow for employment. At the time of the NBER trough, the cyclical component of aggregate employment just reaches trend level in both cases.¹³ In the model developed here, the cyclical situation of employment at the trough will be paramount in determining the model economy’s proneness to jobless recoveries.

This section shows that jobless recoveries at least until recently are an unusual phenomenon in the U.S. business cycle. Both historical jobless recoveries are characterized by an at-trend level cyclical employment component at the end of the preceding recession, whereas in previous cycles the cyclical employment trough either coincides with the end of the recession or lags at most one quarter.¹⁴

3 The Model

The baseline model is an extension of Hansen and Sargent (1988). Due to the quantitative nature of the investigation, it allows for heterogeneity on the establishment side and features fixed adjustment costs to employment which are calibrated to micro data. Thus, any success of the model in the time series dimension is not due to calibration to aggregate data. On the household side, it assumes complete risk sharing and essentially a single representative household. Unlike Hansen and Sargent (1988), I abstract from capital and use the non-separable felicity

¹³This finding is robust to the de-trending method used: a more rigid HP-filter with smoothing parameter 160000, and a band pass filter (6,32) with a moving average window of eight. Table 5 in Appendix A summarizes the peak and trough deviations for HP(1600)-filtered aggregate output and employment.

¹⁴By contrast, aggregate measures of the intensive margin - hours per worker (in particular in the private sector), manufacturing overtime hours and capacity utilization - pick up together with output right from the trough, especially when measured in cyclical components. Appendix A summarizes the main business cycle statistics for GDP, employment and average hours per worker.

specification proposed by Greenwood et al. (1988). The solution technique is taken from Khan and Thomas (2003, 2008), who, in turn, build on Krusell and Smith (1997).

3.1 Establishments

There is a unit mass of establishments, there is no entry nor exit. There is one factor of production, labor services, which can be used in an extensive margin - employment - and an intensive margin - hours per worker. Specifically, establishments have the option of employing their workers for h_1 straight time hours and h_2 overtime hours. h_1 and h_2 are fixed technology parameters, to be calibrated. Establishments employ the total of their workers, n_1 , in straight time, and n_2 of them in overtime. All workers that work overtime also work straight time. Hence, $n_1 - n_2$ is the number of workers that work only the straight time shift.

Establishments use the following Cobb-Douglas production function to produce the single, perishable commodity in this economy every period ($\alpha < 1$):¹⁵

$$y = z\epsilon(h_1 n_1^\alpha + h_2 n_2^\alpha), \quad (1)$$

where z and ϵ denote aggregate and idiosyncratic productivity levels. $\log(z)$ evolves according to an AR(1) process, with normal innovations v with zero mean and variance σ_A^2 :

$$\log(z') = \rho_A \log(z) + v. \quad (2)$$

Idiosyncratic productivity follows a Markov chain that approximates a continuous AR(1) process with Gaussian innovations. The parameters are ρ_I and σ_I , respectively.¹⁶ Aggregate and idiosyncratic productivity innovations are independent, and so are idiosyncratic productivity innovations across establishments. Establishments have the following total wage bill: $w_1 h_1 n_1 + w_2 h_2 n_2$, where w_1 is the straight time wage, and w_2 the overtime wage.

It is easy to see that this set up - establishments choosing n_1 and n_2 - effectively amounts to choosing overall employment, $n = n_1$, and average hours per worker, h . The latter is defined as:

$$h \equiv \frac{h_1 n_1 + h_2 n_2}{n_1} = h_1 + h_2 \frac{n_2}{n_1}. \quad (3)$$

Establishments face fixed adjustment costs to adjust their employment stock, n_1 . There are no costs to adjusting n_2 (or hours).¹⁷ Adjustment costs are symmetric for upward and downward adjustment. Denote output under no employment adjustment, but optimal choice of n_2

¹⁵For simplicity, time indices are suppressed.

¹⁶I use the discretization method from Tauchen (1986).

¹⁷I follow the literature here. For evidence justifying this assumption, see Bilal (1987).

as:¹⁸

$$y^{na}(\epsilon, n_1^-; z) = z\epsilon \left(h_1(n_1^-(1-q))^\alpha + h_2(n_2^*(n_1^-))^\alpha \right). \quad (4)$$

Notice that the choice of n_2 depends on n_1^- , because by construction $n_2 \leq n_1^-$. Then adjustment costs paid conditional on adjusting employment, $n_1 \neq (1-q)n_1^-$ are given by

$$AC(\epsilon, n_1^-, \xi; z) = ((1-\kappa) + \kappa y^{na}(\epsilon, n_1^-; z))\xi. \quad (5)$$

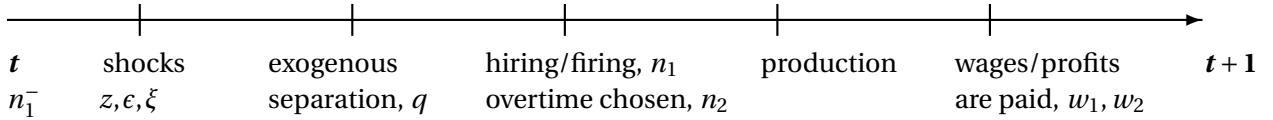
ξ is a stochastic adjustment cost factor. This specification provides a flexible way to capture two aspects of non-convex adjustment costs: a fixed cost proper and the disruption aspect of employment adjustment.¹⁹ Fixed (non-convex) adjustment costs are one way to rationalize the well-documented phenomenon of infrequent and lumpy employment adjustment at the establishment level.²⁰

Adjustment cost factors, ξ , are drawn from the following distribution:

$$\xi \sim G(\xi) = U([0, \bar{\xi}]), \quad (6)$$

where $U[\cdot]$ denotes a uniform distribution.²¹ $G(\xi)$ is time-invariant, establishments draw ξ independently across time and establishments.

Table 1: TIME LINE FOR ESTABLISHMENTS



At the beginning of each model period, an establishment is characterized by its inherited stock of employment, n_1^- , its idiosyncratic productivity level, ϵ , and its adjustment cost factor

¹⁸Since there is no money in this economy, output equals sales. Establishments face an exogenous employment attrition at rate q . These comprise all separations that are not due to the optimal labor demand decision of the establishment. n_1^- denotes the employment stock at the beginning of a period, before attrition.

¹⁹See Cooper et al. (2004). $\kappa = 0$ would allow large establishments to simply outgrow adjustment costs, while $\kappa = 1$, combined with large adjustment costs, leads to an artificial increase in the value of extremely small establishments. Neither effect is desirable. Numerically, I find it convenient to fix κ at 0.75. I check for robustness.

²⁰See Hammermesh (1989), Caballero et al. (1997) and, most recently, Davis et al. (2006). Foster (1999) and Cooper et al. (2004) find strong support for non-convex adjustment costs, using U.S. plant-level manufacturing data; so does Bloom (2009), who uses Compustat data and estimates adjustment costs jointly for capital and employment. The results by Bewley (1999) about the importance of morale are suggestive of the importance of non-convexities on the firing side: firms want to “get the problem out of the door all at once”. Another strand of the literature models inaction in employment adjustment with convex, non-differentiable-at-zero linear adjustment costs: Hopenhayn and Rogerson (1993), Campbell and Fisher (2000, 2002) and Veracierto (2003).

²¹Here I follow Khan and Thomas (2003 and 2008), and King and Thomas (2006). Stochastic adjustment costs are a convenient way to capture realistic heterogeneity in the establishments’ willingness to tolerate deviations from their statically optimal employment level.

ξ . Then the establishment loses part of its workforce at the exogenous rate q . Hiring and firing decisions are made, the optimal intensive margin, i.e. the use of overtime hours, is chosen. Newly hired workers become immediately productive. Production occurs, workers are paid and profits distributed. Then the period ends. The time line above summarizes this sequence of events.

Given the i.i.d. nature of the adjustment cost factors, it is sufficient to describe differences across establishments and their evolution by the joint distribution of establishments over (ϵ, n_1^-) . Let this distribution be denoted by μ . Thus, (z, μ) constitutes the current aggregate state. μ evolves according to the law of motion $\mu' = \Gamma(z, \mu)$, which establishments take as given.

Next, I describe the dynamic programming problem of a typical establishment. Two shortcuts will be taken (details can be found in Khan and Thomas, 2008). First, the problem is stated in terms of utils of the representative household, rather than physical units. The marginal utility of consumption is denoted by $p = p(z, \mu)$. This is the relative intertemporal price used by an establishment to value current output streams. Second, given the i.i.d. nature of the adjustment cost factors, continuation values can be expressed without explicitly taking into account future adjustment costs.

Let $V^1(\epsilon, n_1, \xi; z, \mu)$ denote the expected discounted value - in utils - of a unit that is in idiosyncratic state (ϵ, n_1, ξ) ,²² given the aggregate state (z, μ) . Then the expected value prior to the realization of the adjustment cost draw is given by:

$$V^0(\epsilon, n_1; z, \mu) = \int_0^{\bar{\xi}} V^1(\epsilon, n_1, \xi; z, \mu) \frac{1}{\bar{\xi}} d\xi. \quad (7)$$

With these stipulations the dynamic programming problem can be stated as follows:²³

$$\begin{aligned} V^1(\epsilon, n_1, \xi; z, \mu) = & \\ & \max \left\{ \max_{n_2 \leq n_1(1-q)} \left[z\epsilon \left(h_1(n_1(1-q))^\alpha + h_2 n_2^\alpha \right) - w_1(z, \mu) h_1 n_1(1-q) - w_2(z, \mu) h_2 n_2 \right] p(z, \mu) + \right. \\ & \quad \left. \beta E[V^0(\epsilon', n_1(1-q); z', \mu')], \right. \\ & \left. - AC(\epsilon, n_1, \xi; z) p(z, \mu) + \max_{n'_1} \left(\max_{n_2 \leq n'_1} \left[z\epsilon \left(h_1 n_1'^\alpha + h_2 n_2^\alpha \right) - w_1(z, \mu) h_1 n'_1 - w_2(z, \mu) h_2 n_2 \right] p(z, \mu) + \right. \right. \\ & \quad \left. \left. \beta E[V^0(\epsilon', n'_1; z', \mu')] \right) \right\}, \quad (8) \end{aligned}$$

where both expectation operators average over next period's realizations of the aggregate and idiosyncratic shocks, conditional on this period's values.

²²From now onwards, I drop the minus superscript for the beginning-of-period employment level.

²³ β is the discount factor of the representative household.

The first line represents the flow value - in utils - of an establishment that optimally adjusts overtime employment, but does not adjust its overall employment level. The second line is the continuation value under no employment adjustment. The third line is the flow value under optimal overtime *and* employment adjustment, the final line is the continuation value under optimal employment adjustment.

Taking as given the wages and the pricing kernel, $w_1(z, \mu)$, $w_2(z, \mu)$ and $p(z, \mu)$, and the law of motion $\Gamma(z, \mu)$, the establishment chooses optimally overtime employment, whether to adjust its employment level, and the optimal employment level, conditional on adjustment. This leads to policy functions: $N_1 = N_1(\epsilon, n_1, \xi; z, \mu)$ and $N_2 = N_2(\epsilon, n_1, \xi; z, \mu)$.

3.2 Households

There is a continuum of identical households, whose members pool all their income. Profits, Π , across all establishments, are distributed evenly across households. Each member of a household has the following non-separable felicity function over consumption, c , and hours worked, h :

$$u(c, h) = \log\left(c - A \frac{h^{1-\sigma_h}}{1-\sigma_h}\right), \quad (9)$$

where $\sigma_h \leq 0$ and $A \geq 0$ are constants. σ_h is the curvature parameter for hours worked and one of the determinants of the equilibrium overtime premium. The inverse of the absolute value of σ_h is the labor supply elasticity. This utility specification is a convenient way to eliminate the wealth effects on labor supply in a model without capital.

Each member of the household is endowed with one unit of time. The technologically given consumption set for leisure is: $\{1 - h_1 - h_2, 1 - h_1, 1\}$, working straight and overtime, working straight time only, not working. The household chooses the fraction of its members that consume one of these three options for leisure, \bar{n}'_2 , $\bar{n}'_1 - \bar{n}'_2$ and $1 - \bar{n}'_1$, respectively, and their commodity consumption, c_2, c_1, c_0 , by maximizing the following household utility function:²⁴

$$U(c_0, c_1, c_2, \bar{n}'_1, \bar{n}'_2) = (1 - \bar{n}'_1) \log(c_0) + (\bar{n}'_1 - \bar{n}'_2) \log\left(c_1 - A \frac{h_1^{1-\sigma_h}}{1-\sigma_h}\right) + \bar{n}'_2 \log\left(c_2 - A \frac{(h_1 + h_2)^{1-\sigma_h}}{1-\sigma_h}\right). \quad (10)$$

The household faces the following budget constraint:

$$\Pi + w_1 h_1 \bar{n}'_1 + w_2 h_2 \bar{n}'_2 = (1 - \bar{n}'_1) c_0 + (\bar{n}'_1 - \bar{n}'_2) c_1 + \bar{n}'_2 c_2. \quad (11)$$

²⁴To be consistent in notation with the establishments' problem \bar{n}'_1 denotes the total fraction of members sent to work, \bar{n}'_2 the fraction of members sent to overtime work.

As usual, this problem leads to perfect risk sharing among household members:²⁵

$$c_0 = c_1 - A \frac{h_1^{1-\sigma_h}}{1-\sigma_h} = c_2 - A \frac{(h_1 + h_2)^{1-\sigma_h}}{1-\sigma_h}. \quad (12)$$

Denoting the household's average consumption by $C \equiv (1 - \bar{n}'_1)c_0 + (\bar{n}'_1 - \bar{n}'_2)c_1 + \bar{n}'_2c_2$ and using the risk sharing conditions (12), we find that:

$$c_0 = C - (\bar{n}'_1 - \bar{n}'_2)A \frac{h_1^{1-\sigma_h}}{1-\sigma_h} - \bar{n}'_2A \frac{(h_1 + h_2)^{1-\sigma_h}}{1-\sigma_h}. \quad (13)$$

With this notation, the problem can be re-written as the household choosing average consumption, C , \bar{n}'_1 and \bar{n}'_2 :

$$U(C, \bar{n}'_1, \bar{n}'_2) = \log \left(C - (\bar{n}'_1 - \bar{n}'_2)A \frac{h_1^{1-\sigma_h}}{1-\sigma_h} - \bar{n}'_2A \frac{(h_1 + h_2)^{1-\sigma_h}}{1-\sigma_h} \right), \quad (14)$$

subject to:

$$\Pi + w_1 h_1 \bar{n}'_1 + w_2 h_2 \bar{n}'_2 = C. \quad (15)$$

This formulation has several convenient features for the numerical solution of the problem: first, the wages w_1 and w_2 are pinned down by the household's preferences and the possible consumption sets for leisure. Taking first-order conditions with respect to \bar{n}'_1 and \bar{n}'_2 , yields:

$$w_1 h_1 = A \frac{h_1^{1-\sigma_h}}{1-\sigma_h} \quad \text{and} \quad w_2 h_2 = A \frac{(h_1 + h_2)^{1-\sigma_h} - h_1^{1-\sigma_h}}{1-\sigma_h}. \quad (16)$$

This implies that w_1 and w_2 are constant over time. Notice that this does not imply that the average hourly wage in the economy is constant, because

$$\bar{w} \equiv \frac{w_1 h_1 \bar{n}'_1 + w_2 h_2 \bar{n}'_2}{h_1 \bar{n}'_1 + h_2 \bar{n}'_2} = \frac{w_1 h_1 + w_2 h_2 \frac{\bar{n}'_2}{\bar{n}'_1}}{h_1 + h_2 \frac{\bar{n}'_2}{\bar{n}'_1}}. \quad (17)$$

It varies because the fraction of workers working overtime, $\frac{\bar{n}'_2}{\bar{n}'_1}$, varies over time.

Finally, the pricing kernel for current output streams is given by:

$$p \equiv \frac{1}{C - (\bar{n}'_1 - \bar{n}'_2)A \frac{h_1^{1-\sigma_h}}{1-\sigma_h} - \bar{n}'_2A \frac{(h_1 + h_2)^{1-\sigma_h}}{1-\sigma_h}}. \quad (18)$$

²⁵Notice that here, in contrast to the separable felicity case, $c_2 > c_1 > c_0$, i.e. the more hours a household member works, the higher her consumption.

3.3 Recursive Equilibrium

A recursive competitive equilibrium is a set of functions

$$\left(w_1, w_2, p, V^1, N_1, N_2, C, \bar{n}'_1, \bar{n}'_2, \Gamma \right),$$

that satisfy

1. *Establishment optimality*: Taking w_1 , w_2 , p and Γ as given, $V^1(\epsilon, n_1; z, \mu)$ solves (8), and the corresponding policy functions are $N_1(\epsilon, n_1, \xi; z, \mu)$ and $N_2(\epsilon, n_1, \xi; z, \mu)$.
2. *Household optimality*: Taking w_1 and w_2 as given, the household's consumption, C , and labor supply, \bar{n}'_1 and \bar{n}'_2 , satisfy (15). w_1 and w_2 have to satisfy (16).
3. *Commodity market clearing*:

$$C(z, \mu) = \int \int_0^{\bar{\xi}} z\epsilon \left(h_1 N_1(\epsilon, n_1, \xi; z, \mu)^\alpha + h_2 N_2(\epsilon, n_1, \xi; z, \mu)^\alpha \right) \frac{1}{\bar{\xi}} d\xi d\mu - \int \int_0^{\bar{\xi}} AC(\epsilon, n_1, \xi; z) \mathcal{J} \left(n_1(1-q) - N_1(\epsilon, n_1, \xi; z, \mu) \right) \frac{1}{\bar{\xi}} d\xi d\mu.$$

where $\mathcal{J}(x) = 0$, if $x = 0$ and 1, otherwise.

4. *Labor market clearing*:

$$\bar{n}'_1(z, \mu) = \int \int_0^{\bar{\xi}} N_1(\epsilon, n_1, \xi; z, \mu) \frac{1}{\bar{\xi}} d\xi d\mu \quad \text{and} \quad \bar{n}'_2(z, \mu) = \int \int_0^{\bar{\xi}} N_2(\epsilon, n_1, \xi; z, \mu) \frac{1}{\bar{\xi}} d\xi d\mu.$$

5. *Model consistent dynamics*: The evolution of the cross-section that characterizes the economy, $\mu' = \Gamma(z, \mu)$, is induced by $N_1(\epsilon, n_1, \xi; z, \mu)$ and the exogenous processes for z and ϵ .

Conditions 1, 2, 3, 4 define an equilibrium given Γ , while step 5 specifies the equilibrium condition for Γ .

3.4 Solution

As is well-known, (8) is not computable, because μ is infinite dimensional. Even though the wages, w_1 and w_2 , are time-invariant, and hence independent of μ , $p(z, \mu)$ is obviously not. Hence, I follow Krusell and Smith (1997) and approximate the distribution μ by its first moment over establishment-level beginning-of-period employment, and its evolution, Γ , by a simple

log-linear rule. In the same vein, the equilibrium pricing kernel is approximated by a log-linear rule:

$$\log \bar{n}'_1 = a_n + b_n \log \bar{n}_1 + c_n \log z, \quad (19)$$

$$\log p = a_p + b_p \log \bar{n}_1 + c_p \log z, \quad (20)$$

where \bar{n}_1 - with a slight abuse of notation - denotes aggregate employment at the beginning of a model period, and \bar{n}'_1 aggregate employment at the end of a model period. As is usual with this procedure, this form is posited at the outset, and it is verified that in equilibrium it yields a good fit to the actual law of motion (see Appendix C for details).

Substituting \bar{n}_1 for μ into (8), and using (19) and (20), the dynamic programming problem for the establishments becomes computable:

$$\begin{aligned} V^1(\epsilon, n_1, \xi; z, \bar{n}_1) = & \\ & \max \left\{ \max_{n_2 \leq n_1(1-q)} [z\epsilon (h_1(n_1(1-q))^\alpha + h_2 n_2^\alpha) - w_1 h_1 n_1(1-q) - w_2 h_2 n_2] p(z, \bar{n}_1) + \right. \\ & \quad \left. \beta E[V^0(\epsilon', n_1(1-q); z', \bar{n}'_1)], \right. \\ & - AC(\epsilon, n_1, \xi; z) p(z, \bar{n}_1) + \max_{n'_1} \left(\max_{n_2 \leq n'_1} [z\epsilon (h_1 n_1'^\alpha + h_2 n_2^\alpha) - w_1 h_1 n'_1 - w_2 h_2 n_2] p(z, \bar{n}_1) + \right. \\ & \quad \left. \left. \beta E[V^0(\epsilon', n'_1; z', \bar{n}'_1)] \right) \right\}. \quad (21) \end{aligned}$$

(21) is solved by value function iteration on V^0 and Gauss-Hermitian numerical integration over $\log(z)$; for details see Appendix C.

Several features facilitate the solution of the model. The overtime decision of the establishment is static, conditional on its overall employment decision, $N_1(\epsilon, n_1, \xi; z, \bar{n})$. Hence, a static first-order condition can be used to maximize out the optimal overtime demand in closed form, for the case of employment adjustment and no employment adjustment separately, N_2^a, N_2^{na} :

Next comes the establishment's overall employment decision. Let us denote the gross value of adjustment net of adjustment costs, by V^a :

$$V^a = \max_{n'_1} \left(\left(z\epsilon (h_1 n_1'^\alpha + h_2 N_2^{a\alpha}) - w_1 h_1 n'_1 - w_2 h_2 N_2^a \right) p(z, \bar{n}_1) + \beta E[V^0(\epsilon', n'_1; z', \bar{n}'_1)] \right). \quad (22)$$

Denote the solution to (22), the optimal employment level, conditional on adjusting, by $n^* = n^*(\epsilon; z, \bar{n}_1)$. This quantity does not depend on the establishment's beginning-of-period

employment, or on the level of adjustment costs. Furthermore, denote the value of inaction by:

$$V^{na} = \left(z\epsilon(h_1 n_1(1-q)^\alpha + h_2 N_2^{a\alpha}) - w_1 h_1 n_1(1-q) - w_2 h_2 N_2^a \right) p(z, \bar{n}_1) + \beta E[V^0(\epsilon', n_1(1-q); z', \bar{n}'_1)]. \quad (23)$$

Comparing (22) with (23) shows that $V^a(\epsilon; z, \bar{n}_1) \geq V^{na}(\epsilon, n_1; z, \bar{n}_1)$.²⁶ From the adjustment cost function (5), it follows that there exists an adjustment cost factor that makes an establishment indifferent between adjusting employment and not adjusting:

$$\hat{\xi}(\epsilon, n_1; z, \bar{n}_1) = \frac{V^a(\epsilon; z, \bar{n}_1) - V^{na}(\epsilon, n_1; z, \bar{n}_1)}{\left((1-\kappa) + \kappa y^{na}(\epsilon, n_1; z, \bar{n}_1) \right) p(z, \bar{n}_1)}. \quad (24)$$

I define a threshold adjustment cost factor as $\xi^T(\epsilon, n_1; z, \bar{n}_1) \equiv \min\left(\bar{\xi}, \hat{\xi}(\epsilon, n_1; z, \bar{n}_1)\right)$. Then:

$$N_1 = N_1(\epsilon, n_1, \xi; z, \bar{n}_1) = \begin{cases} n^*(\epsilon; z, \bar{n}_1) & \text{if } \xi \leq \xi^T(\epsilon, n_1; z, \bar{n}_1). \\ n_1(1-q) & \text{otherwise.} \end{cases} \quad (25)$$

This concludes the computation of the establishment's decision rules and value function, given the pricing and movement rules (19) and (20).

The second step of the computational procedure takes the value function $V^0(\epsilon, n_1; z, \bar{n}_1)$ as given, and pre-specifies a randomly drawn sequence of aggregate technology levels: $\{z_t\}$. I start from a distribution, μ_0 , implying a value \bar{n}_{10} . Specifically, I start with a mass point at the average employment level. I then re-compute (21) at every point along the sequence $\{z_t\}$, and the implied sequence of aggregate beginning-of-period employment levels $\{\bar{n}_{1t}\}$, *without* using the guess for the equilibrium pricing kernel, (20):

$$\begin{aligned} \tilde{V}^1(\epsilon, n_1, \xi; z_t, \bar{n}_{1t}, p) = & \max \left\{ \max_{n_2 \leq n_1(1-q)} \left[z_t \epsilon \left(h_1 (n_1(1-q))^\alpha + h_2 n_2^\alpha \right) - w_1 h_1 n_1(1-q) - w_2 h_2 n_2 \right] p + \right. \\ & \left. \beta E[V^0(\epsilon', n_1(1-q); z'(z_t), \bar{n}'_1(\bar{n}_{1t}))], \right. \\ & - AC(\epsilon, n_1, \xi; z) p + \max_{n'_1} \left(\max_{n_2 \leq n'_1} \left[z_t \epsilon \left(h_1 n_1'^\alpha + h_2 n_2^\alpha \right) - w_1 h_1 n'_1 - w_2 h_2 n_2 \right] p + \right. \\ & \left. \left. \beta E[V^0(\epsilon', n'_1; z'(z_t), \bar{n}'_1(\bar{n}_{1t}))] \right) \right\}. \quad (26) \end{aligned}$$

This produces new “policy functions”:

$$\begin{aligned} \tilde{N}_1 &= \tilde{N}_1(\epsilon, n_1, \xi; z_t, \bar{n}_{1t}, p) \\ \tilde{N}_2 &= \tilde{N}_2(\epsilon, n_1, \xi; z_t, \bar{n}_{1t}, p). \end{aligned}$$

²⁶The establishment can always choose $n^* = n(1-q)$.

I then search for a p such that, given these new decision rules and after aggregation, (18) is satisfied. I then use this p to find the new aggregate employment level, \bar{n}'_1 .

This procedure generates time series of $\{\bar{n}_{1t}\}$ and $\{\bar{p}_t\}$, on which the assumed rules (19) and (20) can be updated via a simple OLS regression. The procedure stops, when the updated coefficients (a_n, b_n, c_n) and (a_p, b_p, c_p) are sufficiently close to the previous ones. I relegate the details of the numerical implementation and the numerical evaluations to Appendix C.

4 Calibration

The model period is one quarter. The data time horizon is, unless otherwise stated, I/48 to IV/05, 232 data points altogether. The following parameters are standard and remain unchanged throughout the paper: the discount rate β is 0.99, the output elasticity of employment in the production function, α , is 0.64. h_1 and A are jointly calibrated to match an average aggregate employment level of 0.6 and an average level of per worker hours of $\frac{1}{3}$. These calibrations are repeated for the baseline model, every robustness check and extension.

The next group of parameters is fixed for the baseline scenario and subject to robustness tests in Appendix D. From (16) it follows that the equilibrium overtime premium is given by:

$$\frac{w_2}{w_1} = \frac{(1 + K_h)^{1-\sigma_h} - 1}{K_h}, \quad (27)$$

where $K_h \equiv \frac{h_2}{h_1}$. The overtime premium is, thus, a function of the curvature in the disutility of hours worked and the relative shift length. K_h is taken from Hansen and Sargent (1988) to be $\frac{10}{37} \approx 0.25$, which leads to an average fraction of overtime workers to straight time workers of $\frac{1}{3}$. Since $K_h > 0$, the overtime premium is increasing in the absolute value of σ_h , i.e. the more inelastic labor supply is, the higher the overtime premium. I set $\sigma_h = -0.5$, implying an overtime premium of roughly 1.6, which is close to the one-and-a-half rule prescribed by the Fair Labor Standards Act (see Hansen and Sargent (1988) for details). While an hours supply elasticity of two (the positive inverse of σ_h) is somewhat at odds with traditional micro estimates, for the baseline model I take the stance of matching the overtime premium reasonably well. Given the limited hours choice in the baseline model, the literal interpretation of $-\frac{1}{\sigma_h}$ as an hours supply elasticity, which would require a continuous choice set, is somewhat strained.

The parameters for the idiosyncratic shock process are set to $\rho_I = 0.55$ and $\sigma_I = 0.30$.²⁷ The attrition rate is $q = 0.06$.²⁸ κ in the adjustment cost function is set to 0.75.

I calibrate adjustment costs to match the average aggregate turnover rate of employment over the sample period. The turnover rate is defined as the sum of the job creation and the job destruction rate.²⁹ Concretely, I combine two data sources: from III/92 - II/05, I use the seasonally adjusted quarterly turnover rates for *continuing* establishments as published by the BLS in the Business Employment Dynamics (BED) data set for the total private (non-farm) sector. From II/72 - II/92, I use the Davis and Haltiwanger gross job flow data set for continuing manufacturing establishments.³⁰ Assuming that the relative magnitude of the turnover rate between manufacturing and the total private sector remained stable over time (and over cycles), and using the BED data set for information about this relative magnitude, I then extrapolate back a series of turnover rates for the period between II/72 and II/92. The resulting turnover rate used for calibration is 13.23%. Details of this calculation are relegated to Appendix C.

Finally, the parameters for the aggregate shock process: ρ_A and σ_A . I take the following approach proposed by King and Rebelo (1999): I compute a z_t -series such that the cyclical component of observed GDP is perfectly matched at each point in time.³¹ I then study the implications for aggregate employment and average per worker hours.³²

Table 2 summarizes the calibration results for the baseline scenario. All reported statistics are computed on the simulated “U.S. economy” from I/48 to IV/05. \bar{h} , average hours per worker, denotes the cross-sectional average of (3). All variables are in logs.

In the second row, the average adjustment costs paid, conditional on adjustment, is shown as a fraction of quarterly output/sales. 8.20% is roughly in line with estimates by Bloom (2009, Table III).³³ As section 6 shows, calibrated adjustment costs are reduced, if average hours can be adjusted in a more flexible way than the somewhat stylized baseline model allows. The average fraction of adjusters in a quarter, reported in the third row, is lower than suggested by micro

²⁷ ρ_I is in the middle of the estimates of Cooper et al. (2004), σ_I at the lower end. They estimate these parameters from LRD manufacturing quarterly establishment-level employment and hours data. As in this paper, they exclude establishments that entered or exited during the data period.

²⁸ This value is also used by Veracierto (2003) as well as King and Thomas (2006). The short time series for quits from JOLTS (2001-2005) has an average of just above 0.02 per month.

²⁹ I follow the usual convention and use the average of employment levels, \bar{n}_t, \bar{n}_{t+1} , in the denominator. I check numerically that the time-average of the turnover rate is strictly decreasing in $\bar{\xi}$, so that the parameter is identified.

³⁰ <http://www.econ.umd.edu/haltiwanger/>. I seasonally adjust the published figures.

³¹ The resulting model TFP exhibits the expected cyclical patterns. I assume the economy to be in steady state at the beginning. Details can be found in Appendix C. The results are robust to matching aggregate consumption instead of aggregate output, which corresponds to the assumption that adjustment costs are not counted as part of GDP.

³² Of course, I had to start off the computation with some values for ρ_A and σ_A , in order to have a model to begin with that could be used to back out the z_t . If necessary, I compute a second round equilibrium to make the two parameters mutually consistent. It was never necessary to go beyond one additional round. The R^2 for (19) and (20) for the second round equilibrium computation of the baseline model were: 0.9992 and 0.9994, respectively.

³³ Conditional adjustment costs are 11.33% as a fraction of the wage bill, total adjustment costs 2% of output and 3.15% of the total wage bill.

Table 2: CALIBRATION RESULTS

	Model	Data
ξ :	2.0015	-
Adjustment Costs Paid:	8.20%	-
Fraction of Adjusters:	6.42%	-
$\sigma(\bar{n}_1)$:	1.13%	1.43%
$\rho(\bar{n}_1)$:	0.9284	0.9103
$\sigma(\Delta\bar{n}_1)$:	0.43%	0.67%
$\rho(\Delta\bar{n}_1)$:	0.7352	0.7409
$R^2_{\bar{n}_1}$:	0.8546	-
$\sigma(\bar{h})$:	0.14%	0.42%, 0.51%
$\rho(\bar{h})$:	0.7445	0.7606, 0.8020
$\sigma(\Delta\bar{h})$:	0.10%	0.29%, 0.34%
$\rho(\Delta\bar{h})$:	0.1172	0.1378, 0.2023
$\rho(\bar{n}_1, \bar{h})$:	0.3503	0.4779, 0.3608
$\rho(\Delta\bar{n}_1, \Delta\bar{h})$:	0.4370	0.3643, 0.3463
$\sigma(\bar{w})$:	0.08%	0.90%
ρ_A -backout:	0.7805	-
σ_A -backout:	0.59%	-

data. However, the average fraction of adjusters is not a very robust statistic to be matched, given the parsimony of the micro set-up used here: for instance, allowing the establishments to hire a small amount of a more flexible type of labor (temps) can increase this fraction considerably without changing the aggregate implications of the model.

As far as aggregate statistics are concerned, the persistence of aggregate employment, $\rho(\bar{n}_1)$, and average per worker hours, $\rho(\bar{h})$, as well as the correlation between these two series, $\rho(\bar{n}_1, \bar{h})$, are replicated remarkably well, both in levels and first differences.³⁴ The volatility of aggregate employment, $\sigma(\bar{n}_1)$, is somewhat too low. The requirement to match output perfectly made it as hard as possible for the model to match the volatility of employment. I consider - comparing the cyclical component of the data with the demeaned log-employment series of the model - an R^2 of 85% a good fit. The model fails to capture the volatility of per worker hours and wages, $\sigma(\bar{h})$ and $\sigma(\bar{w})$, respectively. I will address these issues later in section 6, where extensions to the baseline model show that an improvement in matching these volatilities is associated with an improved match of aggregate employment in the jobless recovery episodes.

Given the parsimony of the approach - matching the time average of the job turnover rate with one micro-parameter -, I consider this calibration a success, rendering the model a useful benchmark tool to analyze the behavior of aggregate employment in U.S. post-war recoveries.

³⁴For the definition of \bar{w} , see (17). The first data element for hours refers to data from the CES - hours on payroll -, the second element to data from the "Major Sector Productivity and Costs"-program for the non-farm business sector - hours worked, with the BLS trying to correct the gap between hours on payroll and hours worked.

5 Results

Is this model, calibrated to micro data, capable of producing jobless recoveries in its aggregate behavior? In this section, I show that the answer to this question is affirmative. In two case studies for 1991 and 2001, I investigate the implied paths of aggregate employment for the baseline model. The model predicts roughly 50% and 75% of the continued decline of the cyclical component of aggregate employment during the 1991 and 2001 recoveries, respectively. Altogether, the baseline model explains approximately half of the differential behavior of aggregate employment in the last two recoveries compared with previous ones. Moreover, the model does not produce joblessness in the recoveries before 1991.

Figure 6: De-trended Employment Evolution in the Jobless Recoveries 1991 and 2001

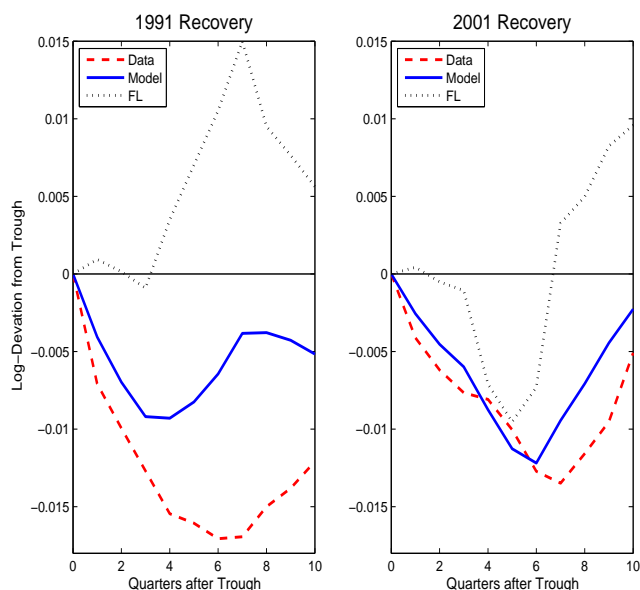
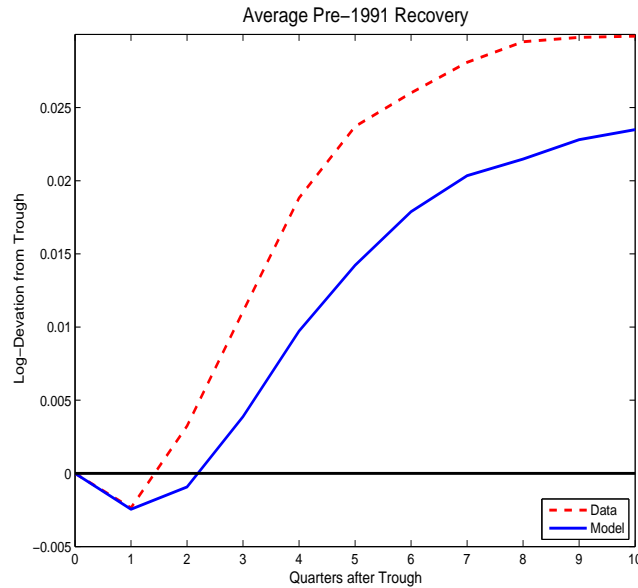


Figure 6 displays the model analogue of figure 2 in section 2; recall that aggregate output is matched by construction. For the 2001 episode, the model captures the observed depth and length of the cyclical component of the jobless recovery fairly well. The model reproduces, averaged over the 10 quarters following the NBER trough, 75% of the (negative) distance of the cyclical component of aggregate employment from trend. A simple frictionless model without adjustment costs and idiosyncratic shocks cannot replicate the steep initial decline in employment and - after capturing the short recessionary interlude - starts to increase too early and too fast. For 1991, the picture looks somewhat different: qualitatively, the model is able to generate a decline in aggregate employment throughout the recovery. Quantitatively, only 47% of the distance of the cyclical component of aggregate employment from trend can be explained. The frictionless model now completely fails. Overall, the baseline model can generate jobless recoveries at least halfway to the extent observed in the data.

Figure 7 presents the model implications for aggregate employment in the “average” recov-

Figure 7: The Model Prediction for the Average Pre-1991 Recovery - Cyclical Component



ery prior to 1991. In the pre-1991 era with deep recessions for both employment and output, jobless recoveries are absent: the data exhibits, averaged over all recoveries before 1991, one quarter of further shallow decline in cyclical employment, which is well captured by the model.

Another way of gauging the success of the model in replicating the differential behavior of aggregate output and employment before the nineties and thereafter are the dynamic output/employment correlations produced by the model: Even though the model is not quite able to replicate the shift in the peak correlation from one quarter output lead to two quarters, it does produce the observed slower decline of the right branch of the correlogram fairly well.

Figure 8: Rightward Shift in Dynamic Output-Employment Correlations

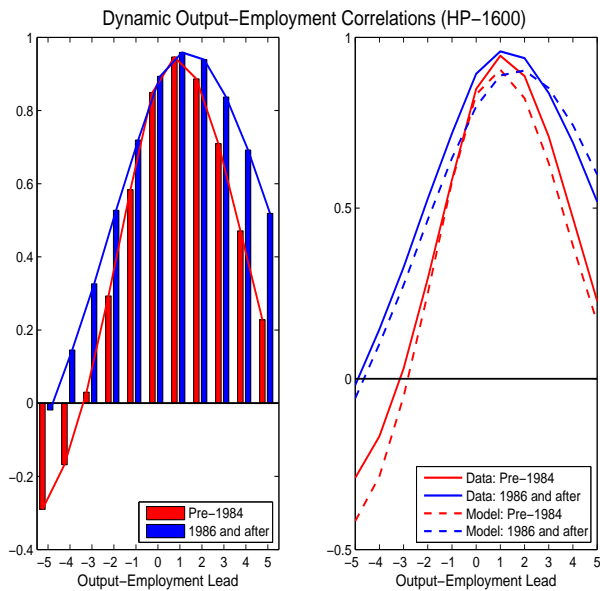
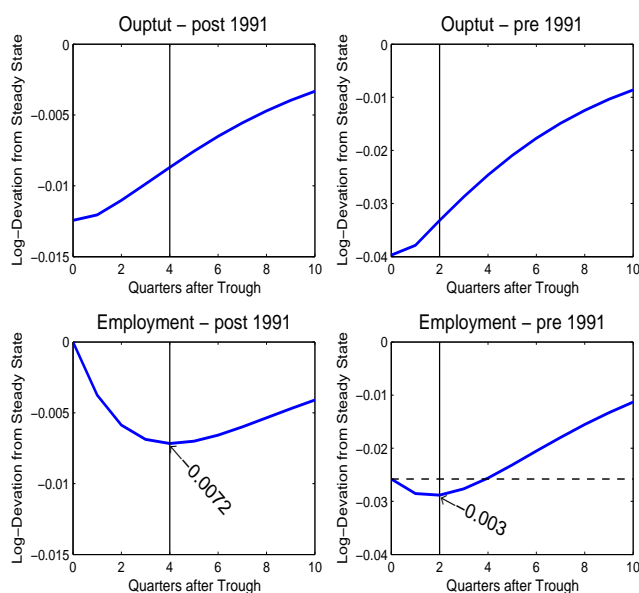


Figure 5 in section 2 shows that the recoveries in 1991 and 2001 are characterized by at-trend cyclical employment at the end of the recessions. In order to isolate the effect of such a cyclical employment overhang, I next show the development for aggregate output and employment, predicted by the baseline model, under the assumption of different initial conditions at the beginning of the recovery, but - counterfactually - identical behavior of aggregate technology afterwards. Concretely, I start the model at an employment deviation of exactly zero at the trough (left-hand panels), and the average pre-1991 cyclical employment deviation: -0.0258 (right-hand panels). Aggregate technology returns to its trend level thereafter.

Figure 9: Employment Evolution with Aggregate Technology Mean-Reverting



After a cyclical situation such as in 1991 and 2001 - aggregate employment at trend -, a jobless recovery - output and technology increasing - occurs for one year, with a trough at 0.7% below trend, as figure 9 shows in its lower left panel.³⁵ The increase in employment thereafter is lackluster: even after ten quarters aggregate employment has not covered half of the distance from its trough. In contrast, in cyclical situations such as in recessions prior to 1991 (right-hand panel), the further employment decline is predicted to be only half a year and only 0.3% from the trough level. Moreover, after one year, aggregate employment has already reached the end-of-recession level, marked by a horizontal line. This shows that part of the jobless recoveries observed in 1991 and 2001 are induced by the cyclical situation at the end of the recession: cyclically strong employment. On the other hand, figures 6, 7 and 9 combined also show that

³⁵Given the Krusell-Smith rule (19) for the model and the good fit with an R^2 well above 0.99 and an analogous equation for aggregate log-output, I can use the observed output deviation at the troughs to back out the technology deviation implied by the model. This suffices to compute the evolution of the employment paths, at least to the first order, using log-linear equations.

the strength of the subsequent recovery is important: with stellar booms in aggregate technology there could not have been prolonged and deep jobless recoveries even in 1991 and 2001.³⁶

Figure 10: De-trended Employment Evolution in the Jobless Recoveries 1991 and 2001

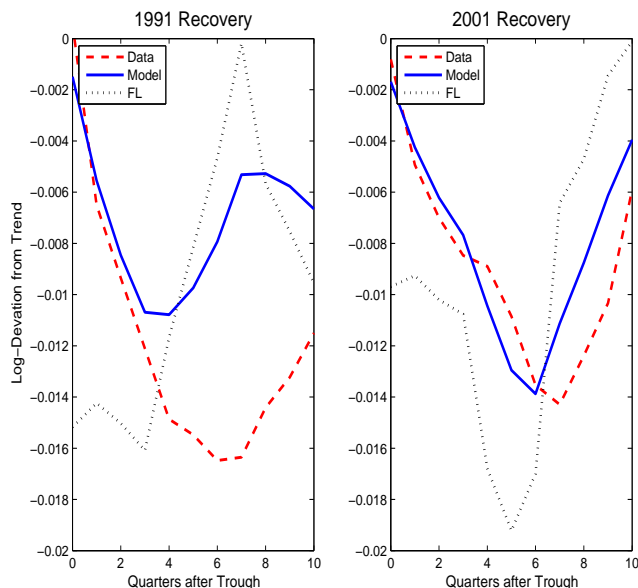
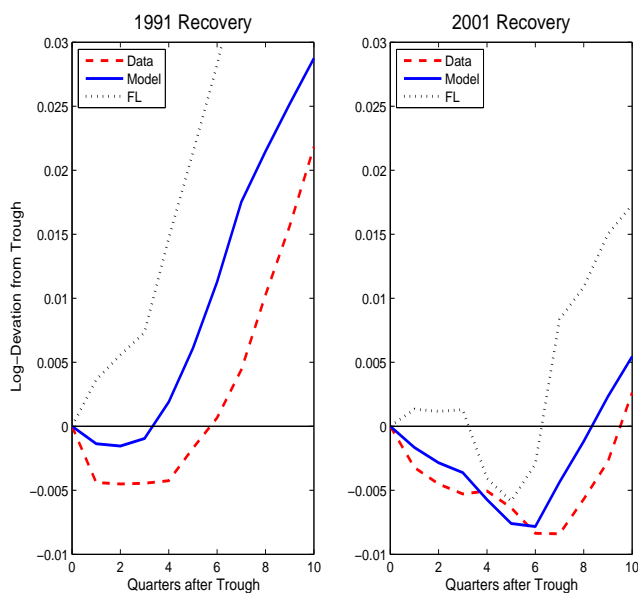


Figure 10 shows that the model endogenously features the fact that in the last two cycles the cyclical component of employment had just reached trend level at the official NBER trough. Again, the frictionless model fails to replicate this important feature of the data.

Figure 11: Employment Evolution in the Jobless Recoveries 1991 and 2001 - Raw Data

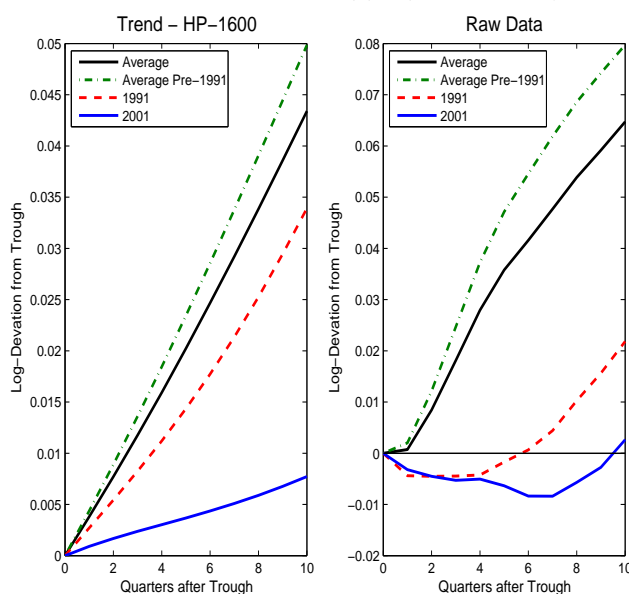


³⁶Wynne and Balke (1992) find a statistically significant relation between the strength of a recession and the strength of the subsequent recovery. This means that letting aggregate technology just mean-revert is probably an underestimation of the strength of a typical recovery that follows a deep recession.

Thus far, I have only explored the cyclical implications of the model. Figure 11 shows that the cyclical component of the model added to the trend from the data - assuming that some other medium- or long-run model produced this trend in an utterly orthogonal fashion - would have produced some observable joblessness in the raw aggregate employment data, albeit quantitatively not as pronounced.

However, figure 11 does not speak to the actual contribution of the cyclical mechanism towards generating jobless recoveries, because of different trends across recoveries. As I have shown, the cyclical component is captured to 75% for 2001, and roughly 50% for 1991. How does this translate into an overall contribution to explaining the differential behavior of the aggregate employment in the last two recoveries as compared to its average behavior?

Figure 12: Raw Data and Trend Components of Aggregate Employment in the Jobless Recoveries



For instance, given the lackluster behavior of the trend component of aggregate employment in the recovery after 2001 (see left panel of figure 12), a fit of even 100% of the cyclical component could still mean a rather modest contribution of the cycle towards explaining the differential behavior of raw aggregate employment in this recovery compared to the average recovery.³⁷ Conversely, the relatively strong trend component of aggregate employment in 1991 can mean that even a relatively poorly matched cyclical component during that episode translates into a large cyclical effect.

In order to quantify the potential cyclical contribution for the differential behavior of raw aggregate employment across recoveries, a prediction for raw aggregate employment is needed that is independent of a changing trend, unlike the model prediction in figure 11. I will use the

³⁷We should recall, however, that figure 4 in section 2 shows that some kind of cyclical mechanism is necessary to understand the jobless recovery even in 2001.

cyclical component in 1991 and 2001, added to the average trend behavior of aggregate employment for this prediction. Then the potential cyclical contribution can be defined as, how much of the (positive) distance between the average development of aggregate employment during a recovery and the development of aggregate employment in a specific recovery - the vertical distance of the black and the red/blue lines in the right panel of figure 12 - is explained by this prediction. To make this definition precise, the following notation is needed: Denote by \bar{E}_t^{raw} the average log-employment deviation from the end of the recession, t quarters after the end of the recession over all post-war recoveries. Denote by $E_t^{raw, 2001}$ the log-employment deviation from the end of the recession in 2001 (for 1991 analogously). Denote by \bar{E}_t^{trend} the average log-deviation of the trend component over all post-war recoveries. Finally, denote by $E_t^{cycle, 2001}$ the log-employment deviation of the cyclical component from the end of the recession in 2001. Then the pointwise potential cyclical contribution is given by:

$$Contrib_t^{pot, 2001} \equiv \frac{\bar{E}_t^{raw} - (\bar{E}_t^{trend} + E_t^{cycle, 2001})}{\bar{E}_t^{raw} - E_t^{raw, 2001}}. \quad (28)$$

In the same vein, the contribution of the model towards generating the jobless recoveries, $Contrib_t^{model, 2001}$, can be defined as in (28), with $E_t^{cycle, 2001}$ being replaced by $E_t^{model, 2001}$, the model's implication for the cyclical component of aggregate employment. This quantity measures pointwise, how much of the distance between the average development of aggregate employment during a recovery and the development of aggregate employment in a specific recovery is explained by the model, when changing trend components as an explanation for aggregate employment behavior are excluded. Figure 13 graphs $Contrib_t^{pot, 2001}$ and $Contrib_t^{model, 2001}$ for 1991 and 2001.³⁸

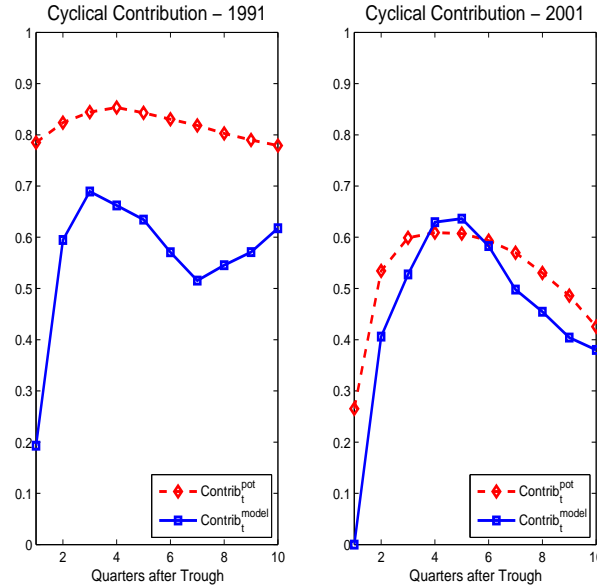
It can be seen that for most time points, the contribution of the model-generated differences in the cyclical component of aggregate employment to the observed jobless recoveries is above 40% for 2001 and well above 50% for 1991. The average contribution over ten quarters is 45% for 2001 and 56% for 1991.³⁹ This is because the trend development of aggregate employment in 1991 is much closer to the average trend behavior than in 2001, and leaves, thus, more room for a cyclical explanation. Figure 13 also shows that the potential for a cyclical explanation hovers around 80% in 1991, whereas it moves substantially in 2001, but never exceeds 60%. Overall, the cyclical mechanism proposed here plays a quantitatively important role to account for jobless recoveries.⁴⁰

³⁸If $Contrib_t^{model, 2001}$ is negative, I set the contribution to zero. This occurred at most during the first quarter.

³⁹These numbers increase slightly to 49% and 58%, when the benchmark is the average pre-1991 recovery (the green line in the right panel of figure 12), instead of the overall average recovery. For the frictionless model, the average contributions are 29% and 20% for 2001 and 1991, respectively.

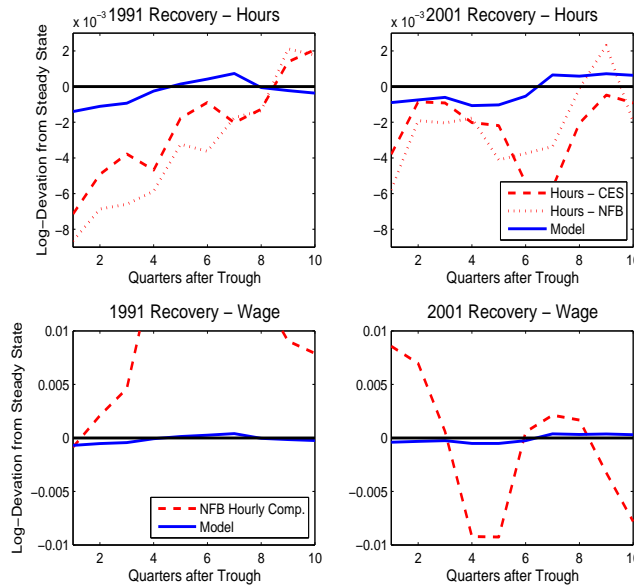
⁴⁰Appendix D discusses the effects of alternative de-trending methods. It is shown that a de-trending method

Figure 13: Pointwise Contribution of the Basic Model to Jobless Recoveries



The tale of two margins suggests that a given output path can be reached in times of a weak recovery by adjusting the intensive margin, overtime work, instead of the extensive margin, employment. Indeed, figure 14 - upper panels - verifies this intuition, at least qualitatively.

Figure 14: Per Worker Hours and Wage Evolution during the Jobless Recoveries

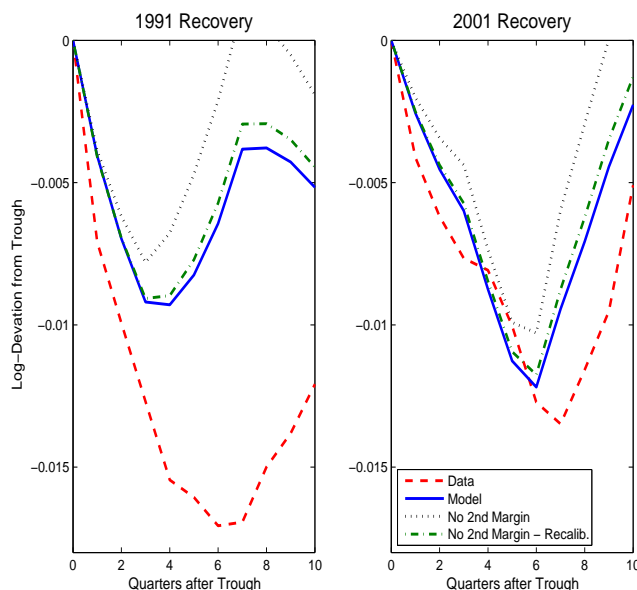


The model predicts an increase in average per worker hours during the jobless recovery phases. However, in light of the failure of the model to account for the observed volatility in that imposes greater rigidity on the trend component than an HP-1600, i.e. that gives an a priori higher weight to a cyclical mechanism such as a HP-160000 or a linear trend, tend to increase the cyclical contribution, at times substantially.

per worker hours, this prediction must quantitatively be inadequate. Figure 14 - lower panels - shows a similar failure of the baseline model to capture the stark increases of wages during a recovery. The composition effect from (17) alone cannot generate observed volatility. Economic intuition suggests the following effect: increasing hours and establishment-level wages lead to an increase in the marginal cost per worker, further delaying hiring in a recovery. Thus, if the model captured these observed dynamics better, the produced joblessness should be exacerbated relative to the baseline model. I address this issue in the following section.

In the remainder of this section, I discuss the effect of removing the second margin from the establishments' choice set on the behavior of the model in the jobless recovery episodes: Figure 15 compares the baseline model with two scenarios, where the second margin - overtime hours - is removed from the establishments' choice set. In the first, the adjustment cost factor estimated for the baseline model was imposed on a model without a second margin.⁴¹ In the second scenario, the model was re-calibrated to again match the average job turnover rate.

Figure 15: De-trended Employment Evolution in the Jobless Recoveries 1991 and 2001



The graph shows that indeed a model with no hours and the same adjustment costs parameter cannot quite produce the inertia of aggregate employment necessary for such prolonged and deep jobless recoveries as observed both in the baseline model and the data: a given aggregate output movement now has to be matched with employment adjustment only, so inertia in employment is lost. Of course, allowing a re-calibration of adjustment costs increases this inertia. In that case, a model with only adjustment costs can generate sizeable jobless recoveries - close to the ones produced by the baseline model with an intensive margin -, but under the

⁴¹The implied average job turnover rate is: 0.1639, the targeted one: 0.1323

hypothesis that establishments indeed use overtime over the cycle, the model would explain jobless recoveries for a somewhat wrong reason.

This concludes the presentation of the main findings for the baseline model: 1) The baseline model captures 47% and 75% of the continued decline of cyclical aggregate employment in the recoveries 1991 and 2001, respectively. 2) The baseline model does not predict joblessness in the recoveries pre-1991, when there was none. 3) The model replicates the outward shift in the dynamic output-employment correlations between before and after 1991. 4) The difference between results 1) and 2) is due to both an employment overhang at the end of the shallow recessions in 1991 and 2001 and a lackluster recovery thereafter. 5) Overall, the cyclical contribution to explaining the differential behavior of aggregate employment across recoveries is 56% and 45%, for 1991 and 2001, respectively. 6) Per worker hours dynamics during the recoveries in 1991 and 2001 are only qualitatively matched, their volatility is gravely underestimated by the baseline model.

6 Extensions

This section develops the following theme: in the previous section we saw that the 1991 and 2001 recoveries were characterized by stark increases in average hours per worker and - at least in 1991 - real wages (per worker and hour). This means that the intensive margin and the compensation per worker increased in the recoveries, thus decreasing the incentive for an establishment to hire an additional worker. In as much as the baseline model fails to capture these effects, it is likely to produce too short and shallow joblessness during the recoveries.

In a first step, tackling the observed volatility of average hours per worker, I generalize the production function in employment and per worker hours:

$$y = z\epsilon \left(n^\alpha (h_1 + h_2^{1-\vartheta} (h - h_1)^\vartheta)^{\frac{\alpha_h}{\vartheta}} \right). \quad (29)$$

Obviously, the production function in the baseline model, (1), is but a special case, with $\alpha = \alpha_h = \vartheta$. In a first step, I assume $\alpha_h = \vartheta > \alpha$, thus giving the hours margin more weight in the production function. Following Osuna and Rios-Rull (2003), I set $\alpha_h = 0.85$. I also allow firms to choose from a wider range of per worker hours, setting K_h to 0.5. This model, while leaving all other specifications the same as in the baseline model, is labeled *EXT1a*.

Next, I set $\vartheta = 1$, leading to the widely used Cobb-Douglas specification: $z\epsilon n^\alpha h^{\alpha_h}$. Again, I set $\alpha_h = 0.85$.⁴² I also lift the assumption of technologically given shift lengths. Instead, I

⁴²I.e. $\vartheta > \alpha_h > \alpha$. See also Appendix D, where I explore the third interesting class of specializations of (29), cases with $\vartheta > \alpha = \alpha_h$.

assume that firms choose h without any technological restrictions and that all workers at an establishment work the same amount of hours on average over a quarter, instead of $n_1 - n_2$ workers working straight time and n_2 workers overtime for the whole quarter.⁴³ Finally, I assume that from the viewpoint of the representative family the employment distribution over establishments is given: they decide about how much to work at each establishment, but the number of workers at each establishment is decided by the labor demand side.⁴⁴ The representative family's problem - see (14) and (15) - then becomes:

$$U(C, h_i) = \log\left(C - A \int n'_i \frac{h_i^{1-\sigma_h}}{1-\sigma_h} di\right), \quad (30)$$

subject to:

$$\Pi + \int n'_i W(h_i) di = C, \quad (31)$$

where i denotes a generic establishment and $W(h)$ a per worker compensation function.

From this new household's problem the following first-order condition for the hours per worker choice follows:

$$W(h_i)' = Ah_i^{-\sigma_h}, \quad (32)$$

leading to the following compensation function for an establishment:

$$Comp(n, h) \equiv nW(h) = n\left(F + A \frac{h^{1-\sigma_h}}{1-\sigma_h}\right), \quad (33)$$

where F is a free constant that together with A is used to calibrate to the average employment rate and the average per worker hours level. Again, this micro-founded compensation function has been widely used in the literature (see Cooper et al., 2004, 2007). Now, the negative inverse of σ_h is truly interpretable as a labor supply elasticity. I set it to $\sigma_h = -\frac{4}{3}$, implying a labor supply elasticity of 0.75. This, in turn, implies, given $\alpha_h = 0.85$, a volatility of per worker hours of 0.48%, right in the middle of the values given by the data. I label this model *EXT1b*. This finishes the exposition of the extensions that produce more realistic hours per worker dynamics. Their implications for the behavior of aggregate employment in the jobless recoveries are shown in figure 16.

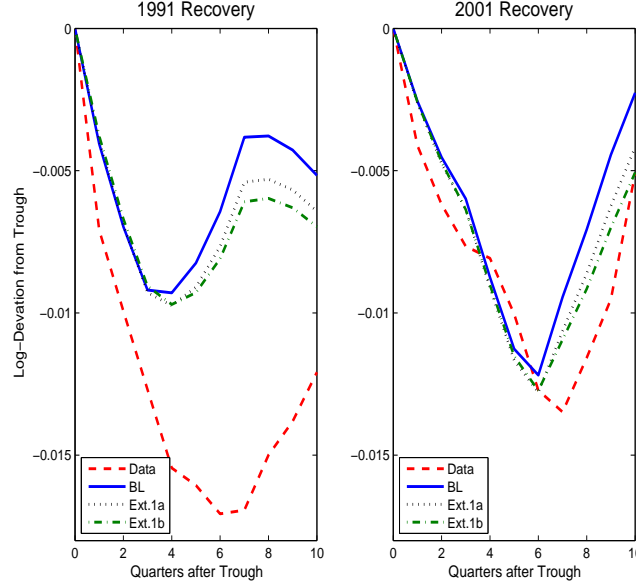
While this group - *EXT1* - makes per worker hours dynamics more realistic⁴⁵ and, at the same time, joblessness longer and deeper during recoveries, none of the above extensions sub-

⁴³This can be achieved by distributing evenly the assignments of the workers to the two shifts over a quarter. It is arguably a more realistic description of actual shift assignments.

⁴⁴For a similar set up, see Andolfatto (1996).

⁴⁵A more flexible hours choice also lowers the adjustment costs needed to match a given turnover rate: the calibrated adjustment cost factor, $\bar{\xi}$, drops to 1.79 and 1.67, respectively for *EXT1a* and *EXT1b*, the average adjustment costs paid, conditional on adjustment and as a fraction of output decline to 7.47% and 6.70%.

Figure 16: Jobless Recoveries and a More Flexible Hours Choice



stantially improves the volatility of wages. In fact, as table 3 below shows, they produce only small increases in the volatility of wages. Both the baseline model as well as *EXT1* have aggregate wages move mainly due to composition effects of changing per worker hours at the establishment level. However, there is no direct aggregate labor supply effect that increases wages in response to the economy wide level of per worker hours.⁴⁶ To capture this effect, admittedly in a somewhat ad hoc manner, I go back - on the establishment side - to the fixed-shifts assumption of the baseline model and its compensation function:

$$Comp(n, h) \equiv nW(h) = w_1 h_1 n_1 + w_2 h_2 n_2 = n \left(\frac{w}{\tau} h_1 + w(h - h_1) \right) = wn \left(\frac{1 - \tau}{\tau} h_1 + h \right), \quad (34)$$

where τ denotes the overtime premium, i.e. $w_2 = \tau w_1$, and using $n_1 = n$, $w_2 = w$.⁴⁷ I also assume that establishments have a legal obligation to pay an overtime premium of $\tau = 1.5$. On the household side, I simply assume the following aggregate labor supply function:⁴⁸

$$w = A(\tilde{h}^s)^{-\sigma h}, \quad (35)$$

where

$$\tilde{h}^s \equiv \frac{\int n'_i h_i di}{\int n'_i di}, \quad (36)$$

⁴⁶Numerically this is reflected by the fact that there is no Krusell-Smith rule for wages in any of these models.

⁴⁷For notational convenience, I use the overtime wage as the overall wage level. It is different from \bar{w} , the total compensation per hour and worker (see (17)).

⁴⁸This is isomorphic to assuming a stand-in utility of the Greenwood et al. (1988)-type directly in \tilde{h}^s , instead of in the distribution over h .

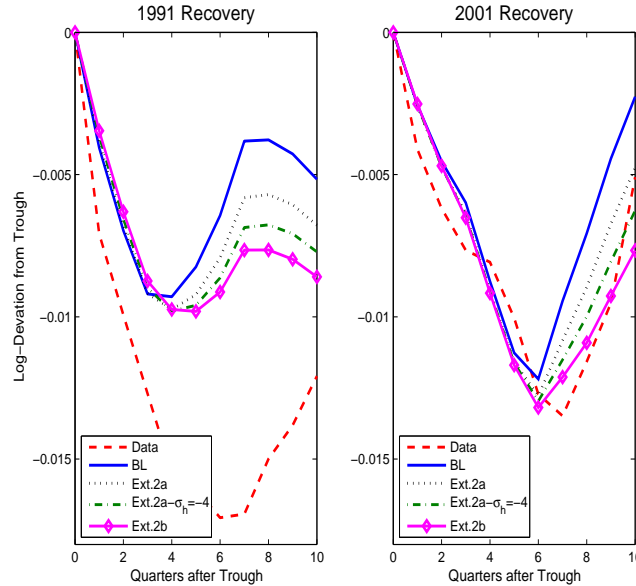
is the employment-weighted average number of hours per worker. Equilibrium requires

$$\bar{h}^s = \frac{\int \int_0^{\bar{\xi}} N(\epsilon, n, \xi; z, \mu) * H(\epsilon, n, \xi; z, \mu)^{\frac{1}{\xi}} d\xi d\mu}{\int \int_0^{\bar{\xi}} N(\epsilon, n, \xi; z, \mu)^{\frac{1}{\xi}} d\xi d\mu}, \quad (37)$$

where $H(\epsilon, n, \xi; z, \mu)$ is the optimal hours demand policy of an establishment with type (ϵ, n, ξ) at aggregate state (z, μ) . In order to compute the equilibrium, I have to add to the Krusell-Smith rules, (19) and (20), an analogous log-linear equation for w . I set the aggregate labor supply elasticity to 0.5, i.e. $\sigma_h = -2$. This model is labeled *EXT2a*.

Figure 17 shows the implications of these aggregate equilibrium wage movements for jobless recoveries:

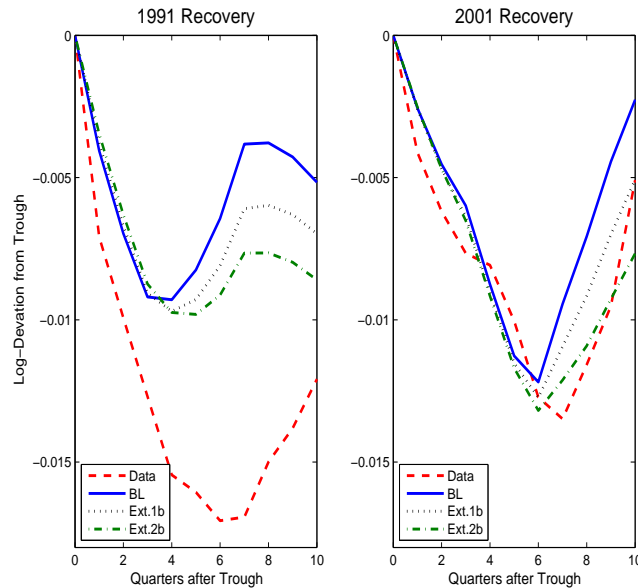
Figure 17: Jobless Recoveries and Aggregate Wage Movements



Equilibrium wage movements lead to a weaker rebound of aggregate employment. The intuition for this is simple: at the end of the recovery, because of the adjustment costs for employment, establishments want to increase their intensive margin first, but this is only possible in equilibrium by paying a higher overall wage level, given (35). This, in turn, increases the marginal cost for an additional worker and deters more establishments from adjusting. Those which adjust hire less. Wage movements work like a cyclically moving additional adjustment cost. I shall demonstrate these effects more in detail below. From figure 17, it can be seen that this effect is stronger, the higher the wage increase is for a given increase in average per worker hours (doubling σ_h), and the more flexibility establishments have in their hours choice: model *EXT2b*, a combination of *EXT1a* ($\alpha_h = 0.85$ and $K_h = 0.5$) and *EXT2a*. Figure 18 compares the behavior of *EXT1b*, the model that by calibration matches the volatility of average per worker

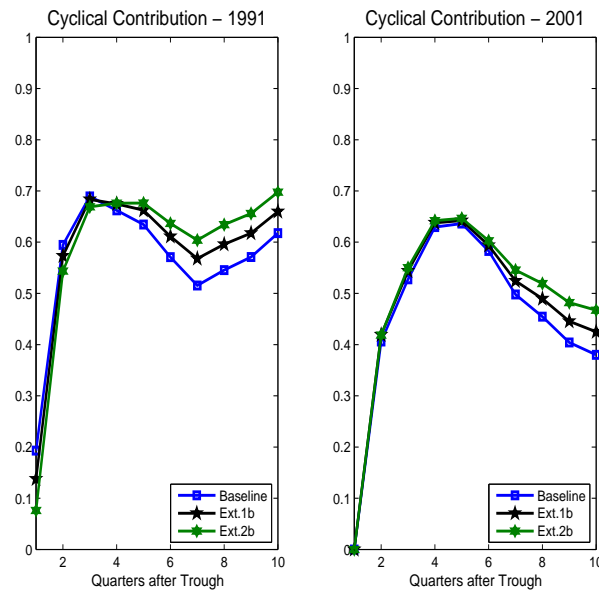
hours, and *EXT2b*, a model that combines equilibrium wage movements and a flexible hours choice. It is clear that both features - aggregate wage movements and more a flexible hours - deepen and lengthen the joblessness in aggregate employment dynamics.

Figure 18: Jobless Recoveries and the Extensions



This can also be seen in the behavior of the contribution measure, defined in section 5:

Figure 19: Pointwise Contribution of the Extensions to Jobless Recoveries



Finally, the shift in the dynamic output-employment correlograms: here, *EXT1b* and *EXT2a* can now match the rightward shift of the peak correlation between the pre- and the post 1990

era, whereas *EXT2b*, combining equilibrium wage movements and more flexible hours even “overshoots” and has the peak correlation at a two-quarter output lead for both periods.

Figure 20: Pointwise Contribution of the Extensions to Jobless Recoveries

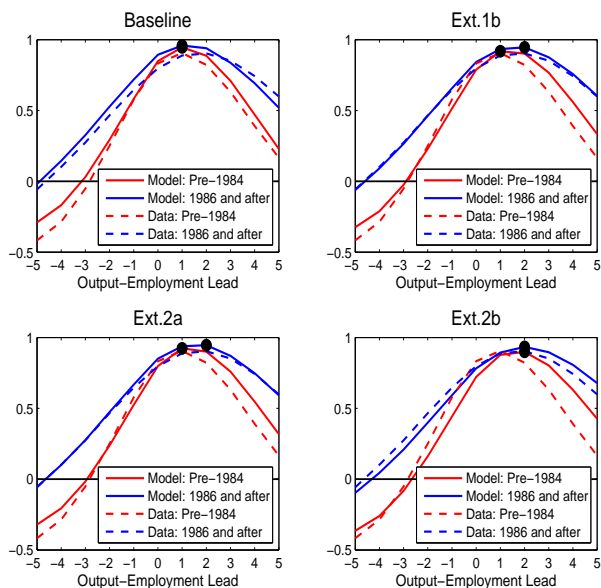


Table 3: EXTENSIONS

	$\sigma(\bar{h})$	$\sigma(\bar{w})$	Cyclical Fit		Overall Contribution	
Data	0.42%, 0.51%	0.90%				
Baseline	0.14%	0.08%	47%	75%	56%	45%
BL- $\alpha_h = 0.85$	0.19%	0.10%	50%	80%	57%	46%
BL- $K_h=0.5$	0.22%	0.12%	49%	78%	57%	46%
<i>EXT1a</i> ($\alpha_h = 0.85, K_h = 0.5$)	0.29%	0.16%	52%	85%	58%	47%
<i>EXT1b</i> - $\alpha_h = 0.64$	0.47%	0.01%	52%	84%	58%	47%
<i>EXT1b</i> ($\alpha_h = 0.85$)	0.48%	0.14%	54%	88%	58%	47%
<i>EXT1b</i> - $\alpha_h = 1$	0.47%	0.24%	55%	90%	58%	47%
<i>EXT2a</i> ($\sigma_h = -2$)	0.13%	0.32%	53%	87%	58%	47%
<i>EXT2a</i> - $\sigma_h = -4$	0.11%	0.50%	56%	93%	58%	48%
<i>EXT2a</i> - $\alpha_h = 0.85$	0.15%	0.40%	56%	92%	58%	48%
<i>EXT2a</i> - $K_h = 0.5$	0.18%	0.46%	56%	93%	59%	48%
<i>EXT2b</i> ($\alpha_h = 0.85, K_h = 0.5$)	0.21%	0.56%	58%	99%	59%	49%

Table 3 summarizes the relevant statistics and documents step-by-step, including for intermediate models, how the extensions lead to improvements in matching the observed volatility in average hours per worker⁴⁹ and wages, as well as a better fit and contribution measure in the jobless recovery episodes, relative to the baseline model.

The following figure 21 - upper panels - shows that the behavior of average per worker hours is remarkably well matched in *EXT1b*. The lower panels exhibit for *EXT2b* at least a substantial improvement in matching the wage behavior relative to the baseline model, even though an obvious tension remains between matching both per worker hours and wages.

Figure 21: Per Worker Hours and Wage Evolution During Jobless Recoveries - Extensions

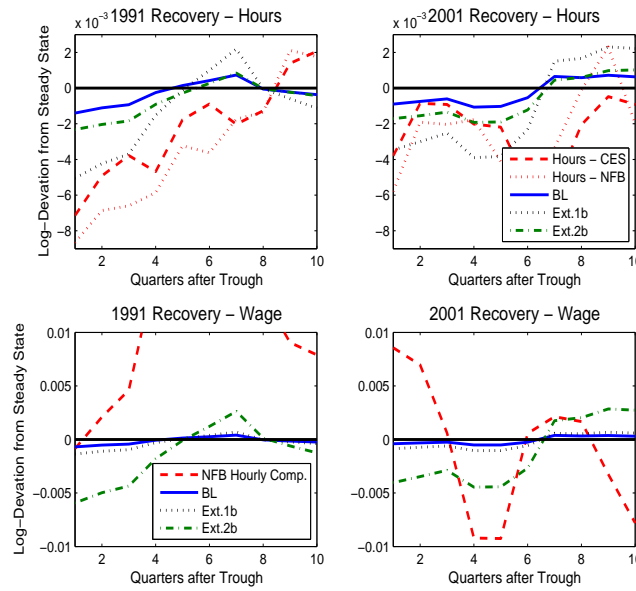


Figure 22 compares the baseline model as well as *EXT2a* and *EXT2b* with analogous scenarios with fixed wages and pricing kernels.⁵⁰ It shows how in particular in the second extension with a very flexible hours choice, *EXT2b*, equilibrium wage movements - increases in wages in the recovery - contribute to deeper and longer joblessness.

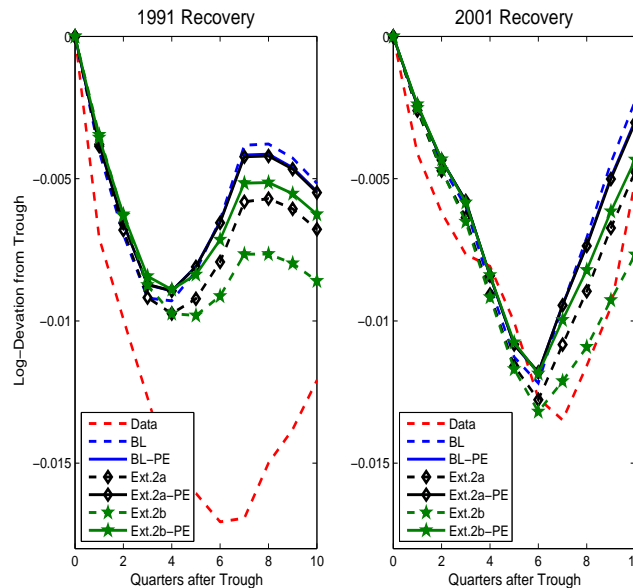
And figure 23 shows, why this is the case. It displays the optimal policies for the establishment - the adjustment probability and the optimal return employment, conditional on adjustment - as a function of aggregate employment, evaluated at an idiosyncratic and aggregate technology level of unity.⁵¹ In partial equilibrium, these functions are flat by construction, the optimal policies only vary with the exogenous states and establishment-level employment. Hence, we can gauge the effect of equilibrium by comparing the models in terms of the variabil-

⁴⁹*EXT1b*-models were re-calibrated to match the volatility of per worker hours in the data. *EXT1b* - $\alpha_h = 0.64$ achieves this with $\sigma_h = -1.25$, *EXT1b* - $\alpha_h = 1$ with $\sigma_h = -1.43$.

⁵⁰By a “fixed” wage, I mean a fixed wage factor, w . These scenarios are labeled “partial equilibrium”, PE.

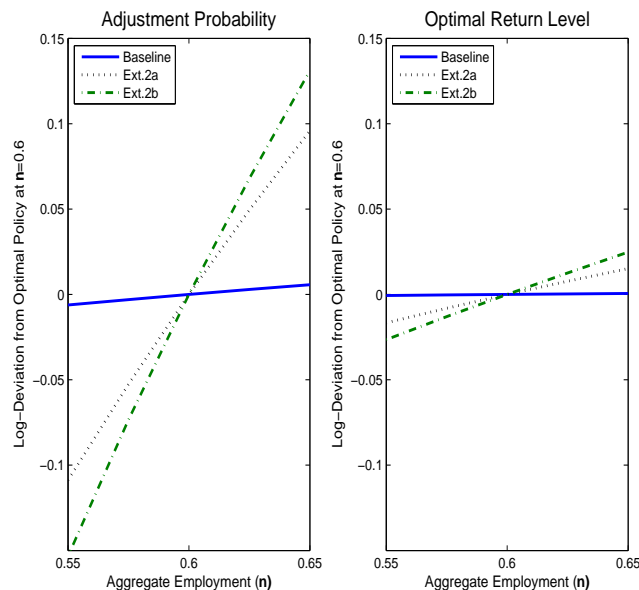
⁵¹Evaluating these policy functions at other values of the aggregate technology does not change the basic picture.

Figure 22: De-trended Employment Evolution in the Jobless Recoveries 1991 and 2001 - Extensions (BL = Baseline Model)



ity they exhibit in the optimal policies as a function of aggregate employment, the endogenous aggregate state variable. The optimal policies are displayed in percentage terms relative to the optimal policy at the average employment level.

Figure 23: Optimal Policies as a Function of Aggregate Employment



Both policy functions are monotonically increasing in aggregate employment, for all three cases. This means that in equilibrium both the optimal return level and the adjustment probability are relatively smaller, when aggregate employment is below trend. This means that equilibrium effects make jobless recoveries feed into themselves.

The first such (smaller) effect is intertemporal substitution: with aggregate employment being below trend, aggregate resources are relatively scarce, i.e. the marginal utility of consumption is relatively high, which causes a delay of employment adjustment, because the latter means wasting real resources. But with exogenous attrition aggregate employment is falling further, joblessness has a negative feedback. This is the only effect present in the baseline model.

EXT2 feature another price effect: in a recovery, establishments have an incentive to first substitute into the intensive margin - hours per worker. This will lead to a wage increase in equilibrium, rising the marginal cost for an additional worker, thus further delaying employment adjustment. Jobless recoveries - through equilibrium price movements - feed into themselves.

7 Conclusion

In this paper, I quantitatively investigate the contribution of a cyclical mechanism to explaining jobless recoveries. Employment is relatively high at the trough of the 1991 and 2001 recessions. During the lackluster recoveries that follow, fewer establishments hire and those that hire, do so by less. Establishments continue to lose employment via attrition, and use the hours per worker margin to take advantage of improving business conditions. This latter effect is considerably strengthened in the extensions to the baseline model with realistically more volatile hours per worker and wages.

I calibrate and compute a dynamic stochastic general equilibrium (DSGE) model with heterogeneous establishments that use two margins of labor services: an intensive margin, hours per worker, and an extensive margin, employment. The main finding is that under a conservative estimate, the baseline model explains roughly half of the observed differential behavior of aggregate employment during the jobless recovery episodes compared to the average post-war behavior in recoveries. This finding is fairly robust to choosing different de-trending methods. Moreover, a 50% explanation through a cyclical mechanism may simply mean that instead of new structural models we need better cyclical models for the joint dynamics of aggregate output, employment, per worker hours and wages. The results in section 6 about the importance of hours per worker and equilibrium wage movements during the jobless recovery episodes suggest that this indeed may be the case.

Future research will show how much the mechanism in this paper, employment overhang and lackluster output recoveries, has also contributed to the weak labor market in the aftermath of the Great Recession and how much has to come from other, more idiosyncratic effects: Beveridge curve shifts, financial disruption, deleveraging, policy uncertainty, etc. I suspect that employment adjustment frictions just as in this paper will always be part of the explanation, because jobless recoveries need an at least temporary decoupling of output and employment.

References

- [1] **Aaronson, A. E. Rissman and D. Sullivan.** 2004a. "Assessing the jobless recovery," *Economic Perspectives - Federal Reserve Bank of Chicago*, 20/2004: 2–20.
- [2] **Aaronson, A. E. Rissman and D. Sullivan.** 2004b. "Can sectoral reallocation explain the jobless recovery?," *Economic Perspectives - Federal Reserve Bank of Chicago*, 20: 36–49.
- [3] **Andolfatto, D.** 1996. "Business Cycles and Labor-Market Search", *The American Economic Review*, **86**(1): 112–132.
- [4] **Andolfatto, D. and G. MacDonald.** 2004. "Jobless Recoveries," mimeo.
- [5] **Bernanke, B.** 2003. "The Jobless Recovery," Remarks by Governor Ben S. Bernanke at the Global Economic and Investment Outlook Conference, Carnegie Mellon University, Pittsburgh Pennsylvania, November 6, 2003. <http://www.federalreserve.gov/BoardDocs/Speeches/2003/200311062/default.htm>
- [6] **Bewley, T.** 1999. "Why Wages Don't Fall During a Recession?," Harvard Univ. Press 1999.
- [7] **Bils, M.** 1987. "The Cyclical Behavior of Marginal Cost and Price", *The American Economic Review*, December 1987, 77(5): 838–855.
- [8] **Birkeland (Koenders), K.** 2005. "Long Expansions and Slow Recoveries: A Closer Look at Employment Fluctuations," mimeo.
- [9] **Bloom, N.** 2009. "The Impact of Uncertainty Shocks," *Econometrica*, 77(3), 623–685.
- [10] **Bowler, M. and T. Morisi.** 2006. "Understanding the employment measures from the CPS and CES survey," *Monthly Labor Review*, February 2006: 23–38.
- [11] **Caballero, R. and E. Engel.** 1993. "Microeconomic Adjustment Hazards and Aggregate Dynamics", *Quarterly Journal of Economics*, **108** (2): 359–383.
- [12] **Caballero, R. E. Engel and J. Haltiwanger.** 1997. "Aggregate Employment Dynamics: Building from Microeconomic Evidence", *The American Economic Review*, **87** (1): 115–137.
- [13] **Campbell, J. and J. Fisher.** 2000. "Aggregate Employment Fluctuations with Microeconomic Asymmetries", *The American Economic Review*, **90**(5): 1323–1345.
- [14] **Campbell, J. and J. Fisher.** 2002. "Idiosyncratic risk and aggregate employment dynamics", *Review of Economic Dynamics*, **7**: 331–353.
- [15] **Cooper, R. W., J. Haltiwanger and J. Willis.** 2004. "Dynamics of Labor Demand: Evidence from Plant-Level Observations and Aggregate Implications", NBER-WP 10297.

- [16] **Cooper, R. W., J. Haltiwanger and J. Willis.** 2007. “Hours and Employment Implications of Search Frictions: Matching Aggregate and Establishment Observations”, *Journal of Monetary Economics*, **54**: 56–78.
- [17] **Davis, S., J. Faberman and J. Haltiwanger.** 2006. “The Flow Approach to Labor Markets: New Data Sources and Micro-Macro Links”, *Journal of Economic Perspectives*, **20**(3): 3–24.
- [18] **Dueker, M.** 2006. “Using Cyclical Regimes of Output Growth to Predict Jobless Recoveries,” *Federal Reserve Bank of St. Louis Review*, March/April 2006, **88** (2): 145–153.
- [19] **Elsby, M., R. Michaels and G. Solon.** 2009: “The Ins and Outs of Cyclical Unemployment”, *American Economic Journal: Macroeconomics*. **1**(1): 84–110.
- [20] **Engemann, K. and M. Owyang.** 2007. “Whatever Happened to the Business Cycle? A Bayesian Analysis of Jobless Recoveries”, Working Paper 2007-013A, Federal Reserve Bank of St. Louis.
- [21] **Faberman, J.** 2008. “Job Flows, Jobless Recoveries and the Great Moderation”, mimeo, Federal Reserve Bank of Philadelphia.
- [22] **Foster, L.** 1999. “Employment Adjustment Costs and Establishment Characteristics”, Center for Economic Studies: 99–15.
- [23] **Gomme, P.** 2005. “Accounting for the Jobless Recoveries,” *Economic Commentary - Federal Reserve Bank of Cleveland*, April 2005: 1–8.
- [24] **Gordon, R. and M. Baily.** 1993. “The Jobless Recovery: Does it Signal a New Era of Productivity-Led Growth?”, *Brookings Papers on Economic Activity*, **1993/1**: 271–316.
- [25] **Gould, E.** 2006. “Measuring Employment Since the Recovery - A comparison of the household and payroll surveys,” *Economic Policy Institute - Briefing Paper*, December 2003: 1–4.
- [26] **Greenwood, J. Z. Herowitz and G. Huffman.** 1988. “Investment, Capacity Utilization, and the Real Business Cycle”, *The American Economic Review*, **78**(3): 402–417.
- [27] **Groshen, E. and S. Potter.** 2003. “Has Structural Change Contributed to a Jobless Recovery?,” *Current Issues in Economics and Finance - Federal Reserve Bank of New York*, **9** (8): 1–7.
- [28] **Groshen, E. S. Potter and R. Sela.** 2004. “Was the 2001 Recession Different in the Labor Market? Comparing Measures,” mimeo.
- [29] **Hammermesh, H.** 1989. “Labor Demand and the Structure of Adjustment Costs”, *The American Economic Review*, **79**(4): 674–689.

- [30] **Hansen, G. and T. Sargent.** 1988. “Straight Time and Overtime in Equilibrium”, *Journal of Monetary Economics*, **21**: 281–308.
- [31] **Hopenhayn, H. and R. Rogerson.** 1993. “Turnover and Policy Evaluation: A General Equilibrium Analysis”, *The Journal of Political Economy*, **101**(5): 915–938.
- [32] **Juhn, C. and S. Potter.** 1999. “Explaining the Recent Divergence in Payroll and Household Employment Growth,” *Current Issues in Economics and Finance - Federal Reserve Bank of New York*, **5** (16): 1–6.
- [33] **Kane, T.** 2004. “Diverging Employment Data: A Critical View of the Payroll Survey,” *Heritage Foundation*, March 4, 2004.
- [34] **Khan, A. and J. Thomas.** 2003. “Nonconvex Factor Adjustments in Equilibrium Business Cycle Models: Do Nonlinearities Matter?,” *Journal of Monetary Economics*, March 2003, **50**(2): 331–360.
- [35] **Khan, A. and J. Thomas.** 2008. “Idiosyncratic Shocks and the Role of Nonconvexities in Plant and Aggregate Investment Dynamics”, *Econometrica*, March 2008, **76**(2): 395–436.
- [36] **King, R. and S. Rebelo.** 1999. “Resuscitating Real Business Cycles”, in: *Handbook of Macroeconomics*, Volume 1, chapter 14: 927–1007.
- [37] **King, R. and J. Thomas.** 2006. “Partial Adjustment without Apology”, *International Economic Review*, August 2006, **47**(3): 779–809.
- [38] **Koenders, K. and R. Rogerson.** 2005. “Organizational Dynamics Over the Business Cycle: A View on Jobless Recoveries,” *Federal Reserve Bank of St. Louis Review*, July/August 2005, **87** (4): 555–579.
- [39] **Krusell, P. and A. Smith.** 1997. “Income and Wealth Heterogeneity, Portfolio Choice and Equilibrium Asset Returns”. *Macroeconomic Dynamics* **1**: 387–422.
- [40] **McConnell, M. and J. Tracy.** 2006. “Structural and Cyclical Adjustments in U.S. Labor Markets,” mimeo.
- [41] **Melloan, G.** 2003. “That ‘jobless recovery’ isn’t so jobless after all,” *The Wallstreet Journal*, December 9, 2003.
- [42] **Meltzer, A.** 2003. “A jobless recovery?,” *The Wallstreet Journal*, September 26, 2003.
- [43] **Osuna, E. and V. Rios-Rull.** 2003. “Implementing the 35 Hour Workweek by Means of Overtime Taxation”, *Review of Economic Dynamics*, **6** (1): 179–206.

- [44] **Schreft, S. and A. Singh.** 2003. "A Closer Look at Jobless Recoveries," *Economic Journal - Federal Reserve Bank of Kansas City*, 2nd Quarter: 45–73.
- [45] **Schreft, S. A. Singh and A. Hodgson.** 2005. "Jobless Recoveries and the Wait-and-See Hypothesis," *Economic Journal - Federal Reserve Bank of Kansas City*, 4th Quarter: 81–99.
- [46] **Schultze, C.** 2004. "Offshoring, Import Competition, and the Jobless Recovery", *The Brookings Institution Policy Brief*, August 2004, Policy Brief 136.
- [47] **Schweitzer, M.** 2003. "Another Jobless Recovery," *Federal Reserve Bank of Cleveland - Economic Commentary*, March 2003: 555–579.
- [48] **Schweitzer, M. and G. Venkatu.** 2004. "Employment Surveys Are Telling the Same (Sad) Story," *Federal Reserve Bank of Cleveland - Economic Commentary*, May 2004.
- [49] **Shimer, R.** 2005. "The Cyclical Behavior of Equilibrium Unemployment and Vacancies," *The American Economic Review*, **95**(1): 25–49.
- [50] **Shimer, R.** 2010. "Wage Rigidities and Jobless Recoveries," mimeo.
- [51] **Tauchen, G.** 1986. "Finite State Markov-Chain Approximations To Univariate and Vector Autoregressions". *Economics Letters* **20**: 177–181.
- [52] **van Rens, T.** 2004. "Organizational Capital and Employment Fluctuations," mimeo.
- [53] **Wu, T.** 2004. "Two Measures of Employment: How different Are They?," *Federal Reserve Bank of San Francisco - Economic Letter*, August 2004: 555–579.
- [54] **Wynne, M. and N. Balke.** 1992. "Are deep recessions followed by strong recoveries?," *Economics Letters*, July/August 2005, **39**: 183–189.
- [55] **Veracierto, M.** 2003. "Firing Costs and Business Cycle Fluctuations," WP 2003-29, Federal Reserve Bank of Chicago.

A Data Description and Business Cycle Statistics

Table 4: BUSINESS CYCLE STATISTICS

	St. dev.	Persistence	St. dev. rel. to Outp.	St. dev. rel. to Empl.
GDP:	1.69%	0.8420	1	1.17
Employment:	1.43%	0.9103	0.85	1
Hours-I:	0.42%	0.7606	0.25	0.29
Hours-II:	0.51%	0.8020	0.31	0.36
Real Comp. per Worker per Hour:	0.90%	0.7691	0.54	0.63

All series are logged and HP-filtered with a smoothing parameter of 1600. The time horizon is I/48 to IV/05, unless otherwise stated.

- GDP is quarterly, seasonally adjusted output in chained 2000-Dollars in annual rates (GDPC96 series from the St. Louis FED database).
- Employment is the quarterly averages of seasonally adjusted monthly payroll non-farm employment data, as published by the BLS (CES0000000081).
- Hours-I is average weekly hours on payroll per worker (including overtime), for production workers (CES0500000005), quarterly averages of seasonally adjusted monthly data. The series starts in 1964.
- Hours-II is average weekly hours worked - with the BLS trying to measure the gap between hours on payroll and hours worked - per worker for all workers, seasonally adjusted quarterly data from the "Major Sector Productivity and Costs"-program for the non-farm business sector (PRS85006023). Obviously, Hours-II is somewhat more volatile than Hours-I, because hours worked overshoot hours paid in a boom, and undershoot them in a recession, and it is subject to higher measurement error.
- Real Comp. per Worker per Hour: is real hourly compensation in the non-farm business sector, published by the BLS, seasonally adjusted quarterly data (PRS85006153).

Table 5 complements figure 5 in section 2, and shows the time span in quarters between an NBER-peak and an NBER-trough, and the cyclical components of aggregate employment and output at the trough, in percentage deviations from the trend.

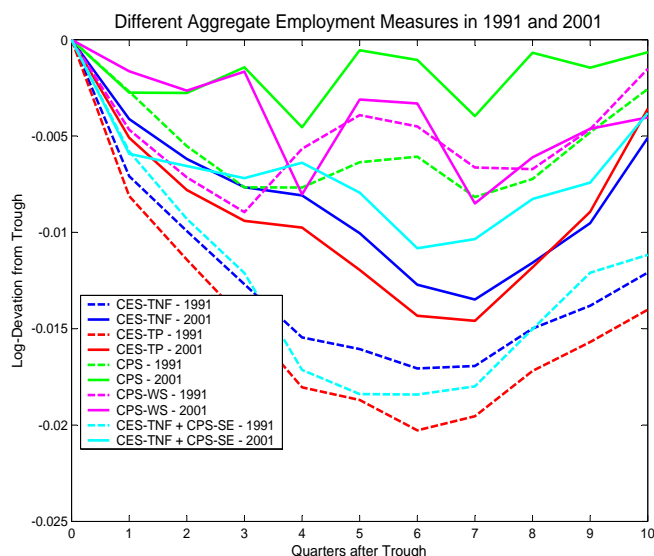
Table 5: CYCLES COMPARED

	1949	1954	1958	1961	1970	1975	1982	1991	2001
Peak-Trough:	4	3	3	3	4	5	5	2	3
CES at trough:	-4.86%	-2.18%	-3.09%	-1.26%	-1.49%	-1.77%	-3.40%	0.06%	-0.08%
GDP at trough:	-5.99%	-2.99%	-4.20%	-2.71%	-3.39%	-3.79%	-4.75%	-1.52%	-0.97%

B Different Aggregate Employment Measures

There has been a debate in the literature about the right employment measure in the context of jobless recoveries, and whether the existence of the two jobless recoveries after 1991 and 2001 is robust to the choice of this employment measure. The Bureau of Labor Statistics publishes two independent employment measures, one from the Current Employment Statistics (CES), establishment level data, and one from the Current Population Survey (CPS), household level data. The largest conceptual difference between the two employment measures are the self-employed, which are excluded in the former, but included in the latter. Melloan (2003), Meltzer (2003) and Kane (2004) have argued that using the CPS measure of employment makes at least the last jobless recovery in 2001 disappear. Indeed, figure 24 shows that, when either total CPS data (CPS) or only the wage and salary workers in non-agricultural sectors (CPS-WS) are used, both jobless recoveries are considerably less jobless. Figure 24 displays cyclical components.⁵²

Figure 24: Comparison of Different Employment Measures



However, this graph also shows that the difference cannot be explained by the different statistical units used in the two surveys. The total CPS measure and the CPS-WS series display a similar pattern, by contrast, the CPS-WS series does not move close to CES data at all. This finding is confirmed in more detail in Aaronson et al. (2004a) as well as Bowler and Morisi (2006). In fact, just adding the self-employed in non-farm sectors from the CPS database to CES data (CES-TNF + CPS-SE) only slightly changes the jobless recovery diagnosis for 1991 and 2001. In 1991, the jobless recovery becomes even deeper, in 2001 it would be somewhat shallower.

In addition, Aaronson et al. (2004a) find that rises in self-employment after a recession do not necessarily signal a strong labor market: on the contrary, they find that self-employment in

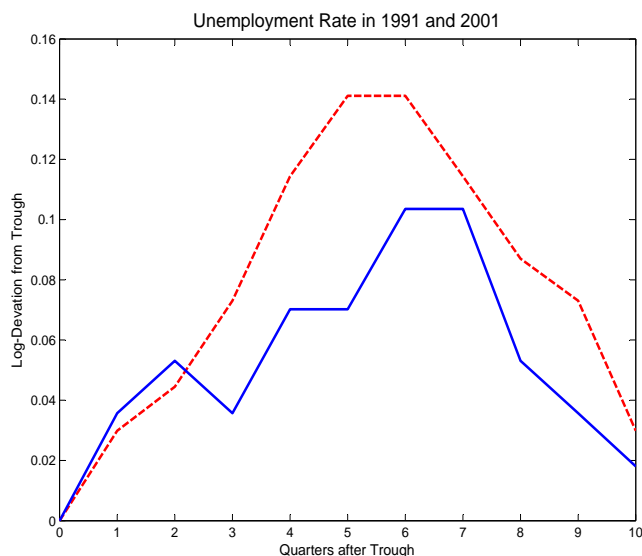
⁵²CPS is the LNS12000000Q series of the BLS. CPS-WS is LNS12032187. CPS-SE is LNS12032192. CES-TP is CES0500000001.

the CPS is countercyclical, suggesting that the CPS data suffer from a reporting problem: persons who seek wage and salary employment report themselves as self-employed, with de facto no or little contribution to market production. This shows that including the self-employed, as the CPS does, most likely embellishes the cyclical state of the labor market.

If the dissimilarities between CES and CPS cannot be explained by conceptual differences, the gap must come from practical differences in the two surveys: the CES has a much larger scope and is benchmarked once a year against a universe count of jobs from the unemployment insurance statistics. The CPS relies on population estimates from the U.S. population census, which is updated only every ten years. Indeed, figure 24 suggests that the CPS data are much more erratic than the CES data, which could be a sign of more noise. Moreover, to the extent that immigration patterns display themselves a cyclical component - immigrants are more likely to enter the U.S. in a boom and with a strong labor market -, inter-census population estimates are likely to be downward biased in a boom and upward biased in a recession and thereafter (see Bernanke (2003) for this argument; see also Schweitzer and Venkatu (2004) for a related point).

Finally, as figure 25 shows, the unemployment rate from the CPS actually mimics the CES pattern in an almost exactly inverse way.⁵³ But rising unemployment that is concomitant with a non-declining employment measure would mean a rush from non-participation into unemployment, which is inconsistent with the findings in Elsby et al. (2009).

Figure 25: The Unemployment Rate in the Jobless Recoveries after 1991 and 2001



Altogether, a (weak) consensus seems to have been established that the CES data are superior (see Juhn and Potter (1999), Bernanke (2003), Aaronson et al. (2004a) and Wu (2004)). Finally, figure 24 also shows that the jobless recovery effect is even more pronounced, if the government sector were to be excluded (CES-TP).

⁵³I use the quarterly unemployment rate for all ages, races and sexes: LNS14000000Q. The series is not filtered.

C Numerical Details

In this appendix, I describe briefly - a full description, including specific numerical details, can be made available upon request - the numerical procedures used to compute the results in the main part. I start with a brief overview of the steps. For convenience, I repeat the description and the value of the parameters used for the (second iteration of the) baseline model here:

Table 6: MODEL PARAMETERS

Parameter	Description	Baseline Value
β	discount factor	0.99
ϑ	employment elasticity in the production function	0.64
α	scale elasticity in the production function	0.64
ρ_I	autoregressive parameter for idiosyncratic technology	0.55
σ_I	conditional standard deviation for idiosyncratic technology	0.30
q	exogenous job separation rate	0.06
κ	distributional parameter in the adjustment cost function	0.75
$\bar{\xi}$	upper bound of the uniform adjustment cost distribution	2.0015
h_1	straight time shift length	0.3038
K_h	relative shift length of the overtime shift	$\frac{10}{37}$
A	preference parameter	2.2506
σ_h	inverse of the negative hours supply elasticity	-0.5
ρ_A	autoregressive parameter for aggregate technology	0.7817
σ_A	conditional standard deviation for aggregate technology	0.60%

1. For each set of establishment-level parameters $(\vartheta, \rho_I, \sigma_I, q, \kappa, K_h)$ and an initial guess for ρ_A and σ_A , $\bar{\xi}$ is estimated by matching the (time) average job turnover rate in U.S. data. A fixed straight time wage, $w_{1t} = \bar{w}_1$, and pricing kernel $p_t = 1$ are assumed.
2. The aggregate technology levels that make the partial equilibrium model match exactly the cyclical component of observed output - quarter by quarter - are backed out.
3. Steps 1. and 2. are repeated with the new ρ_A and σ_A .
4. With the adjustment cost parameter estimated in steps 1.-3. and an initial guess for ρ_A and σ_A , I compute the equilibrium, where p_t (and in the *EXT2*-extensions w_t) are endogenously determined.
5. The aggregate technology levels that make the general equilibrium model match exactly the cyclical component of observed output are backed out.
6. Steps 4. and 5. are repeated with the new ρ_A and σ_A .

C.1 Partial Equilibrium Estimation

For each set of establishment-level parameters $(\vartheta, \alpha_h, \rho_I, \sigma_I, q, \kappa, K_h)$ and an initial guess for ρ_A and σ_A , the adjustment cost parameter, $\bar{\xi}$, is estimated by matching it exactly to the time average of the job turnover rate of continuing establishments in U.S. data.

The target job turnover rate is 13.2292%. This is calculated as follows: I combine two data sources: from III/92 - II/05, I use the seasonally adjusted quarterly turnover rates for *continuing* establishments as published by the BLS in the Business Employment Dynamics (BED) data set for the total private (non-farm) sector. On average, turnover by continuing establishments accounts for almost 80% of total turnover. From II/72 - II/92 I use the Davis and Haltiwanger gross job flow data set for continuing manufacturing establishments.⁵⁴ Assuming that the relative magnitude of the turnover rate between manufacturing and the total private sector remained stable over time, and using the BED data set for information about this relative magnitude, I then extrapolate back a series of turnover rates for the period between II/72 and II/92. The relative magnitude of total private and manufacturing turnover rates is 11.9981% to 8.1116% in the BED sample period for continuing establishments. In the small overlap period between the two data sets from III/92-IV/93 the BED reports an average turnover rate of 8.5333%, and Davis and Haltiwanger of 8.8094% for continuing manufacturing establishments. The similarity also holds for job creation and destruction rates separately. This provides some confidence that the two data sets are similar enough.

For each candidate value of the adjustment cost parameter, two subproblems have to be solved: the single-establishment decision problem - the fixed price counterpart of (8), which is solved by value function iteration, and a simulation of a cross-section of establishments, using the policy functions from the first. I integrate the conditional expectations over aggregate productivity with Gauss-Hermitian integration with 5 nodes. Off-the-grid points are interpolated using multidimensional cubic spline interpolation with the 'not-a-knot'-condition to close the degrees of freedom associated with splines (see Khan and Thomas, 2003). The process for idiosyncratic technology is approximated by a Markov chain, which is computed using Tauchen's procedure (see Tauchen, 1986) with nine grid points. Then I simulate a cross-section of this economy, μ , starting from a mass point at 0.6, the targeted average employment level, and the implied stationary distribution of the Markov chain for the idiosyncratic technology grid.

With these two subproblems for each candidate value of the adjustment cost parameter, the calibrated adjustment cost parameter is found by a simple line search to match the simulated job turnover rate exactly to the observed job turnover rate of 13.2292%. This finishes the description of step 1 in the algorithm outlined above.

⁵⁴<http://www.econ.umd.edu/haltiwanger/>. I seasonally adjust the published figures.

In step 2, I use the value function and the adjustment cost parameter computed in step 1 to find the level of aggregate productivity, so that the model matches the cyclical component of observed real GDP in every quarter from I/48 to IV/05 - 232 observations - perfectly. The cyclical component of the data is given by log-hp(1600)-filtered real GDP. The cyclical component of the model is defined as $\log y_t^{model} - \log y_{steadystate}^{model}$. The result of this step is a new log-aggregate productivity series, whose ρ_A and σ_A will be used to repeat step 1 and 2 (step 3). Typically two iterations suffice to make the input ρ_A and σ_A very close to the output ρ_A and σ_A .

Step 1. - 3. estimate the adjustment cost parameter, which will then enter as a fixed input into steps 4. - 6. It should be noted that the simulated time-averaged job turnover rate is almost independent of equilibrium wage and price movements, which allows me to estimate it conveniently in a partial equilibrium setting.

C.2 General Equilibrium Computation

The equilibrium computation is similar to the procedures described in the last section, except that the value function computation now has to incorporate an additional state variable - average employment as a proxy for the employment distribution.⁵⁵ And in the simulation part (as well as the back out part), which consists of 600 steps with randomly drawn aggregate technology levels, of which the first 100 are discarded, when computing the updates for the Krusell-Smith rules, now the market clearing pricing kernel (and wage in *EXT2*) have to be computed with a root-finding routine: As described in section 3.4, in the baseline model there is essentially just one market clearing condition to be satisfied, for the commodity market, at each step of the simulation. The labor market always clears, because the demand side fully determines the quantities due to the specific felicity function used: (10). Given an initial guess for p , aggregate labor demand, aggregate commodity supply and demand can be computed. Since profits are just a residual in this model, aggregate commodity supply and demand are actually by construction the same; however, the computed consumption and employment levels may lead to a different pricing kernel than the initially assumed one, by (18). So, commodity market clearing really means a consistency condition on the pricing kernel.

After convergence, the backing out procedure proceeds as described in the partial equilibrium estimation section. This completes the description of steps 4. and 5. Step 6., finally, repeats steps 4. and 5. with an updated ρ_A and σ_A , using the backed out z_t -series from step 5. I note again that one repetition was typically enough to make the ρ_A and σ_A , used to compute the equilibrium of the model, very close to the ones estimated from the final back out series.

The final Krusell-Smith rules for the baseline model are: $(a_n = -0.122, b_n = 0.763, c_n = 0.483), R^2 = 0.9992$, and $(a_p = 2.326, b_p = -0.065, c_p = -2.674), R^2 = 0.9994$.

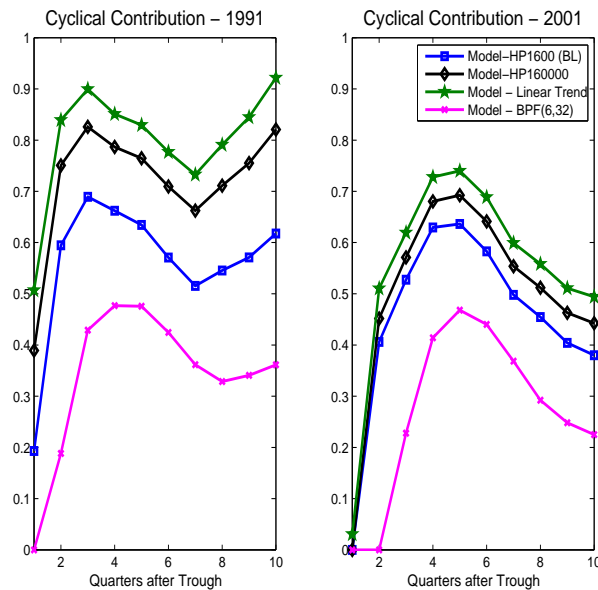
⁵⁵I added the log standard deviation of employment with only insignificant changes in the behavior of aggregate employment.

D Robustness

The finding that the cyclical mechanism proposed in this paper can account for roughly half of the differential behavior of aggregate employment in the last two recoveries is fairly robust to the de-trending method used. This is the main result of this appendix. I also discuss, how robust the occurrence of jobless recoveries is with respect to some of the choices for the micro parameters. I finish this appendix with a few remarks about two model simplifications: the lack of capital, and excluding entry and exit.

Figure 26 shows that the overall contribution of the cyclical mechanism of the benchmark model is fairly robust to the way, the cyclical components of aggregate output and employment are extracted. Specifically, I repeat the baseline computation with an HP-filter with smoothing parameter 160000, a deterministic linear trend and a band pass filter that isolates the frequencies 6 to 32, using a moving average of 8.

Figure 26: Pointwise Contribution to Jobless Recoveries - Different De-Trending



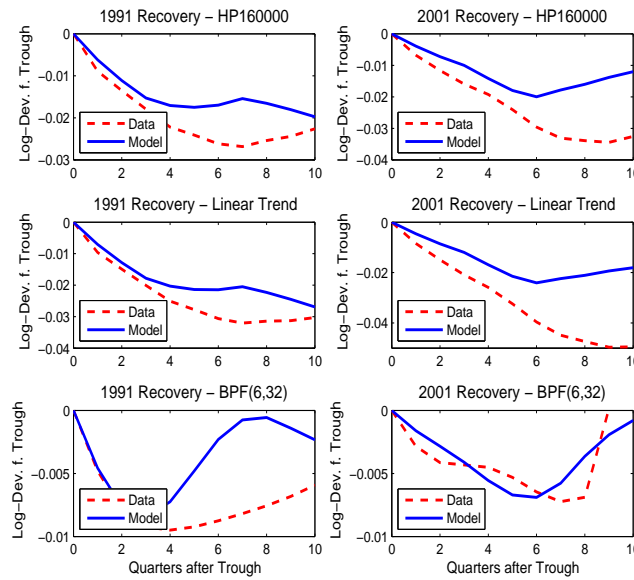
With the methods that lead to a more rigid trend, the overall contribution increases slightly, the band pass filter leads to a decrease of the overall contribution.⁵⁶ Altogether it remains substantial. The following table 7 conveniently summarizes these contributions as well as the cyclical fit; Figure 27 displays the behavior of cyclical aggregate employment in the two recoveries after 1991 and 2001 under different de-trending methods.⁵⁷

⁵⁶It should be noted, however, that the band pass filter with the moving average is particularly sensitive at the beginning and the end of a time series: excluding the 1949 recovery, which just starts eight quarters after the beginning of the data horizon, leads to considerably higher values: 46% and 32% on average, for 1991 and 2001,

Table 7: INFLUENCE OF DE-TRENDING

	Cyclical Fit		Overall Contribution	
	1991	2001	1991	2001
Baseline HP-1600	47%	75%	56%	45%
HP-160000	73%	58%	72%	50%
Linear Trend	78%	53%	80%	55%
BPF(6,32)	51%	87%	34%	27%

Figure 27: Jobless Recoveries - Different De-Trending Methods



Next, I briefly discuss how robust the occurrence of jobless recoveries is with respect to some of the choices for the micro parameters.

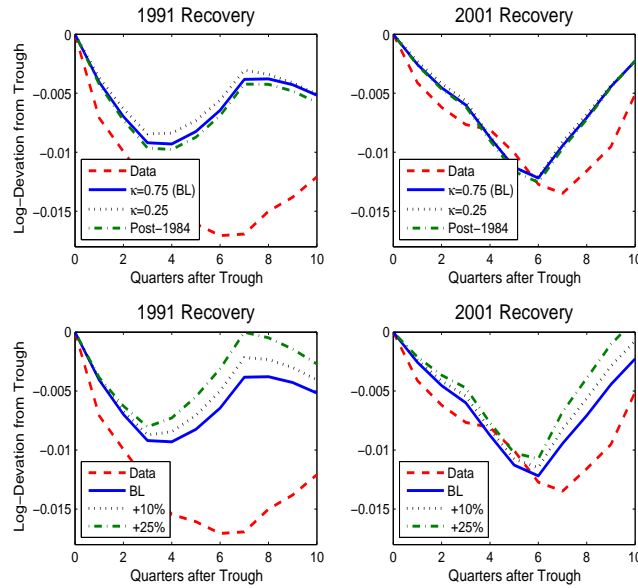
Figure 28 - upper panels - shows that the baseline result is fairly robust to changing κ in the adjustment cost function, (5), from $\kappa = 0.75$ to $\kappa = 0.25$. There it is also shown that the results of the baseline model remain virtually unaltered, if the estimate of the aggregate technology process was based on the post-1984 era, i.e. when the great moderation set in.

Thus far, I have calibrated adjustment costs to match the average job turnover rate of continuing establishments in U.S. data. If the job turnover rate was biased downward by measurement error or the assumptions made in the calculation of the job turnover rate over the sample, then the calibration procedure would lead to adjustment costs that are too high, and too much emphasis would be put on adjustment costs as an explanatory variable. Figure 28 - lower pan-

respectively.

⁵⁷When using a BP-filter the cyclical component in 2001 is already positive after eight quarters, hence the cyclical fit number uses only those eight observations.

Figure 28: Jobless Recoveries and: a Different κ , Different Turnover Rates (BL = Baseline Model)



els - shows the aggregate employment dynamics for the baseline model under the assumption of a 10% and a 25% higher job turnover rate than measured: 14.5521%, 16.5365%, respectively. While it can be seen that joblessness is less severe with smaller adjustment costs,⁵⁸ the results are by and large preserved.

Figure 29: Jobless Recoveries and Lower OTP, ϑ (BL = Baseline Model)

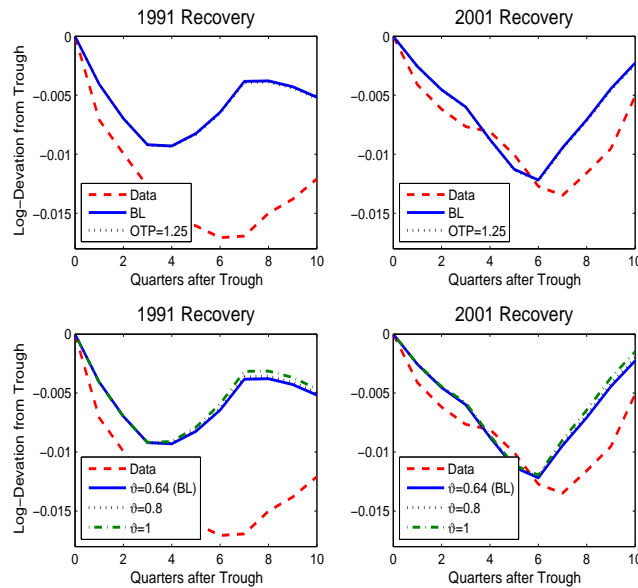


Figure 29 - upper panels - shows that a smaller overtime premium than assumed in the baseline model does not change the results.

⁵⁸ $\bar{\xi}$ is lowered from 2.0015 to 1.5323 and 1.1879, respectively.

Figure 29 - lower panels - demonstrates the robustness of the baseline results to another specialization of (29), setting $\vartheta > \alpha = \alpha_h$. Concretely, I explore $\vartheta = 0.8$ and $\vartheta = 1$, the case of perfect substitutability between straight-time work and overtime work.

Many researchers have favored a random walk for idiosyncratic productivity dynamics; most recently, Bloom (2009). With $\rho_I = 0.55$ this paper deviates considerably from this assumption. I nevertheless view this as a reasonable value, because even though pure technology shocks may be characterized by high persistence, firms in reality are hit by other shocks - a stochastic quit rate, for instance - for which the assumption of high persistence is less tenable. Thus, a model that captures all idiosyncratic uncertainty in one variable should not use a random walk. Nevertheless, I test the effect of this assumption and set $\rho_I = 0.95$.⁵⁹ Moreover, I investigate the effect of lowering σ_I to 0.2, maintaining $\rho_I = 0.55$. As figure 30 - upper panels - shows, with higher persistence in the idiosyncratic technology process the jobless recoveries become slightly milder, but the basic picture remains unchanged. With a lower σ_I , the joblessness is much milder: Now, matching the observed job turnover rate requires smaller adjustment costs, so that the cycle mechanism proposed has less room to play out. However, as has been pointed out above in section 4, $\sigma_I = 0.3$ is already at the lower end of empirical estimates, when it is combined with a relatively small persistence parameter for the idiosyncratic shock process.

Figure 30: Jobless Recoveries and Different ρ_I, σ_I, q (BL = Baseline Model)

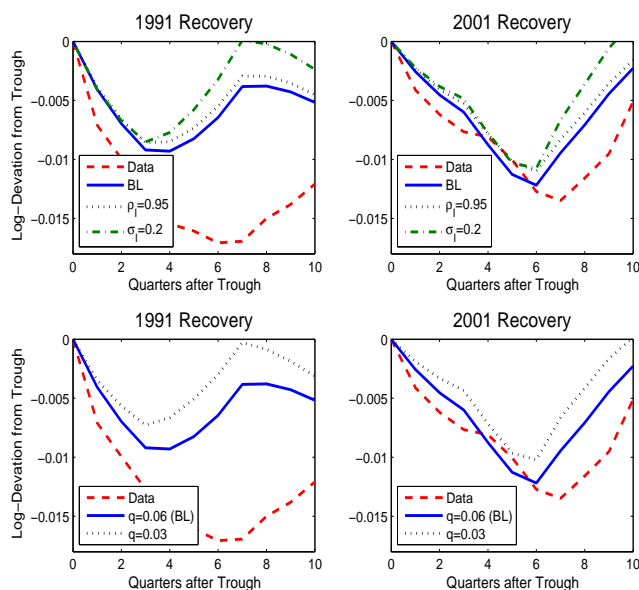


Figure 30 - lower panels - demonstrates the importance of the attrition rate in generating jobless recoveries: Halving the attrition rate mitigates the joblessness in the recoveries. Sim-

⁵⁹This value allows me to still use a Markov chain as an approximation device. Also, I lower the value of σ_I to 0.1, because I find that the original value leads to absurdly high adjustment costs in the calibration. With these values for ρ_I and σ_I , the unconditional standard deviation of the idiosyncratic technology process remains roughly the same: 0.36 in the basic scenario, 0.32 with the higher ρ_I .

ple economic intuition suggests why a high attrition rate plays an important part in generating jobless recoveries: firstly, in the recession most firms just let attrition play out and do not fire, because in this case they would incur costs, so that after short recessions they will typically end up with a relatively high employment level. That means most firms do not need to hire immediately in a recovery, and because of adjustment costs they do not want to do that. Then the second effect of attrition sets in: aggregate employment continues to decline, at first through shedding overhead employment, and then because establishments use the second margin for a while to take advantage of better business environments.

The following table summarizes the effects of changing the micro parameters:

Table 8: INFLUENCE OF MICRO-PARAMETERS

	Cyclical Fit		Overall Contribution	
	1991	2001	1991	2001
Baseline	47%	75%	56%	45%
$\kappa = 0.25$	43%	73%	53%	45%
Post-1984	50%	77%	58%	46%
+10%	40%	65%	53%	43%
+25%	32%	53%	49%	41%
$OTP = 1.25$	47%	76%	56%	45%
$\vartheta = 0.8$	46%	74%	56%	45%
$\vartheta = 1$	45%	71%	55%	44%
$\rho_I = 0.95$	42%	66%	54%	43%
$\sigma_I = 0.2$	33%	52%	50%	41%
$q = 0.03$	30%	52%	48%	40%

I finish this section with a few remarks about two model simplifications: the lack of capital, and the exclusion of entry and exit. Given the central theme of this paper - jobless recoveries - these are potentially substantial omissions, which are mainly justified by analytical clarity and numerical tractability. However, economic intuition suggests that adding these features would only enforce joblessness in recoveries. If entry and exit are similarly subject to fixed costs as hiring and firing, then a short recession will not lead to the elimination of all non-profitable businesses, and, conversely, new firms will wait with entering the market until a recovery is more solid. Similarly, adding capital with capital adjustment costs and flexible capacity utilization would strengthen the tale of two margins. I leave a quantitative investigation of the implications of these omissions for future research.