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Three Essays on Labor Market Friction and the Business Cycle

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THREE ESSAYS ON LABOR MARKET FRICTION AND THE BUSINESS CYCLE

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DEDICATION

To Professor Soohaeng Kim
(1942–2015)

and

To My Wife Youngji Cho

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ABSTRACT

THREE ESSAYS ON LABOR MARKET FRICTION AND THE BUSINESS CYCLE

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This dissertation examines the macroeconomic impact of reduced labor market friction on the U.S. business cycle after the mid–1980s. The first two essays investigate the relationship between labor market flexibility and macroeconomic stability from a post–Keynesian perspective. In the third essay which reviews the relationship between labor market flexibility and patterns of U.S. business cycle, I test the argument that after 1985 Okun's coefficient became larger due to the flexible labor market.

In essay 1, considering two aspects of labor market flexibility, employment flexibility and real wage flexibility, I adopt the flex–output model (Skott, 2015) to first discuss employment flexibility and then extend it by incorporating real wage dynamics induced from a wage–price Phillips curve (Flaschel and Krolzig, 2006) to address real wage flexibility. The simulation of model explains that employment flexibility increases instability of an economy whereas real wage flexibility reduces it. Empirical

results of this paper suggest that during the Great Moderation, real wage flexibility played a major role in stabilizing the U.S. economy. On the other hand, employment flexibility has contributed to destabilizing the economy during the Great Recession.

In essay 2, using structural VAR analysis, I provide more rigorous empirical evidence to support the hypothesis in essay 1—real wage flexibility played a major role in stabilizing U.S. economy during the Great Moderation, and employment flexibility has contributed to destabilizing the economy during the Great Recession. I found that during the Great Moderation (1) Employment and real wage flexibilities were operating simultaneously; (2) The employment flexibility was not so severe; (3) Flexible real wages functioned as an autonomic stabilizer; (4) Therefore, stabilized goods market during the Great Moderation can be explained by dominating effect of the real wage flexibility over the employment flexibility. For the Great Recession, however, severe asymmetry in the business cycle and the lack of observations obstructs reliable empirical work.

In essay 3, I discuss the observations of increased cyclicality in aggregate hours and increased responsiveness of the (un)employment rate to output changes after 1985, which have contributed to recent debate about the validity of Okun's law. To investigate this, I measure Okun's coefficients in three phases of the business cycle—recessions, early expansions and late expansions. Related findings include: (1) The main determining factor for an increased coefficient for aggregate hours is the increased responsiveness of the employment rate during late expansions. (2) The increased responsiveness of hours per employee in early expansion is another main determining factor for more reactive aggregate hours. These findings conflict with the flexible labor market hypothesis that focuses mainly on firms' firing behaviors during recessions when they incur less costs than previously.

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CHAPTER 1

INTRODUCTION

Two puzzling views about the flexible labor market's impact on macroeconomic stability motivated me to pursue this topic. On the one hand, as a contributor to the Great Moderation (1984–2007), labor market flexibility has been regarded as an important factor mitigating macroeconomic shock (Burnside et al., 1990; Galí and Gambetti, 2009). On the other hand, different recovery processes in the U.S. and Germany during the Great Recession have raised questions about the positive role of a flexible labor market on stability (Burda and Hunt, 2011).

However, existing literature on this topic which has focused on explanations for the Great Moderation overlooks two crucial factors: (1) aggregate demand, (2) adjustment of real wages. Most influential explanations emphasize a supply side link running from institutional change to macroeconomic outcome. For example, Galí and Gambetti (2009); Stiroh (2009) explain that labor productivity became less procyclical since labor market flexibility enables a firm to adjust its output margins through levels of employment rather than through labor productivity. According to their theory, this weakened propagation mechanism—decreased volatility in labor productivity—contributes to a decline in output volatility since any shocks will quickly die.

The main contribution of my dissertation is to show the demand side nexus between institutional changes in the labor market and macroeconomic stability using a post–Keynesian framework in which both aggregate demand and income distribution are accommodated.

In essay 1 (chapter 2), titled *Macroeconomic Stability in a Flexible Labor Market*, I developed a post–Keynesian model to investigate the macroeconomic impact of the flexible labor market. Considering two aspects of labor market flexibility, employment flexibility and real wage flexibility, I adopt the flex–output model (Skott, 2015) to first discuss employment flexibility and then extend it by incorporating real wage dynamics induced from a wage–price Phillips curve (Flaschel and Krolzig, 2006) to address real wage flexibility. The simulation of model explains that employment flexibility increases instability of an economy whereas real wage flexibility reduces it. Empirical results of this paper suggest that during the Great Moderation, real wage flexibility played a major role in stabilizing the U.S. economy. On the other hand, employment flexibility has contributed to destabilizing the economy during the Great Recession.

In essay 2 (chapter 3), titled *Does Labor Market Flexibility Stabilize an Economy?: A Structural VAR Approach*, using structural VAR analysis, I provide more rigorous empirical evidence to support the hypothesis in essay 1—real wage flexibility played a major role in stabilizing U.S. economy during the Great Moderation, and employment flexibility has contributed to destabilizing the economy during the Great Recession. I found that during the Great Moderation (1) Employment and real wage flexibilities were operating simultaneously; (2) The employment flexibility was not so severe; (3) Flexible real wages functioned as an autonomic stabilizer; (4) Therefore, stabilized goods market during the Great Moderation can be explained by dominating effect of the real wage flexibility over the employment flexibility. For the Great Recession, however, severe asymmetry in the business cycle and the lack of observations obstructs reliable empirical work.

From these two essays we can get a clue how to answer the conflicting attitudes towards flexible labor market: It is not flexibilized employment but flexible real wages that contributed to macroeconomic stability during the Great Moderation. In this regard, using an active labor market policy to reverse a downward spiral during a recession is worthwhile considering as suggested by the German experience.

Unfortunately, the supply side perspective has been pervasive in the realm of policy makers or researchers conducting policy studies on the labor market. One such example can be seen in the recent debate on Okun's law presumably representing firms' adjustment behavior on the margin of production.

In essay 3 (chapter 4), titled *Changes in Cyclical Patterns of the U.S. Labor Market: From the perspective of Nonlinear Okun's Law*, I discuss the observations of increased cyclicality in aggregate hours and increased responsiveness of the (un)employment rate to output changes after 1985, which have contributed to recent debate about the validity of Okun's law. To investigate this, I measure Okun's coefficients in three phases of the business cycle—recessions, early expansions and late expansions. Related findings include: (1) The main determining factor for an increased coefficient for aggregate hours is the increased responsiveness of the employment rate during late expansions. (2) The increased responsiveness of hours per employee in early expansion is another main determining factor for more reactive aggregate hours. These findings conflict with the flexible labor market hypothesis that focuses mainly on firms' firing behaviors during recessions when they incur less costs than previously.

A lesson from essay 3 is that a rule of thumb, based on the simple assumption that a representative firm adjusts its product margins, cannot properly capture the interaction between the labor market and goods market. Furthermore, this rule of thumb cannot explain the mechanism how an unstable labor market contributes to a stabilized product market. This theoretical limitation leads us to essays 1 and 2 while underscoring the necessity of a demand side approach. (In fact, essay 3 prompted me to write essays 1 and 2.)

CHAPTER 2

MACROECONOMIC STABILITY IN A FLEXIBLE LABOR MARKET

2.1 Introduction

The remarkable decline in macroeconomic volatility of the U.S. economy from the mid-80s until 2007 (known as the Great Moderation) was accompanied by less procyclicality (or volatility) of labor productivity. The most prevalent explanation for these changed patterns is labor market flexibility, featured by weakened employment protection legislation (EPL) and the resulting ease by which a firm can adjust its output margins through levels of employment rather than through labor productivity (Gordon, 2010). A weakened propagation mechanism—decreased volatility in labor productivity—contributes to a decline in output volatility since any shocks will quickly die (Galí and Gambetti, 2009; Stiroh, 2009). These studies, however, overlook two crucial factors in macroeconomics: (1) demand side; (2) adjustment of real wages.[1] The main purpose of this paper is to provide a coherent model to investigate institutional changes in the labor market (supply side) and their impact on macroeconomic stability via the distribution channel (demand side). I also consider the aspects of labor market flexibility using two dimensions: employment flexibility and real wage flexibility (Abbritti and Weber, 2010).

[1] Galí and van Rens (2010) include a wage bargaining set in their model in which a reduction in labor market friction narrows the bargaining set and endogenously makes wages more sensitive to shocks. Given these conditions, increased flexibility of wages dampens volatilities of output and employment in response to shocks. However, the absence of a demand side still exists in that real wage merely plays a role as one of the output margins.

For this research purpose, I adopt a post–Keynesian approach known as the flex–output model (Skott, 2015) to discuss employment flexibility but extend it by incorporating real wage dynamics induced from a wage–price Phillips curve (Flaschel and Krolzig, 2006) to discuss the real wage flexibility. The main simulation result of the model suggested by this paper is that employment flexibility increases instability of an economy whereas real wage flexibility reduces it. I also provide empirical results suggesting that, during the Great Moderation, real wage flexibility played a major role in stabilizing the U.S. economy. By contrast, employment flexibility has contributed to destabilizing the economy during the Great Recession.

To model employment flexibility, a recent empirical finding concerning increased Okun's coefficients—the responsiveness of the employment rate to output change—is of particular interest. Gordon (2010) argues that the coefficient has increased from 1/3 to 1/2 due to reduced labor hoarding. The real business cycle (RBC) theory has also studied the varying utilization rate of labor input as an important transmitter of technological shocks (Burnside et al., 1990). However, from a post–Keynesian perspective in which more emphasis is placed on long–run distributional effects on growth, there have been rare efforts to model the effects of short–run variation in the utilization rate of labor or labor hoarding.[2] A stylized method is varying the capital utilization rate to capture changes in aggregate demand while setting labor productivity constant unless long–run technical changes are an issue. On the other hand, the flex–output model in Skott (2015) highlights a firm's labor hoarding behavior. Using this framework, a transition toward flexible employment can be elaborated; then, the dynamic impact of institutional change in the labor market on goods market stability can be discussed.

[2]van der PLOEG (1983) and You (1994) are a few exceptions.

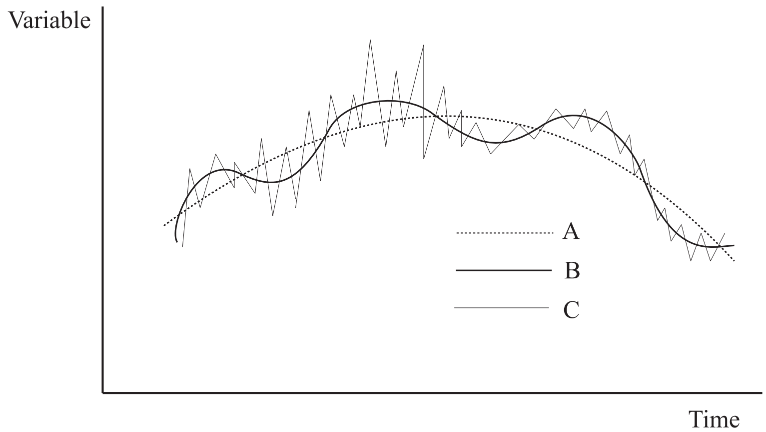
To model flexible real wage, I modify the wage–price Phillips curve developed by Flaschel and Krolzig (2006) following the tradition of the conflict claim model (Rowthorn, 1977). Induced real wage dynamics is a function of profit share, utilization rates and employment rates. In this paper, real wage is considered to be flexible if the growth rate of real wage becomes more responsive to changes in both the utilization rate and employment rate, implying that that real wage adjusts more rapidly upon short–run changes in economic variables compared to a rigid real wage.

It is worthwhile mentioning the different statistical emphases that economists place on the macroeconomic impact of the flexible labor market. First, most Kaleckian literature draws on movement in the long–run or medium–run trends of certain variables: for example, profit share or its impact on economic growth (Line A in Figure 2.1). In this tradition, a flexible labor market renders the distribution to favor profit share, bringing about a negative (positive) growth if the economy is under a wage (profit)–led growth regime. Another direction of the research from this tradition is to show that labor market deregulation causes a negative impact on labor productivity growth, hence economic growth (Naastepad, 2006; Storm and Naastepad, 2009; Vergeer and Kleinknecht, 2010).[3]

Second, in new Keynesian dynamic stochastic general equilibrium (DSGE) models or RBC theories, the stability of the economy is expressed by the degree of fluctuation (Line C in Figure 2.1): the stochastic adjustment process upon preference or technological shocks. For instance, Galí and Gambetti (2009) address the stability issue highlighting the second moment (variance) of variables to capture the relative volatility of the variable of interest with respect to output volatility.

[3]The main focus of this productivity channel is low labor costs in a flexible labor market and firms' lack of incentives for adopting labor saving techniques. In this situation, employment flexibility can crowd out induced technical changes. For example, Michie and Sheehan (2003) show that a flexible labor market correlates negatively with innovation.

Figure 2.1: Different Viewpoints on the Labor Market Flexibility



Alternatively, this paper, adopting the perspective of the endogenous business cycle, addresses the issue of macroeconomic stability by examining the *amplitude* of the business cycle (Line B in Figure 2.1). On the one hand, this paper's approach is similar to the exogenous business cycle theories in that any changes in the labor market affect the propagation mechanism in the cycle. On the other hand, this paper's divergence from those theories is in the nature of shocks in the creation of the business cycle. Rather than one time shocks creating stochastic fluctuations of the variables, the business cycle is driven by endogenous interaction among the variables of the labor market and goods market.

By examining the amplitude of a business cycle, this paper actually departs from the typical post–Keynesian perspectives which regard a cycle as medium–run or long–run fluctuations of variables. Nonetheless, this close up view enables us to see a purely functional aspect of flexibility in the labor market and its impact on short–run macroeconomic stability. Accordingly, any long–run transitions in the relative bargaining power between firms and workers resulting from flexibilization of the labor market and their impacts on the macroeconomy will not be addressed in this paper.

The remainder of this paper is organized as follows: Section 2.2 presents the flex–output model in Skott (2015) to discuss employment flexibility. A two–dimensional dynamical model of the labor–capital ratio (l) and employment rate (e) is provided and simulation results based on this model will be discussed. In section 2.3, a dynamic equation of real wage (w) is induced from the wage–price Phillips curve in Flaschel and Krolzig (2006) and, as a state variable, is incorporated into the dynamic system. Simulation results of a 3D model are provided to discuss the impact of flexibilized real wage on stability. In section 2.4, an empirical investigation is conducted to discuss the transitions of the U.S. labor market during the Great Moderation and Great Recession. Section 2.5 concludes.

2.2 Flex–Output Model with Fixed Real Wage

This and the following sections elaborate a model which analyzes the impact of labor market flexibility on macroeconomic stability. If 'flexible labor market' refers to the historical transition in advanced economies since the early 1980s, the core element behind the transition is a weakening EPL that facilitates the firing process of firms. Then, the question becomes how the easiness to fire and hire can be modeled. A clue can be found in the concept of labor hoarding according to which firms, faced with hiring and firing costs, adjust labor intensity rather than level of employment when demand changes (Okun, 1970; Oi, 1962). The more friction in adjusting the level of employment, the more volatile labor productivity becomes. Thus, allowing variation in the labor productivity or labor utilization rate is the first step in modeling a flexible labor market.

For this purpose, Skott (2015)'s flex–output model—a variant of the Kaldor–Goodwin model (Skott, 1989)—provides a theoretical framework. Following his lead, the flex–output economy can be defined as follows.

Definition 1. *(Flex–Output Economy) The disequilibrium in the goods market is adjusted by changes in the labor utilization rate* (λ) *under these conditions: (i) capital adjusts more sluggishly than labor* ($\partial\hat{L}/\partial l > \partial\hat{K}/\partial l$) *over a business cycle; (ii) the* *accumulation rate depends on the employment–capital ratio* (l) $(\hat{K} = lf(l))$ *where* $\lambda = Y/L$ *and* $l = L/K$.

The time horizon in this paper is separated into an 'ultra–short run' or 'short–run' in a similar fashion to Skott (1989). In an ultra–short run, neither the stock of capital (K) nor employment (L) can be adjusted instantaneously. If aggregate demand of an economy changes, firms clear market disequilibrium by flexibly changing the level of output (Y) given predetermined levels of employment (L). In this sense, the utilization rate of labor ($\lambda = Y/L$) is the accommodating variable to clear goods market disequilibrium.

In the 'short–run', however, firms have an incentive to change their level of employment to meet a changed business environment because the utilization rate of labor cannot increase or decrease ad infinitum. The employment expansion function that will be later discussed specifies firms' behavior in deciding the size of employment in the short–run. Condition (i) implies that firms' primary concern in the short–run is to change the level of employment. The rationale of condition (ii) is that "capital accumulation responds mainly to changes in the slow–moving state variable" which is the employment–capital ratio rather than the output–capital ratio in the flex–output economy (Skott, 2015).

In section 2.2.1, I will begin by explaining the flex–output model which is reduced to two dynamic systems of the employment–capital ratio (l) and employment rate (e). Section 2.2.2 will discuss employment flexibility with some simulation results based on the flex–output model.

2.2.1 Model Specification and Dynamic Analysis

In post–Keynesian literature, varying labor productivity has been allowed mainly to analyze the long–run impact of technical change. To date, neither many discussions nor modeling efforts on short–run labor hoarding have been undertaken. The production function should be modified to address firm's labor hoarding behavior. Output is determined by a fixed coefficient production function (2.1) generally used in post–Keynesian approaches. Using a fixed coefficient production function can be further justified since our main interest is short–run in which prices of labor and capital are not competitive.

$$Y = min\{\lambda L, \sigma K\}; \qquad \lambda = Y/L \leq 1, \quad \sigma = Y/K \leq \sigma^{max} \tag{2.1}$$

where Y = real gross output; L = employment; K = capital stock; σ^{max} = maximum utilization rate of capital; σ = actual utilization rate of capital; λ = actual utilization rate of labor.

The upper limit of the utilization rate of labor is normalized to one, thereby the labor utilization rate, *i.e.* labor hoarding, varies cyclically between 0 and 1 while technical change is abstracted away. Using a manipulation, the utilization rate of labor (λ) can be expressed in terms of the capital utilization rate (σ) and the employment–capital ratio (l):

$$\lambda = \frac{Y}{L} = \frac{Y}{K}\frac{K}{L} = \sigma\frac{1}{l} \tag{2.2}$$

(2.2) implies that, due to the Leontief property of the production function, the capital utilization rates and, thus, the level of capital will be endogenously determined once L and λ are determined. Besides the production function, the flex–output model consists of following six equations:

$$S = Yg(\pi(\lambda)); \qquad g_\pi > 0, \quad \pi_\lambda > 0 \tag{2.3}$$

$$I = Lf(l); \qquad f_l > 0 \tag{2.4}$$

$$\hat{K} = I/K \tag{2.5}$$

$$\hat{e} = \hat{L} - n \tag{2.6}$$

$$\hat{L} = h(\lambda, e); \qquad h_\lambda > 0, \quad h_e < 0 \tag{2.7}$$

$$I = S \tag{2.8}$$

where e = the employment rate; π = the profit share; I = gross investment in real terms; n = growth rate of population.

(2.3) is a Kaldorian saving function in which the savings rate from profits is larger than that of wage income. The utilization rate of labor affects the saving function via changes in profit share. In this section, I assume that the real wage rate is fixed and profit share is a function solely of the labor utilization rate ($\pi = 1 - \bar{w}/\lambda$). However, in section 2.3, wage and price inflation are discussed, and, thus, the strong assumption of a fixed real wage is relaxed.

(2.4) is a Harrodian investment function which is a positive function of the employment–capital ratio. Being a function of the employment–capital ratio (l), it satisfies condition (ii) in Definition 1. (2.5) is a function relating changes in capital stock to gross investment in which any depreciation in capital stock is ignored for the sake of simplicity.

(2.6) states that growth in the employment rate is, by definition, the combined result of growth in employment and the labor force. There is a limit in the supply of labor, which is relevant for most advanced economies. This means that, unlike the dual economy case in which labor is supplied without limit at the prevailing wage, workers exercise a certain level of bargaining power in the decision processes of both employment and wages (Kalecki, 1943). Then, the flexibilization of the labor market can be understood as a social transition to counteract the bargaining power of workers.[4]

(2.7), the employment expansion function specifies firms' behavior in deciding the size of employment of the next period.[5] Two variables—the utilization rate of labor (λ) and the employment rate (e)—influence firms' decisions. First, a signal from the goods market is reflected in the degree of the labor utilization rate, namely the condition of the internal labor market. Firms use workers more intensely when demand expands and *vice versa*. However, intensity cannot be raised infinitely, and firms have to expand employment to meet demand. Second, the signal from the labor market—more exactly, the external labor market—comes from the employment rate. This effect is the relative surplus labor effect: a high rate of employment incentivizes firms to reduce employment and mollify militant workers. Here, the ease with which firms adjust the size of employment is our main interest that will be discussed later in this section.

Finally, (2.8) describes the condition for the goods market equilibrium. This condition is inherently different from the condition in the Kaldor–Goodwin model, which is an ultra short–run Marshallian equilibrium given a market clearing price vector. (2.8) is still Marshallian in that firms continue to have an incentive to renew the size of employment. However, in the flex–output model, it is not price but the utilization

---

[4]Notice the difference from the Kaldor–Goodwin model (Skott, 1989) where $\hat{Y}$ and $\hat{L}$ coincide and, hence, $\hat{e}$ equals $\hat{Y} - n$. In the flex–output model, allowing for labor hoarding, the growth rates of two variables are conceptually different since $\hat{Y} = \hat{\lambda} + \hat{L}$ from (2.1).

[5]This behavioral function is the counterpart to the output expansion function ($\hat{Y}$) in the Kaldor–Goodwin model.

rate of labor that accommodates for the ultra short–run disequilibrium in the product market. In other words, the jump variable in the flex–output model is not π but λ.

Solving (2.3), (2.4) and (2.8) with respect to the utilization rate of labor (λ) yields a function of the jump variable for the ultra short–run equilibrium (2.9).[6]

$$S/K = \lambda l g(\pi(\lambda)) = l f(l) = I/K$$

$$\lambda = \lambda(l); \qquad \lambda_l > 0 \tag{2.9}$$

If we insert the employment expansion function (2.7) into both the law of motion of l ($\hat{l} = \hat{L} - \hat{K}$) and (2.6) and replace λ for (2.9), two dynamic equations of l and e can be obtained.

$$\hat{l} = h(\lambda(l), e) - l f(l) \tag{2.10}$$

$$\hat{e} = h(\lambda(l), e) - n \tag{2.11}$$

This dynamic system, containing the same mathematical structure as the Kaldor–Goodwin model, has a unique balanced growth equilibrium (see Appendix B). The Jacobian matrix of this system can be constructed as follows:

$$J(l,e) = \begin{pmatrix} l(h_\lambda \lambda_l - f - l f') & l h_e \\ e h_\lambda \lambda_l & e h_e \end{pmatrix} \tag{2.12}$$

$$Det = l^* e^* h_e(-f - l^* f') > 0 \tag{2.13}$$

[6]This corresponds to $\pi = \pi(\sigma)$ in the Kaldor–Goodwin model.

$$Tr = l^*(h_\lambda \lambda_l - f - l^* f') + e^* h_e \tag{2.14}$$

To apply the endogenous business cycle theory, I must show that this dynamic system can create a limit cycle by checking the Hopf bifurcation condition for local stability. The necessary conditions for the existence of a limit cycle are a positive determinant and a positive trace of the Jacobian matrix (2.12). The sign of the determinant (2.13) is unambiguously positive, meaning that the dynamics of the system can possibly create a cycle. As to the sign of the trace (2.14), the first term, which can be reformulated to $l^*(\partial \hat{L}/\partial l - \partial \hat{K}/\partial l)$, is obviously positive by Definition 1. Although the sign for the entire terms is ambiguous algebraically, following the same reasoning as Skott (1989), I assume that adjustment of employment to changes in the labor utilization rate (h_λ) is sufficiently faster than adjustment of capital so that the effect from the relative surplus labor (h_e) is dominated by it.

Assumption 1. *In the flex–output economy, $\partial \hat{L}/\partial l \gg \partial \hat{K}/\partial l$ such that $l^*(\partial \hat{L}/\partial l - \partial \hat{K}/\partial l) + e^* h_e > 0$*

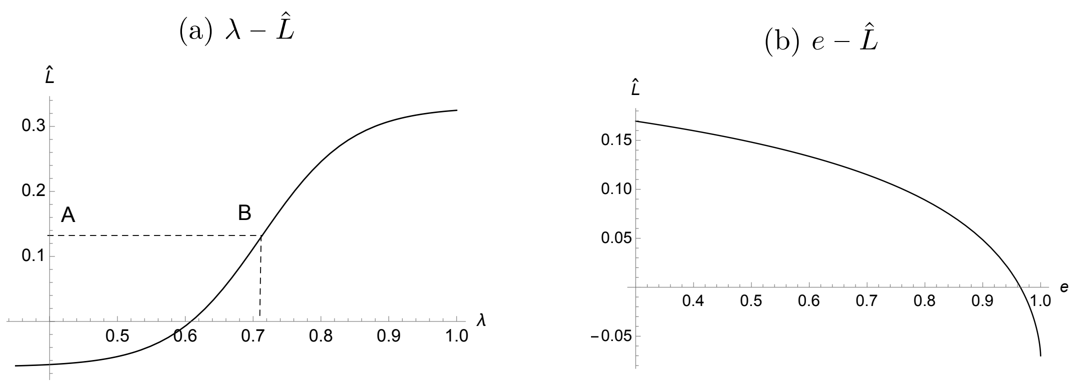
The implication of this assumption is straightforward. In the flex–output economy, prior motivation for a firm to change its level of employment derives from the condition of the internal labor market, *i.e.* labor hoarding. Positive trace thereby the instability of the system are guaranteed by Assumption 1. Therefore, the dynamics of the system can possibly show a limit cycle.

However, the Hopf bifurcation condition for *local* stability involves linearization of nonlinear dynamics in the vicinity of the equilibrium point. As we move away from the equilibrium point, nonlinear forces play an increasingly major role. The next task is using a simulation method to determine whether the cycle is explosive or stable *globally*.

In Appendix A, the specifications and parameter values used in the simulation are listed. Among them, a concrete form of the employment expansion function which takes a crucial role in capturing any institutional changes in the labor market merits discussing. Following Skott and Zipperer (2012), I use below a logistic functional form to present the employment expansion function.

$$\hat{L} = h(\lambda, e) = \frac{0.4}{1 + exp(-15(\lambda - 0.6 + 0.1ln(1-e)))} - 0.07 \tag{2.15}$$

Figure 2.2: Employment Expansion Function



Panels (a) and (b) of Figure 2.2 plot the employment expansion function (2.15) in $\hat{L}$–λ and $\hat{L}$–e planes, respectively. Three functional properties of the logistic function can be highlighted.

Property 1 of Employment Expansion Function: In panel (a), the function has an upper bound of 0.33 and lower bound of -0.07. (2.15) and simple algebra show that if λ goes to $+\infty$ in the denominator, $\hat{L}$ approaches $0.33(= 0.4 - 0.07)$; if λ goes to $-\infty$, $\hat{L}$ approaches -0.07. Similarly, the reason why $\hat{L}$ goes to $-\infty$ when e approaches 1 (full employment) in panel (b) can also be mathematically proved using (2.15).

Property 2 of Employment Expansion Function: Since the function is non-linear, the slopes of the employment expansion function are not constant. Taking the derivative of $h(\lambda, e)$ with resect to λ and e yields the following slopes:

$$h_\lambda = \frac{0.4 \cdot 15 \cdot exp(-15(\lambda - 0.6 + 0.1ln(1-e)))}{(1 + exp(-15(\lambda - 0.6 + 0.1ln(1-e))))^2} \tag{2.16}$$

$$h_e = \frac{-0.4 \cdot 0.1 \cdot 15 \cdot exp(-15(\lambda - 0.6 + 0.1ln(1-e)))}{(1 + exp(-15(\lambda - 0.6 + 0.1ln(1-e))))^2} \cdot \frac{1}{1-e} \tag{2.17}$$

As can be seen, the slopes of the employment expansion function are not constant and dependent on the other variable on the right hand side.

Property 3 of Employment Expansion Function: The third property is relating to the midpoint of the logistic function in panel (a) Figure 2.2. If the term $0.6 - 0.1ln(1-e)$ is zero in (2.15), the function will be symmetrical at the midpoint B whose coordinate would be $(0, 0.13)$. The geometric role of $0.6 - 0.1ln(1-e)$ which corresponds to the length of $\overline{AB}$, or λ value of the midpoint in panel (a) of Figure 2.2 is to move the midpoint to the right by that amount.[7]

[7]This property is also useful in obtaining the maximum sensitivity of $\hat{L}$ with respect to λ, which is merely the slope of the employment expansion function at the midpoint. Since $\lambda = 0.6 - 0.1ln(1-e)$ at the midpoint, (2.16) can be simplified to $(0.4/4) \cdot 15$. Note that the sensitivity of $\hat{L}$ with respect to e goes to ∞ as employment approaches full employment.

I will return to these properties later. The simulation for the benchmark case is conducted based on the employment expansion function (2.15) along with the functions in Appendix A. Panels (a) and (b) of Figure 2.3 illustrate simulation results showing the existence of a clockwise limit cycle and cyclical movements of the variables. The amplitude of e in this benchmark case is around 0.025 while that of l is 0.011.[8]

Subsequently, two questions relevant for the research purpose of this paper arise: Which parameters in (2.15) capture employment flexibility? What are the macroeconomic impacts when they change? Two scenarios immediately come to mind. I will discuss them in the next section.

2.2.2 Comparative Static Analysis for Flexible Employment

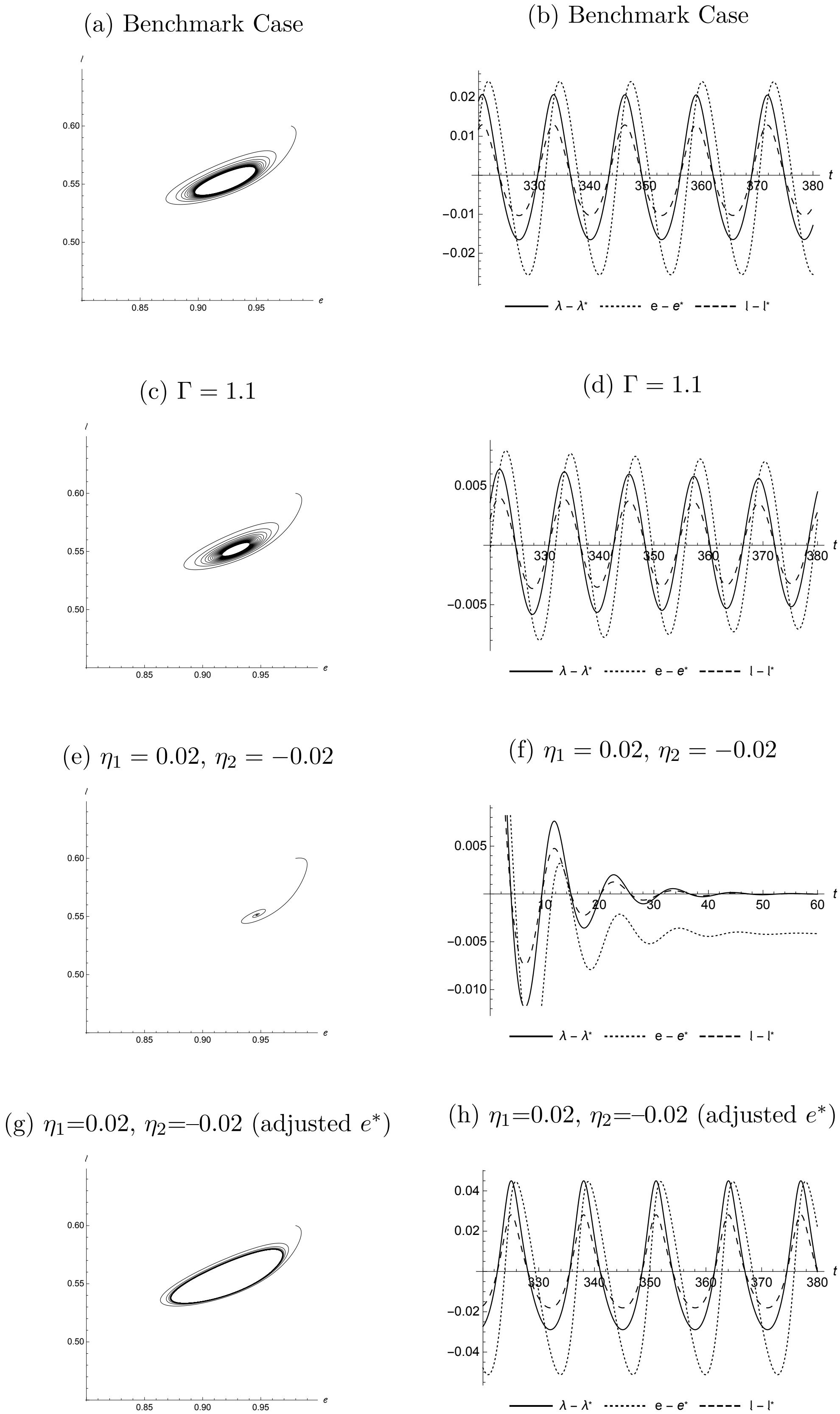
In the first scenario, flexibilization of employment refers to a firm's increased ability to promptly change its level of employment when the business environment changes. To address this change in firms' behavior, a parameter (Γ), representing the speed of adjustment, can be attached to the employment expansion function. Thus, (2.15) can be replaced by:

$$\hat{L} = \Gamma h(\lambda, e) = \Gamma(\frac{0.4}{1 + exp(-15(\lambda - 0.6 + 0.1ln(1-e)))} - 0.07) \qquad (2.15')$$

From Property 1 of the employment expansion function, the role of Γ in the dynamic system becomes clear. Higher Γ simultaneously both heightens and lowers the upper and lower bounds of $\hat{L}$ and enlarges the range of $\hat{L}$. Intuitively, this would destabilize

[8] If a wave is symmetrical, its amplitude is the distance from the center line to the top of a crest or to the bottom of a trough. If not—for instance, sharpened peaks (sudden crisis) and round trough (slow recovery)—the amplitude can be measured by half the width of the wave.

Figure 2.3: Limit Cycles(Left) & Cyclical Movements of Endogenous Variables(Right)



the economy in that the higher and lower bounds of $\hat{L}$ which supposedly turn the cycle in the opposite directions will be allowed: hence, a larger centrifugal force. However, the result is not actually so simple due to two combined effects of the increased speed of adjustment.

First, from Property 2 of the employment expansion function, a higher Γ changes the slopes of $\hat{L}$ by Γ times. Now, the sensitivities of $\hat{L}$ with respect to λ and e become Γh_λ and Γh_e, respectively.[9] The effect of an increased h_λ—caused by higher Γ—on economic stability is certainly destabilizing since as λ rises, firms will increase the growth rate of employment further *vice versa*, making the employment cycle fluctuate more than previously. This destabilizing force is, however, mitigated by rises in $|h_e|$—the strengthened relative surplus labor effect—which will stabilize the economy: when the employment rate rises, firms fire workers more intensively to reduce labor costs. In this paper, the net effect of the increased speed of adjustment will end up destabilizing the economy since the sensitivity of λ is set much greater than the sensitivity of e by Assumption 1.

Second, a higher Γ also changes the long–run steady state equilibrium point which brings about a feedback impact on the short–run stability of the dynamic system. A higher Γ results in a small increase in e^* (see Appendix B) which will, in turn, affect the stability property of the system due to the appearance of e^* in the trace of the Jacobian matrix (2.14).[10] If research were to investigate any changes in parameters and their impacts on *purely* short-run stability, ignoring this effect may result in a faulty conclusion.

The simulation result of the first scenario is presented in panels (c) and (d) of Figure 2.3 where, if the speed of adjustment increases by 10% ($\Gamma = 1.1$), the ampli-

[9]The maximum sensitivity of $\hat{L}$ with respect to λ becomes $(0.4\Gamma/4) \cdot 15$ accordingly.

[10]Note that l^* and, thus, λ^* are not affected by changes in any parameters relating to the labor market since they are independently determined by parameters in both the saving and investment functions, in other words, from the goods market.

tudes of e and l are reduced to 0.008 and 0.004, respectively.[11] However, as discussed, it is misleading to state that flexibilization of employment by increasing the speed of adjustment stabilizes the economy since two other effects are co-mingled. More importantly, it should be questioned whether the first side effect, increased h_λ and $|h_e|$, is in accordance with the changed direction of firms' behavior after flexibilization. This question leads us to the next scenario.

Theories suggest that increased employment flexibility by a weakened EPL implies that firms increasingly rely on the external labor market and *relatively* less on the internal labor market since any firing or rehiring costs become less important than in a rigid labor market. Responding to the increased utilization rate of existing workers—a sign of an expansionary goods market—firms can increase the size of employment more easily with reduced friction. Thus, a trait of flexible employment is *weakened labor hoarding* meaning the increased sensitivity of employment growth to changes in the utilization rate of labor.

On the side of the labor market, as I discussed earlier, the level of employment rate affects firms' decisions regarding the size of employment in the next periods: a high rate of employment incentivizes firms to reduce employment to mollify employees' militancy. However, under a flexible labor market, since employees' overall bargaining position has deteriorated, firms need not worry too much about the high rate of employment in a boom. Thus, another trait of flexible employment is a *weakened relative surplus labor effect* meaning decreased sensitivity of the employment growth to changes in the employment rate.

Thus, the second scenario of employment flexibility is to vary two sensitivities of the employment expansion function, which changes the slope between the upper and

[11]The periods length—defined as the distance from a particular height on a wave to the next spot on a wave—also has decreased. This finding does not conform to the post–1980 U.S. experience during which a longer cycle has been observed.

lower bounds. In this paper, flexible employment accompanies a higher h_λ and lower $|h_e|$ meaning that $\hat{L}$ becomes more sensitive to changes in λ; less, to changes in e. The definition of flexible employment follows:

Definition 2. *(Flexible Employment) Employment is considered to become flexible if* $\Delta h_\lambda > 0$ *(weakened labor hoarding) and* $\Delta|h_e| < 0$ *(weakened relative surplus labor effect).*

Let function h' be the employment expansion after parametric changes toward flexible employment. Then, Definition 2 implies that $h'_\lambda > h_\lambda > 0$ and $h_e < h'_e < 0$. Accordingly, (2.15) should be revised to (2.15″) in which parametric changes can be captured by η_1 and η_2.

$$\hat{L} = h'(\lambda, e) = \frac{0.4}{1 + exp(-15((1+\eta_1)\lambda - 0.6 + 0.1(1+\eta_2)ln(1-e)))} - 0.07 \quad (2.15'')$$

Then, the changed sensitivities are:

$$h'_\lambda = \frac{0.4 \cdot 15 \cdot (1+\eta_1) \cdot exp(-15((1+\eta_1)\lambda - 0.6 + 0.1(1+\eta_2)ln(1-e)))}{(1 + exp(-15((1+\eta_1)\lambda - 0.6 + 0.1(1+\eta_2)ln(1-e))))^2} \quad (2.18)$$

$$h'_e = \frac{-0.4 \cdot 0.1 \cdot 15 \cdot (1+\eta_2) \cdot exp(-15((1+\eta_1)\lambda - 0.6 + 0.1(1+\eta_2)ln(1-e)))}{(1 + exp(-15((1+\eta_1)\lambda - 0.6 + 0.1(1+\eta_2)ln(1-e))))^2} \cdot \frac{1}{1-e} \quad (2.19)$$

In a nonlinear function in which the sensitivities vary, a reasonable mathematical expression of a sensitivity change is addressing the sensitivity changes at the point of maximum sensitivity while expecting the same rate of changes to be applied in other ranges as (2.18) and (2.19) show. By Property 3 of employment expansion function, h'_λ is maximum at the midpoint in which $(1+\eta_1)\lambda - 0.6 + 0.1(1+\eta_2)ln(1-e)$ is zero. In this case, maximum h'_λ induced by (2.18) is simplified to $(0.4/4)\cdot 15 \cdot (1+\eta_1)$. Likewise, the maximum h'_e can be obtained as $(1+\eta_2)\cdot\infty$.[12] In this respect, η_1 and η_2 can effectively capture the parametric changes in the nonlinear function.

The direction of changes described in Definition 2, in fact, makes the Assumption 1 more convincing by letting the first term of the trace (2.14) become more positive and the second, less negative. Hence, the possibility of a dampened cycle moving toward steady state equilibrium is more likely to be excluded as an outcome of flexible employment.[13] From this point, Proposition 1 follows:

Proposition 1. *If h_λ is sufficiently high and $|h_e|$ is sufficiently low under flexible employment, the stationary point of the dynamic system (2.10)–(2.11) cannot be locally stable.*

To check global property, a simulation with the employment expansion function (2.15″) is conducted. Here, I consider the case that h_λ increases by 2% ($\eta_1 = 0.02$); $|h_e|$ decreases by 2% ($\eta_2 = -0.02$). The result reported in panels (e) and (f) of Figure 2.3, refuting our expectations, shows a convergence of the fluctuation. This inconsistency can be explained by the aforementioned effect incurred by a change in the steady state equilibrium point. Given the steady state level of the employment rate for the benchmark case, $e^*(\risingdotseq 0.92)$, increased h_λ along with decreased $|h_e|$ results in a higher level of $e^{*\prime}(\risingdotseq 0.95)$. (See Appendix B). Benefitting from this side effect, workers

[12]This simplified expression can be calculated from (2.19) by approximating e to 1.

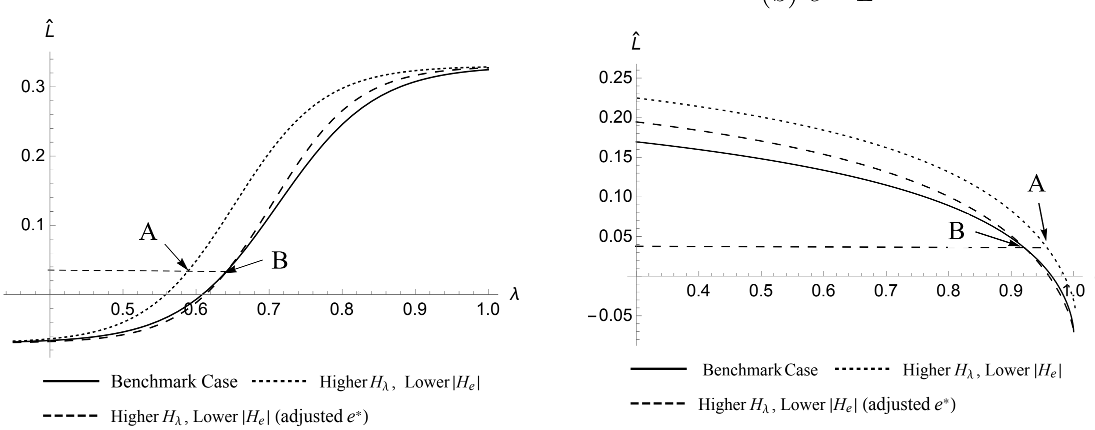
[13]Note that transitioning toward flexible employment does not eliminate economic fluctuation since it cannot change the determinant (2.13) of the system from positive to negative.

exercise enhanced bargaining positions at every single point of the employment rate, causing a shift in the employment expansion function.

Figure 2.4 presents the shifts in the employment expansion function caused by changes in sensitivities. In panel (a), the employment expansion function is drawn on the λ–$\hat{L}$ plane. A rise in h_λ will rotate the function from a solid to a dashed line. However, due to the decrease in $|h_e|$, and resulting increase in e^*, the curve shifts upto the dotted line. Under this circumstance, the λ–distance between points A and B corresponds to the influence of changed h_e on the steady state equilibrium value of e^*, which equals $\Delta h_e \cdot e^*$.[14] Similarly, in panel (b) of Figure 2.4 presenting the same employment expansion function on the e–$\hat{L}$ plane, the distance between points A and B reflects the overall enhanced position of employees.

Figure 2.4: Shifts of Employment Expansion Function

(a) $\lambda - \hat{L}$ (b) $e - \hat{L}$



Notes: The employment expansion function for the benchmark case is $\hat{L} = \frac{0.4}{1+exp(-15(\lambda-0.6+0.1ln(1-e)))} - 0.07$. For the purpose of illustration, the changes in the parameters are exaggerated.

[14]Note that the long–run equilibrium points of both λ^* and e^* in panels (a) and (b) of Figure 2.4 exist at the intersection with $\hat{L} = n = 0.034$ which is the natural growth rate.

In order to focus on the short–run stability issue incurred purely by changes in sensitivities, I propose eliminating the feedback effect caused by the long–run positional change between firms and employees. This is quite similar to Slutsky wealth compensation in the consumer's theory in which the wealth effect ($= \Delta p \cdot x^*$) is subtracted to disentangle the pure effect of price changes—the substitution effect—from the entire effects on changes in quantity. For this application, the following employment expansion function can be used:

$$\hat{L} = \frac{0.4}{1 + exp\{-15[(1+\eta_1)\lambda - \eta_1\lambda^* - 0.6 + 0.1((1+\eta_2)ln(1-e) - \eta_2 ln(1-e^*)) + \eta_3]\}} - 0.07 \tag{2.15$'''$}$$

In (2.15$'''$), the terms, $-\eta_1\lambda^*$ and $-\eta_2 ln(1-e^*)$, work exactly as if Slutsky wealth compensation. In fact, the former term is unnecessary for the 2D model since, as we discussed, λ^*, a function of l^*, is not affected by any changes in the flexibility parameters. Later in the 3D model, however, this term becomes necessary because—as (2.9$'$) suggests—λ^* depends not only on l^* but also on w^* that is prone to be affected by any changes in parameters relating to wage flexibility. Here I underscore the role of the latter term ($-\eta_2 ln(1-e^*)$) as a compensator for functional shift. If $|h_e|$ decreases by η_2, the second term functions to compensate or neutralize the positional change caused by an increase in e^*, thereby shifting the equilibrium points back from A to B in panels (a) and (b) in Figure 2.4.[15]

[15] In the benchmark case, $0.6 - 0.1ln(1-e)$ is λ value of midpoint (see Property 3 of employment expansion function). Given this property, the term, $\eta_2 ln(1-e)$, in (2.15$'''$) would move the midpoint of the logistic function to the left; the term, $-\eta_2 ln(1-e^*)$, to the right. In this respect, removing the effect of the enhanced bargaining power involved in the parametric changes can be seen as pushing back the x–value of the midpoint to the right by adding a certain value to x_0, or, equivalently, adding a certain level of bargaining power to firms.

In addition, for general discussion, η_3 is augmented in (2.15‴) to represent a shift in bargaining power between firms and workers which resulted from changes in factors other than the labor utilization rate or employment rate. I will set this parameter aside ($\eta_3 = 0$) for simplification.

For simulation of this modified model, I consider changes parallel with scenario 2: h_λ increases by 2% ($\eta_1 = 0.02$); $|h_e|$ decreases by 2% ($\eta_2 = -0.02$). Panels (g) and (h) in Figure 2.3 show that the modification overturns the results of scenario 2. Compared to the benchmark case, the amplitudes of e and l have clearly increased to 0.0475 and 0.0225, respectively. These results suggest that *flexible employment driven by a weakened EPL destabilizes the economy.*

Figure 2.5: Cause–and–Effect of Flexibilized Employment (Expansion)

$$\begin{tikzcd}
l \arrow[r, rightsquigarrow] & \lambda \arrow[r, "(+)"] & \hat{L}\uparrow \arrow[r] \arrow[dr] & l\uparrow \arrow[r, rightsquigarrow] & \lambda\uparrow \arrow[r] & \hat{L}\uparrow\uparrow \arrow[r] \arrow[dr] & l\uparrow\uparrow & \cdots \\
e \arrow[urr, "(+)"'] & & & e\uparrow \arrow[urr] & & & e\uparrow\uparrow & \cdots
\end{tikzcd}$$

Notes: The squiggle arrow ($\rightsquigarrow$) implies an ultra–short run adjustment of the jump variable; the solid arrow ($\rightarrow$), a short run adjustment of the state variable; (+)s represent the timing of changes in the parameters; the arrow attached to a variable expresses the relative size of the variable compared to the benchmark case.

The source of the destabilizing force can be grasped by Figure 2.5. First, let's consider the stage of expansion. Once h_λ increases and $|h_e|$ drops as a result of flexible employment at the timing specified with (+)s, the growth rate of L will be certainly increased compared to the growth rate before changes in the parameters. Subsequently, an increased growth rate of L will raise the growth rates of l and e. Thus, the levels of l and e end up higher compared to the rigid employment case.

In the second round, the goods market is in excess demand since the higher l investment outweighs savings. Higher λ is required so that the goods market is in equilibrium in the ultra–short run. Then, higher λ will raise the $\hat{L}$ even further unless it hits the upper bound of $\hat{L}$ from where the economy reverses direction towards a recession. In a recession, variables move in opposite directions. As a result, the ups and downs in the variables of both the goods market (l) and the labor market (e) are amplified.

This result is incomplete since we unrealistically fixed the real wage rate. In the next section, the strong assumption of a constant real wage rate will be relaxed by examining real wage dynamics in great detail.

2.3 Flex–Output Model with Varying Real Wage

Increasingly, many post–Keynesian studies depart from the canonical Kaleckian assumption of constant mark–up pricing that sets profit share as an exogenous variable depending on the degree of monopoly. Given this uncoupling, it is debatable whether the growth rate of profit share is procyclical or countercyclical. The Kaleckian perspective asserts that profit share is countercyclical since a profit squeezing mechanism—a growing wage share with enhanced bargaining power of workers—comes into play as an economy approaches full employment (Barbosa-Filho and Taylor, 2006; Diallo et al., 2011). In contrast, the Kaldorian view emphasizes firms' ability to raise prices, dominating the profit squeezing influence of workers as the economy approaches full utilization of capital (Skott, 1989).

By incorporating firms' labor hoarding behavior (λ) into our thesis, we gain an extra degree of freedom and, thus, neither the Kaleckian nor Kaldorian positions are simply confirmed. This point will be clarified by understanding twofold influences of the labor utilization rate on distribution.

First, by hoarding labor in the course of an expansion, firms can improve their profit share. The growth rate of profit share can be decomposed into three components ($\hat{\pi} \equiv ((1-\pi)/\pi)(\hat{P} - \hat{W} + \hat{\lambda})$). Since $\hat{\lambda}$ along with $\hat{P}$ is positively correlated with the growth rate of profit share, inclusion of the labor utilization rate reinforces the Kaldorian position of procyclical profit share.[16] This labor saving—or productivity enhancing—effect can be termed a *quantity effect* of labor hoarding on distribution.

The second effect which is a *price effect* of labor hoarding is that increased productivity enables workers to bid up the wage rate at the bargaining table. This avenue definitely curtails profit share during an expansion. However, this effect may not be so strong considering a dual labor market in which wage raises in the primary sector are cancelled out or mitigated by stagnated real wages in the secondary sector. More importantly, as I will discuss later, an empirical study suggests that this effect is negligible in the U.S. labor market (Blanchard and Katz, 1999).

Keeping this distribution theory in mind, this section examines real wage dynamics ($\hat{w} = \hat{W} - \hat{P}$) to discuss real wage flexibility. Then, a complete 3D model based on the dynamic interaction among l, e and w will be provided.

2.3.1 Real Wage Dynamics

Flaschel and Krolzig (2006) elaborated a wage–price spiral model for dynamic analysis of real wage. Adopting their approach for our research purpose, the wage and price Phillips curves are as follows:[17]

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[16] Hahnel and Sherman (1982) conducted an empirical analysis showing that, in the case of the U.S., the hypothesis of procyclical profit share better represents reality since wage share is a negative function of the labor utilization rate.

[17] There is an important difference in the settings of the wage bargaining model between new and post–Keynesian traditions. The new Keynesian models which concern nominal rigidity focus mainly on the money wage Phillips curve. Price level is *functionally* determined by a monetary authority which is politically neutral in nature. To the contrary, post–Keynesian inflation theories, indebted to Rowthorn (1977), emphasize the *conflict* between workers who decide the money wage and firms which decide the price level by mark–ups.

$$\hat{W} = -\gamma_1(\frac{W}{P} - \alpha_w - \gamma_2 e) + \gamma_3 \hat{P}^e \tag{2.20}$$

$$\hat{P} = \beta_1(\frac{W}{P} - \alpha_p + \beta_2 \sigma) + \beta_3 \hat{W}^e \tag{2.21}$$

where α_w and α_p are the references for real wage that workers and firms think proper regardless of current levels of employment and the capital utilization rate.

The first term—denoted as an error–correction term by Blanchard and Katz (1999) since it explains the feedback from the target real wages of each class—creates a recursive movement in real wage dynamics in the 3D model. Originally, a starting point for a general discussion of real wage bargaining in Flaschel and Krolzig (2006) is that both workers and firms consider not only the current level of real wage but also the level of labor productivity (λ) when they each decide the growth rate of wage and price, respectively. However, Blanchard and Katz (1999) point out that there is an institutional difference in the estimates of γ_1: U.S data suggests a very weak error–correction effect ($\gamma_1 \approx 0$) whereas European countries show a strong effect ($\gamma_1 \approx 0.25$). This difference is, according to Blanchard and Katz (1999), due to a greater direct effect of firms' productivity on wages in Europe than in the U.S.[18] Considering this difference, for the U.S. economy, I will ignore and omit the labor productivity term in the error–correction term.[19] In other words, I will use W/P instead of $W/P\lambda$.

[18]In their model the coefficients have two compounded effects: (1) direct effect of productivity on wages given the reservation wage; (2) direct effect of productivity on the reservation wage. The latter effect can be explained by the role of the underground economy for the unemployed in many continental European countries. However, they cannot find any direct evidence for it.

[19]Of course, we can reinsert λ into the equation when we turn to the European labor market. In this case, increases in λ cause two countervailing effects on the growth rate of real wage in (2.24): (1) a positive effect by reducing the wage share with a subsequent correction; (2) a negative effect by raising utilization rates and active mark–up pricing that causes inflation.

The rest parts in the first terms are the target real wages of workers ($\alpha_w + \gamma_2 e$) and target real wage of firms ($\alpha_p - \beta_2 \sigma$), respectively. The workers (firms) consider the employment (utilization) rate when they establish targets and decide the growth rate of wage (price). Then, the aspiration gap in Rowthorn (1977)'s sense is $\alpha_w + \gamma_2 e - (\alpha_p - \beta_2 \sigma)$.

The second terms represent expectation of future prices and nominal wages by workers and firms. This paper assumes a static price level expectation ($\hat{P}^e = \hat{W}^e = 0$) meaning that workers and capitalists care only about the gap between the previous real wage and the target real wage.

Combining (2.20)–(2.21) with the assumption of static price level expectation, a real wage Phillips curve can be derived as follows:

$$\hat{w} = -(\gamma_1 + \beta_1)w + \gamma_1 \alpha_w + \beta_1 \alpha_p - \beta_1 \beta_2 \sigma + \gamma_1 \gamma_2 e \tag{2.22}$$

Making the reference real wages of both parties identical to α_o and using the relation, $\sigma = \lambda l$, from (2.2), further simplifications can be made:

$$\hat{w} = -(\gamma_1 + \beta_1)(w - \alpha_o) - \beta_1 \beta_2 \lambda l + \gamma_1 \gamma_2 e \tag{2.23}$$

or more simply,

$$\hat{w} = -\theta(w - \alpha_o) - \beta \lambda l + \gamma e \tag{2.24}$$

where $\theta = \gamma_1 + \beta_1$; $\beta = \beta_1 \beta_2$; $\gamma = \gamma_1 \gamma_2$.

Note that the second and third terms conjointly reflect the relative influence of workers and capitalists on the determination of real wage.

Next, a similar question can be raised as in the previous section: which parameter(s) in the real wage Phillips curve (2.24) captures wage flexibility? First, assuming α_0 to be a secular trend of w, the coefficient of the error–correction term (θ) can be regarded as a mean reversion of the error–correction model in the time series. In this respect, the larger the θ, the greater the response of w to the previous period's deviation from α_0. In this paper, however, θ for each specific country is assumed to be constant over time. Rather, the magnitude of θ is important in the context of a comparative study of wage bargaining across countries as Blanchard and Katz (1999) suggest.

To address the issue of short–run stability derived from real wage dynamics, I instead focus on β and γ—the influences of each party on the growth rate of real wage. The changes in these parameters in the real wage Phillips curve influence the growth rates of the other two state variables ($\hat{l}$ and $\hat{e}$), and, hence, the amplitude of their cyclical movements through a dynamic process. Broadly speaking, flexible real wage means a prompt response of real wage growth to changes in the business environment. More specifically, the definition of flexible real wage is as follows:

Definition 3. *(Flexible Real Wage) Real wage is considered to become flexible if* $\Delta\beta > 0$ *(more active firms' mark–up pricing) and* $\Delta\gamma > 0$ *(more active workers' nominal adjustment).*

Higher β implies flexibilized real wage dynamics in that inflationary *mark–up pricing* will be promptly reflected in the growth rate of real wage. Unlike the canonical post–Keynesian model in which firms' ability to mark–up (β) simply represents their influence on the goods market, in this paper, firms' decision on the labor utilization rate (λ) influences the extent of mark–up indirectly. (Note that $\sigma = \lambda l$.)

Similarly, higher γ—the sensitivity of the growth rate of real wage with respect to the employment rate—reflecting more active workers' *nominal wage adjustment* also plays a critical role in wage flexibility.

This definition differs from Franke et al. (2008)'s approach which distinguishes labor market led ($\beta < \gamma$) and goods market led ($\beta > \gamma$) regimes in the adjustment process of real wages. Using this framework, they conclude that if a profit–led (wage–led) economy is combined with a labor market led (goods market led) adjustment, the economy will become more destabilized. The discrepancy in these two approaches can be ascribed to different research interests on the aspects of the flexible labor market which is discussed in the introduction. This paper focuses more on the short–run effect of a flexible labor market caused by *sensitivities changes* in behavioral functions. On the other hand, Franke et al. (2008) explore the longer term consequences of the interaction between the labor market and goods market by focusing more on the *positional change* between firms and workers in terms of their relative influences in the determination of real wages.

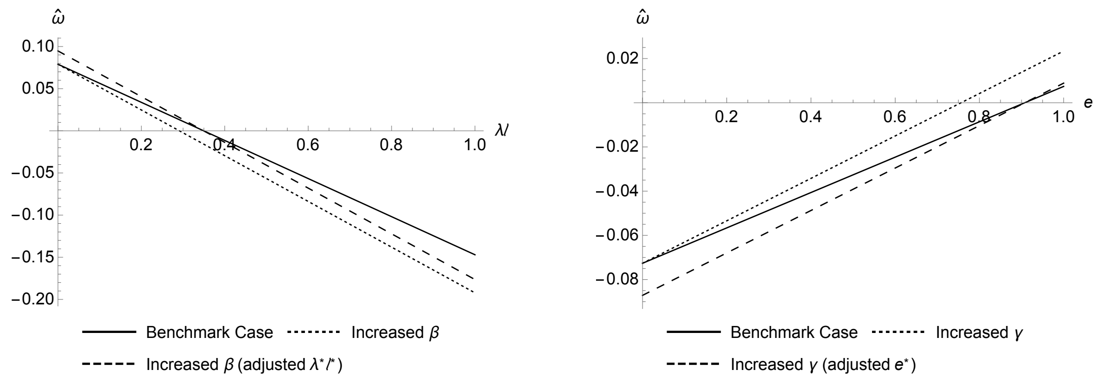
For a comparative static analysis of short–run stability, the same compensation mechanism discussed in employment flexibility also applies. The real wage Phillips curve (2.24) can be modified as follows:

$$\hat{w} = -\theta(w - \alpha_o) - (\beta + \nu_1)\lambda l + \nu_1 \lambda^* l^* + (\gamma + \nu_2)e - \nu_2 e^* \tag{2.25}$$

As a result of increased β by ν_1, the long–run steady state level of capital utilization rate will be reduced. Since this change involves an overall positional change against workers, it is hard to address the macroeconomic impact caused by pure sensitivity changes unless a compensation of $\nu_1 \lambda^* l^*$ is bestowed on workers. This mechanism is illustrated in panel (a) of Figure 2.6. Panel (b) presents the compensation mechanism when γ increases.

Figure 2.6: Shifts in Real Wage Phillips Curve

(a) Relationship between $\hat{w}$ and λl (b) Relationship between $\hat{w}$ and e



Notes: The real wage Phillips curve for the benchmark case is $\hat{w} = -0.7(w - 0.6) - 0.226\lambda l + 0.08e$. The increases in both β and γ are 20%.

2.3.2 3D $(l - e - w)$ Dynamic Model

By relaxing the assumption of fixed real wage, the saving function in the 2D model should be modified accordingly.

$$S = Yg(\pi(\lambda, w)); \qquad g_\lambda > 0, \quad g_w < 0 \tag{2.3$'$}$$

Solving (2.3′), (2.4) and (2.8) with respect to labor productivity (λ) yields the goods market equilibrium condition (2.9′).

$$S/K = \lambda l g(\pi(\lambda, w)) = l f(l) = I/K$$

$$\lambda = \lambda(l, w); \qquad \lambda_l > 0, \quad \lambda_w > 0 \tag{2.9$'$}$$

In any discrepancy between saving and investment, firms adjust output and thereby, at a given employment, change the degree of labor hoarding. Note that disequilibrium in the goods market is now expressed multi–dimensionally by l and w. When the employment–capital ratio (l) increases (investment outweighs saving), firms use existing workers more intensively (λ increases) to rebalance the goods market. Likewise, when real wages increase, thereby reducing profit rate (saving is underweight), raising the utilization rate of labor balances the goods market.

The dynamic equations for three state variables, l, e and w, are:

$$\hat{l} = h(\lambda(l, w), e) - lf(l) \tag{2.10}$$

$$\hat{e} = h(\lambda(l, w), e) - n \tag{2.11}$$

$$\hat{w} = -\theta(w - \alpha_o) - \beta\lambda(l, w)l + \gamma e \tag{2.24}$$

At first glance, this formulation looks similar to Flaschel et al. (2008) configuring four state variables, σ, e, w and l.[20] Nevertheless, they delete l from the reduced-form by assuming that l remains at its predetermined steady state value. This paper, instead, focuses on the dynamic interactions among l, e and w since, as we discussed earlier in the Definition 1, capital accumulation responds mainly to changes in the slow–moving state variable, l, in the flex–output model. $\hat{\sigma}$ can be retrieved by (2.2) and its law of motion, $\hat{\sigma} = \hat{l} + \hat{\lambda}$.

A stationary solution for this 3D system can be attained using a stationary condition, $\hat{l} = \hat{e} = \hat{w} = 0$. (2.10)–(2.11) and the stationary condition, $\hat{l} = \hat{e} = 0$, yields l^* satisfying the following relation:

$$l^* f(l^*) = n \tag{2.26}$$

Then, inserting l^* into the stationary conditions $\hat{e} = \hat{w} = 0$, we have

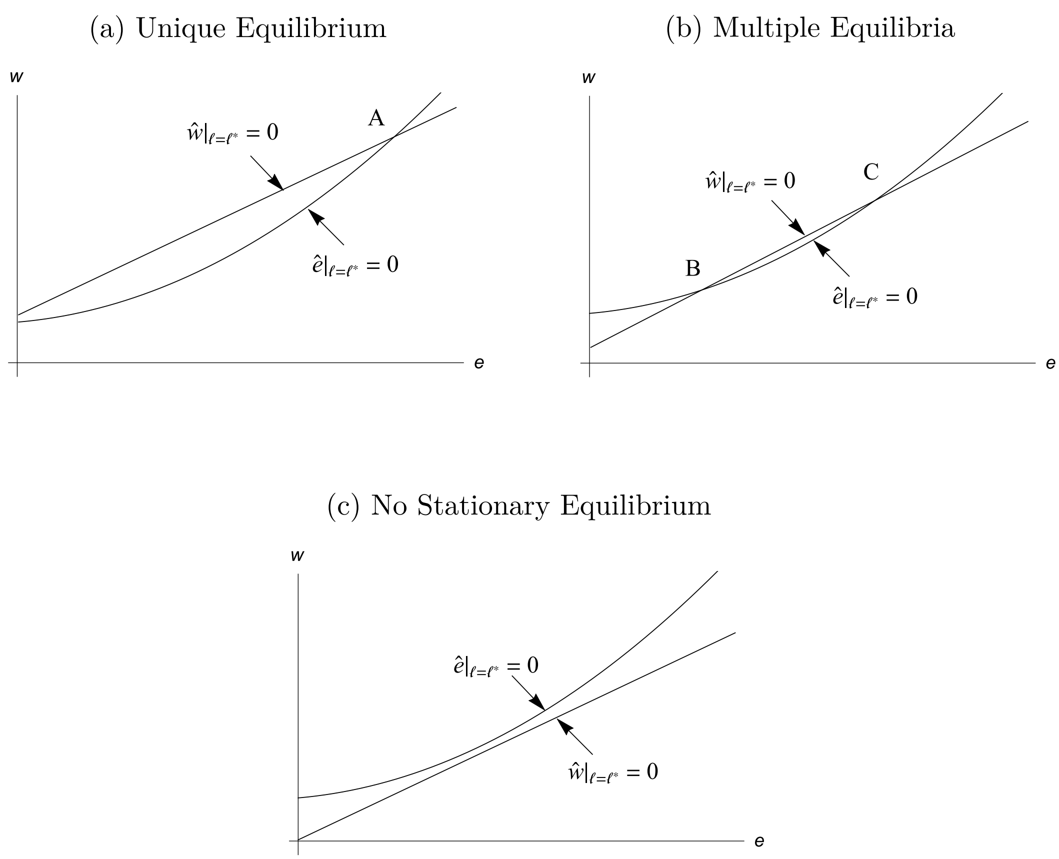
[20] According to them, the first two variables describe the Keynes–Kaleckian goods market and employment dynamics; the last two, Goodwin–Rose growth cycle dynamics.

$$h(\lambda(l^*, w), e) = n \tag{2.27}$$

$$-\theta(w - \alpha_o) - \beta\lambda(l^*, w)l^* + \gamma e = 0 \tag{2.28}$$

By solving (2.27) and (2.28), e^* and w^* can be obtained. Figure 2.7 plots the trajectories of w and e that maintain these variables in a steady state while holding l to l^*.

Figure 2.7: Cases of Stationary Solutions



Excluding case (c) which is theoretically uninteresting, either case (a) with a unique equilibrium or case (b) with multiple equilibria is plausible. Note that, due to nonlinearity in the employment expansion function, the existence of a unique solution is guaranteed if y–intercept of $\hat{w}|_{l=l^*}=0$ is greater than y–intercept of $\hat{e}|_{l=l^*}=0$. From this property, Proposition 2 follows:

Proposition 2. *Let $w = F_1(e)$ pairs of w and e that satisfy (2.27); $w = F_2(e)$ pairs of w and e that satisfy (2.28). A unique steady state equilibrium exists if and only if $F_1(0) < F_2(0)$. $F_1(0)$ increase as h_λ increases. $F_2(0)$ decreases as β increases.*

Proof of Proposition 2 is moved to Appendix C. Proposition 2 implies that, assuming panel (a) to be the benchmark case, the multiple equilibria (panel (b)) may exist if the degree of flexibilities—either employment or real wage (or both)—exceeds a certain threshold.

In addition, the slope of $\hat{w}|_{l=l^*}=0$ is also affected by changes in the parameters relating to flexible real wage.

Proposition 3. *The slope of $F_2(e)$ declines as β increases. The slope of $F_2(e)$ increases as γ increases. If β and γ increase by the same amount, the slope of $F_2(e)$ becomes steeper unambiguously if $\beta > \gamma$.*

Proof of Proposition 3 is also moved to Appendix C. In this paper, I assume that $\beta > \gamma$ and the slope of $F_2(e)$ would certainly become steeper if both β and γ increase by the same amount after flexibilization of real wages. In other words, flexiblization of real wage corresponds to a down shift in $F_2(e)$ while the curve rotates counterclockwise. Otherwise, case (c)—no stationary equilibrium—cannot be excluded. This assumption also implies that the adjustment process of real wages in this paper is a goods market led regime using Franke et al. (2008)'s terminology.

In this paper, considering an economy such as case (a) in Figure 2.7, I set the parameters in such a way to ensure a unique equilibrium in the simulation analysis. Nevertheless, case (b) will be dealt with later in the discussion of recent U.S. experience: prolonged slumps in the labor market during the Great Recession.

The Hopf bifurcation condition for local stability of the 3D dynamic system is provided in Appendix D. As will be seen, the existence of a limit cycle is difficult to prove mathematically due to complexity of the Jacobian matrix. In the next section, I will implement a quantitative approach to show a limit cycle.

2.3.3 Simulation with Real Wage Dynamics

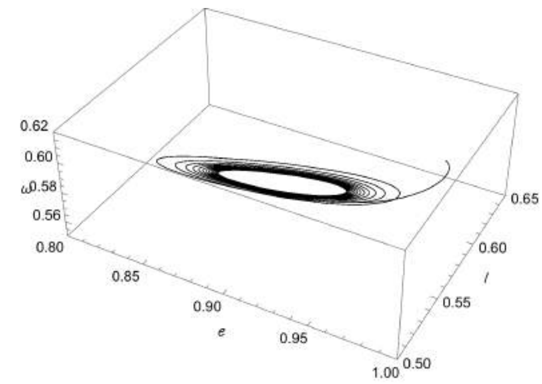
In the simulation for the 3D model, I examine only the effect of real wage flexibility since all the conclusions for employment flexibility based on the 2D model are already embedded in the 3D model.

Panels (a) and (b) in Figure 2.8 show the limit cycle and cyclical movements of variables for the benchmark case. (See Appendix A for the specifications and parameters for the simulation.) Note that real wages move counter–cyclically since, by Proposition 3, firms' ability to mark–up is modeled to dominate workers' ability to squeeze profits given the rate of employment ($\beta > \gamma$). In addition, the accommodation role of the labor utilization rate (λ) upon the goods market disequilibrium is clearly seen in panel (b). λ as a jump variable passes through the intersections of l and w with larger amplitude. After this ultra–short run adjustment by λ, other state variables (w, l and e) start to adjust at a moderate speed.

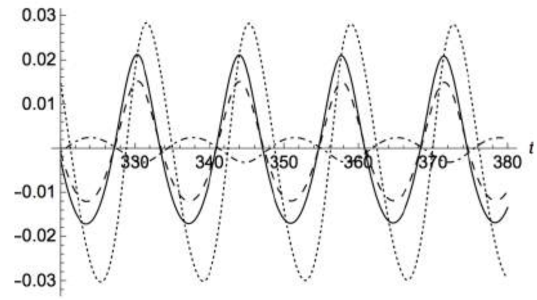
Panels (c) and (d) show the limit cycle and the fluctuations of the variables when both β and γ are increased by 20%. Compared to the benchmark case—although they are not easily discernible—the amplitudes of λ, e and l become narrower while the amplitude of w becomes wider. As discussed, however, it is more appropriate to remove the effect created by a positional change using the modified real wage Phillips curve (2.25). The result of this treatment is reported in panels (e) and (f) in which the amplitude becomes significantly narrower. From this exercise, we can conclude that *flexible real wage stabilizes the economy*, other things being equal.

Figure 2.8: Limit Cycles (Left) and Cyclical Movements of Endogenous Variables (Right) for 3D Model

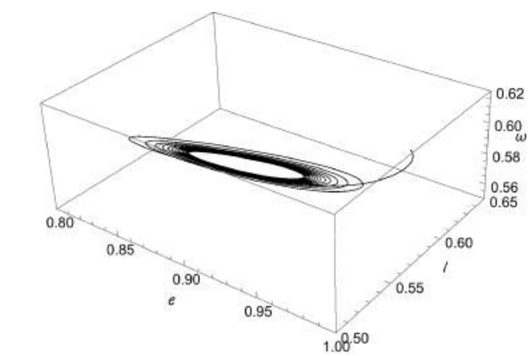
(a) Benchmark Case



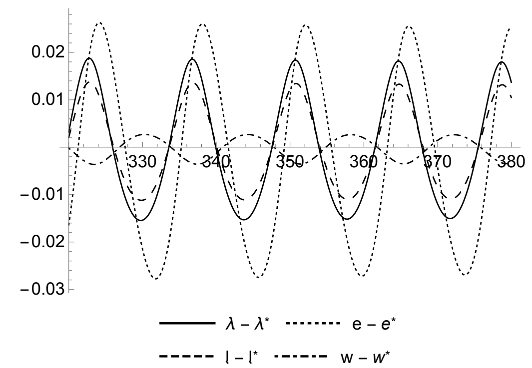
(b) Benchmark Case



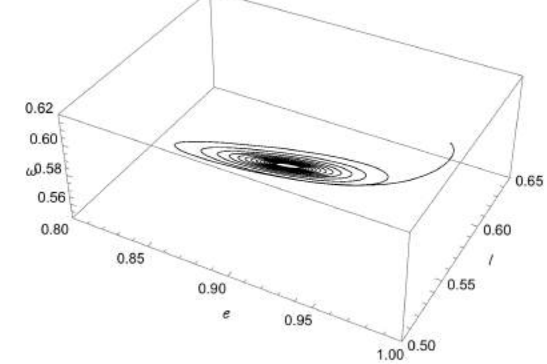
(c) Increased β and γ by 20%



(d) Increased β and γ by 20%



(e) Increased β and γ by 20% (adjusted e^* and w^*)



(f) Increased β and γ by 20% (adjusted e^* and w^*)

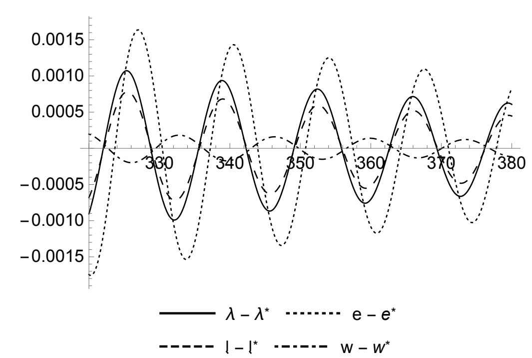
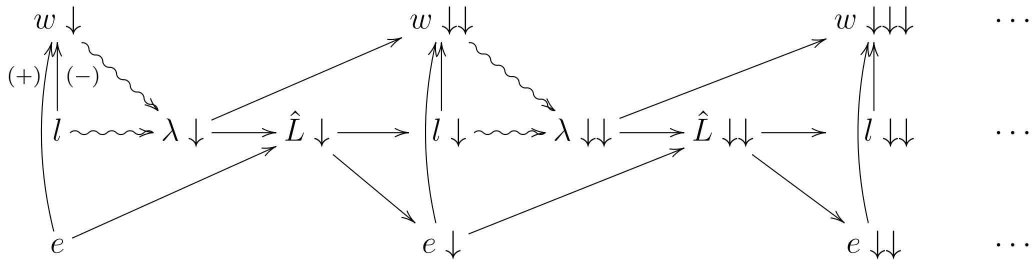


Figure 2.9: Cause–and–Effect of Flexibilized Real Wages (Expansion)



Notes: The squiggle arrow ($\rightsquigarrow$) implies an ultra–short run adjustment of the jump variable; the solid arrows ($\rightarrow$), a short run adjustment of the state variable; $(+)$ and $(-)$ are the points in time when the parameters are changed; the arrow attached to a variable expresses the relative size of the variable compared to the benchmark case.

Figure 2.9 illustrates the source of the stabilizing force caused by real wage flexibility. In the beginning of the first round when an economy is poised to expand, l and e rise while imposing opposite effects on the growth rate of real wages. However, since we assumed $\beta > \gamma$, real wages grow negatively during expansion. If so, flexibilization of real wage ($\Delta\beta > 0$; $\Delta\gamma > 0$) at the timing specified by $(+)$ and $(-)$ would make the growth rate of real wage even more negative compared to $\hat{w}$ under a rigid real wage regime or the benchmark case.

At the outset of expanding demand in the goods market being reflected by increasing l and excess investment, adjusting λ closes the gap between saving and investment in the ultra–short run. However, the savings function (2.3′) suggests that this gap is actually much smaller compared to the fixed real wage case since, upon decreases in real wages, profit share ($\hat{\pi} \equiv ((1-\pi)/\pi)(\hat{\lambda} - \hat{w})$) rises as a result, as does saving. Therefore, variation in real wage functions as an automatic stabilizer, and the extent to which firms have to adjust the labor utilization rate is lessened. The direct consequence of real wage flexibility, thus, is a stabilized goods market.

Subsequent short–run processes are straightforward. Since λ increases less than a rigid real wage regime, so does the growth rate of employment although it is still positive. The second round starts, repeating this process until $\hat{L}$ hits the maximum upper limit and the dynamics are reversed towards a recession. In a recession, variables move in the exact opposite direction. When a new limit cycle is eventually obtained, this downward spiral will be terminated perpetuating regular dynamic movements.

2.4 The U.S. Labor Market during the Great Moderation and Great Recession

Table 2.1 summarizes four conceivable labor markets differing in the extent of flexibility in both employment and real wage. Flexibilization of a labor market can refer to a transition from Type I to IV in which both dimensions of flexibility operate simultaneously while the clout of labor unions at the bargaining table is degraded. Of course, contingent on the existence of the social agreement or conflict, remaining in either Type II or III is also possible.

Table 2.1: Labor Market Flexibilities and Types of Labor Markets

	Rigid Real Wage	Flexible Real Wage
Rigid Employment	(Type I) h_λ, $\lvert h_e\rvert$, β, γ	(Type II) h_λ, $\lvert h_e\rvert$, $\beta\uparrow, \gamma\uparrow$
Flexible Employment	(Type III) $h_\lambda\uparrow$, $\lvert h_e\rvert\downarrow$, β, γ	(Type IV) $h_\lambda\uparrow$, $\lvert h_e\rvert\downarrow$, $\beta\uparrow, \gamma\uparrow$

In section 2.2, the simulation shows that flexible employment destabilizes the economy. The simulation in section 2.3, on the other hand, suggests that flexible real wage stabilizes the economy. If both aspects of flexibility are operating simultaneously, whether the economy becomes stable or not will depend on their relative strengths.

In this section, I will estimate the employment expansion function and real wage Phillips curve for the U.S. economy, which can help illustrate the transitions of U.S. labor market since the 1980s. (See Appendix E for data sources). The employment expansion function to be estimated is:

$$\hat{L} = \frac{0.4}{1 + exp(-15((1+\eta_1)\lambda - 0.6 + 0.1(1+\eta_2)ln(1-e)))} - 0.07 \qquad (2.15'')$$

Since the function (2.15″) is nonlinear, a nonlinear least squares (NLLS) regression is conducted. Unlike linear least squares, NLLS algorithms require specification of the starting values for the parameters. We can compute starting values using the ordinary least squares (OLS) regression (Fox and Weisberg, 2010). The OLS specification for this purpose is:

$$\hat{L}_t = a_0 + a_1\lambda'_{t-1} + a_2 ln(1 - e_{t-1}) + a_3 GM\lambda'_{t-1} + a_4 GMln(1 - e_{t-1}) + \varepsilon_t \qquad (2.29)$$

where $\hat{L}$ is the growth rate of employment; λ, labor productivity; e, the employment rate; GM, a dummy for the Great Moderation (1984:1–2007:4); ε, an error term.

In this section, the variable with prime (′) denotes a detrended series. Detrended labor productivity, $\lambda'(= \lambda - \lambda^*)$, can be interpreted as the utilization rate of labor in which secular growth in labor productivity due to technical changes is abstracted away. The dummy variable GM interacts with both the labor utilization rate and log of the unemployment rate to capture changes in the sensitivities of the employment expansion function (η_1 and η_2 in (2.15″)).

The estimates from the specification (2.29) in which GM interacts with λ'_{t-1} and $ln(1 - e_{t-1})$ are reported in column (1) of Table 2.2. In column (2), estimates using the specification in which GR—dummy for the Great Recession (2008:1–2015:2)—interacts with λ'_{t-1} and $ln(1 - e_{t-1})$ are reported. In the specification for column (3), both GM and GR interact.

Table 2.2: The Estimates for the Employment Expansion Function ($\hat{L}_t$)

	(1) OLS	(2) OLS	(3) OLS	(4) NLLS	(5) NLLS	(6) NLLS
λ'_{t-1}	0.012***	0.007***	0.012***	1.474***	0.773***	1.353***
	(0.002)	(0.001)	(0.002)	(0.202)	(0.128)	(0.187)
$ln(1-e_{t-1})$	0.004***	0.002*	0.003***	0.463***	0.223*	0.370***
	(0.001)	(0.001)	(0.001)	(0.141)	(0.128)	(0.130)
GMλ'_{t-1}	-0.010***		-0.010***	-1.241***		-1.113***
	(0.002)		(0.002)	(0.275)		(0.255)
GM$ln(1-e_{t-1})$	-0.001		-0.001	0.064		-0.063
	(0.000)		(0.000)	(0.043)		(0.040)
GRλ'_{t-1}		-0.001	-0.006**		-0.170	-0.778***
		(0.002)	(0.003)		(0.257)	(0.288)
GR$ln(1-e_{t-1})$		-0.002***	-0.002***		-0.219***	-0.270***
		(0.001)	(0.001)		(0.056)	(0.058)
Constant	-0.002	0.001	-0.001	-0.597**	-0.073	-0.269
	(0.002)	(0.002)	(0.002)	(0.236)	(0.218)	(0.217)
Observations	240	270	270	240	270	270
Adj. R-sq.	0.21	0.17	0.23			

*** p<0.01, ** p<0.05, * p<0.1

Notes: The dependent variable is the growth rate of employment ($\hat{L}_t$); λ: labor productivity; e: employment rate; GM: dummy for the Great Moderation (1984:1–2007:4); GR: dummy for the Great Recession (2008:1–2015:2); standard errors in parentheses; ($'$) indicates a detrended series; (1) and (4) use samples of 1948:2–2007:4. (2), (3), (5) and (6) use samples of 1948:2–2015:2.

Then, as discussed, the OLS estimates in (1), (2) and (3) can be used as the initial values of the NLLS counterparts. The NLLS specification with the dummy for the Great Moderation is:[21]

$$\hat{L}_t = \frac{A}{1 + exp[-(b_0 + b_1\lambda'_{t-1} + b_2 ln(1-e_{t-1}) + b_3 GM\lambda'_{t-1} + b_4 GMln(1-e_{t-1}))]} + B + \varepsilon_t \tag{2.30}$$

Column (4) in Table 2.2 reports the coefficients of the specification (2.30). Columns

[21] 'A' represents the difference between the upper and lower bounds of $\hat{L}_t$. 'B' is the lower bound of $\hat{L}_t$. These values can be calculated from the sample.

(5) and (6) report estimates using specifications with GR and both GM and GR, respectively, which are counterparts of (2) and (3). By plugging these coefficients into (2.15″), we get estimated employment expansion functions for specifications (4), (5) and (6), from which h_λ and h_e can be determined using calculus. I evaluated these sensitivities at the sample means of λ' and $ln(1-e)$. Table 2.3 reports the calculated h_λ and h_e for three time horizons: 1948:2-1983:4, 1984:1-2007:4 and 2008:1-2015:2.

Table 2.3: Estimated h_λ and h_e from Nonlinear Least Square Regression

	(4)	(5)	(6)
	NLLS	NLLS	NLLS
h_λ (1948:2-1983:4)	0.0127***		0.0125***
	(0.0001)	0.0072***	(0.0012)
h_λ (1984:1-2007:4)	0.0020***	(0.0009)	0.0022***
	(0.0005)		(0.0007)
h_λ (2008:1-2015:2)		0.0057***	0.0055***
		(0.0006)	(0.0019)
h_e (1948:2-1983:4)	-0.0040***		-0.0034***
	(0.001)	-0.0020*	(0.0014)
h_e (1984:1-2007:4)	-0.0035***	(0.0013)	-0.0028**
	(0.001)		(0.0016)
h_e (2008:1-2015:2)		-0.00004	-0.0009**
		(0.001)	(0.0005)

*** p<0.01, ** p<0.05, * p<0.1

Notes: Standard errors are obtained using the delta method.

The first finding is that, from pre–1984 to the Great Moderation, h_λ was reduced by 82.4% (from 0.0125 to 0.0022), which can be interpreted as an operation of the labor hoarding mechanism despite a weakened EPL. A possible explanation for this reduction is that, during the Great Moderation, employment flexibility and real wage flexibility were complementary to a certain degree (Abbritti and Weber, 2010; Galí and van Rens, 2010). Thus, firms need not lay off workers as much as they needed in a recession since they had other options of adjusting real wages of workers. This supplementary relationship ended, however, at the onset of the Great Recession. Even though h_λ decreased by 56% (from 0.0125 to 0.0055) compared to pre–1984 level, it more than doubled compared to during the Great Moderation.

Second, the relative surplus labor effect measured by the absolute value of h_e decreased after 1984. In panel (6) of Table 2.3, for example, it was reduced by 17.6% (from 0.0034 to 0.0028) in the Great Moderation compared to pre–1984 which corresponds to the benchmark case in the theoretical part. Further reduction— −73.5% (from 0.0034 to 0.0009) compared to pre–1984—occurred during the Great Recession. The basic findings in estimating the employment expansion function are summarized in Table 2.5.

Estimating the real wage Phillips curve is not as neat as estimating the employment expansion function while encountering the similar problems discussed in the Phillips curve literature. The real wage Phillips curve to be estimated is:

$$\hat{w} = -\theta(w - \alpha_o) - (\beta + \nu_1)\sigma + (\gamma + \nu_2)e \tag{2.31}$$

The main difference between the equation (2.24)—derived from the theory of conflicting claims (Rowthorn, 1977; Myatt, 1986)—and the traditional Phillips curve is the inclusion of a term explaining firms' mark–up ability as one of the explanatory variables (the second term in (2.31)). Conventional approach in the Phillips curve literature is assuming a constant mark–up. Under this assumption, wage pressures will be proportionally passed on to the mark–up price. However, this harmonized view disagrees with the perspective of the conflict claim model in which the growth rate of real wages is determined by two conflicting forces and their relative influences. To estimate firms' mark–up ability, I use both output gap (detrended real GDP) and the Federal Reserve's capacity utilization as proxy variables for the utilization rate of capital (σ) on which the mark–up rates supposedly depend. The specification for estimating real wage Phillips curve is:

$$\hat{w}_t = c_0 + c_1 \Delta w_{t-1}^{(4)} + c_2 y_t' + c_3 e_t' + c_4 GMy_t' + c_5 GMe_t' + c_6 F\&E_t + c_7 \Delta\lambda_t' + c_8 uc_{t-1}' + \varepsilon_t \tag{2.32}$$

where $\hat{w}$ is the growth rate of real wage; y, output (or capacity utilization); F&E, food–energy effect; uc, unit labor cost.

The lagged dependent variable $\Delta w^{(4)}$ is a 4 quarters moving average of changes in real wages as a smoother alternative indexing variable in a similar fashion to Galí (2010). Following Gordon (1997)'s triangle method, inclusion of F&E allows capturing supply shocks. F&E is defined as the difference between the rates of change in the overall PCE deflator and the core PCE deflator. $\Delta\lambda'$ is to capture the effect of labor productivity on the growth rate of real wage. I also control the previous (detrended) level of unit labor cost uc_{t-1}' following Lown and Rich (1997) who found that incorporating labor costs into the model explains the lack of inflationary pressures at low rates of unemployment between 1990 and 1995.

Table 2.4 reports the estimates for the real wage Phillips curve from OLS regressions. The regressions (1)–(4) use real GDP to obtain the coefficient capturing the influence of mark–up pricing on the growth rate of real wage whereas (5) and (6) use the capacity utilization. The starting year for the regressions (1)–(4) is 1959:4 since the series for the F&E is attainable only from that point in time. Similarly, the starting year for regressions (5) and (6) is 1967:2, the earliest year that the capacity utilization rates series is available.

Table 2.4: The Estimates for the Real Wage Phillips Curve ($\hat{w}_t$)

	(1)	(2)	(3)	(4)	(5)	(6)
	y = Output				y = Capacity Utilization	
$\Delta w^{(4)}_{t-1}$	88.356***	93.015***	94.429	96.922***	89.381***	86.373***
	(10.702)	(10.569)	(10.712)	(10.418)	(11.629)	(11.640)
y'_t	-0.190***	-0.387***	-0.183**	-0.470***	-0.066	-0.075
	(0.063)	(0.117)	(0.071)	(0.126)	(0.047)	(0.047)
e'_t	0.380***	0.428***	0.330**	0.438**	0.090	0.146
	(0.119)	(0.155)	(0.133)	(0.172)	(0.202)	(0.202)
GMy'_t		0.160		0.274*	-0.085	-0.078
		(0.137)		(0.152)	(0.072)	(0.071)
GMe'_t		0.254		0.220	0.510*	0.486*
		(0.232)		(0.262)	(0.283)	(0.281)
GRy'_t			0.037	0.239	-0.016	0.003
			(0.120)	(0.145)	(0.069)	(0.069)
GRe'_t			0.559*	0.760**	0.636**	0.647**
			(0.301)	(0.308)	(0.307)	(0.305)
F&E$_t$	-0.987***	-0.859***	-1.145***	-1.027***	-1.086***	-1.103***
	(0.167)	(0.168)	(0.159)	(0.157)	(0.169)	(0.168)
$\Delta\lambda'_t$	0.400***	0.465***	0.287***	0.369***		0.185*
	(0.090)	(0.092)	(0.089)	(0.090)		(0.094)
uc'_{t-1}	-0.211***	-0.289***	-0.327***	-0.423***	-0.359***	-0.383***
	(0.043)	(0.050)	(0.045)	(0.051)	(0.052)	(0.053)
Constant	0.059	0.027	0.044	0.018	0.052	0.061
	(0.052)	(0.052)	(0.051)	(0.050)	(0.054)	(0.054)
Observations	193	193	223	223	193	193
Adj. R-Sq.	0.47	0.50	0.49	0.52	0.48	0.49

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Notes: The dependent variable is the percentage growth rate in real wage ($\hat{w}_t$); $\Delta w^{(4)}$: 4 quarters moving average of changes in real wage; y: output in (1)–(4), capacity utilization in (5)–(6); e: employment rate; GM: dummy for the Great Moderation (1984:1–2007:4); GR: dummy for the Great Recession (2008:1–2015:2); F&E: food–energy effect; $\Delta\lambda'$: changes in the detrended labor productivity; uc: unit labor cost; standard errors in parentheses; ($'$) indicates a detrended series

First, let's examine regressions (1)–(4) in which output gap is used as a proxy variable for the utilization rate of capital. Several findings can be highlighted. The signs of the coefficients of both output gap (y'_t) and employment rate gap (e'_t) support the supposed property of the conflict claim model. In addition, the coefficients for the three controls—F&E$_t$, $\Delta\lambda'_t$ and uc'_{t-1}—are significant showing expected signs.

Concerning the two sensitivities of interest regarding real wage flexibility in Definition 3, the coefficients of $\mathrm{GM}y_t'$ and $\mathrm{GR}y_t'$ which represent the changed impact of mark–up pricing on the growth of real wage do not support the direction of changes in parameters β in the manner assumed in the theoretical part of this paper. First of all, the coefficients from all but one of the regressions are not significant. Second, the signs from the regressions (1)–(4) are not negative, refuting the expectation elicited by theoretical part. Of course, the signs become negative if the capacity utilization is used for the proxy variables in regressions (5) and (6). Nevertheless, the issue of significance still remains.

This unsatisfactory result from the estimates for mark–up pricing can be ascribed to the difficulty in finding a relevant proxy variable for the rate of capital utilization. Particularly, in research including any sensitive quantitative analysis such as using an interaction dummy, it is likely that output gap failed to fulfill the requirements as a good proxy variable. In addition, theories on mark–up pricing are one of the unclear areas in macroeconomics partly because firms' mark–up pricing is not directly observable by macroeconomic data (Blanchard, 2008). However, there have been a number of studies showing procyclicality in mark–up pricing using industry and firm level data (Haskel et al., 1995; Morrison, 1994; Chirinko and Fazzari, 1994).[22]

By contrast, the coefficients of $\mathrm{GM}e_t'$ and $\mathrm{GR}e_t'$ which represent the changed impact of workers' nominal wage adjustment on the growth of real wage are increased. Concretely, in regression (4), the coefficient of $\mathrm{GM}e_t'$ is 0.220—though it is not significant—meaning that the coefficient for the employment rate is increased by 0.220 (from 0.438) in the Great Moderation. Moving on to regressions (5) and (6), the coefficients become significant at the 10% significance level. For the Great Recession, however, all these coefficients are unambiguously and significantly increased.

[22]Nekarda and Ramey (2011) discuss the theoretical flaws in the papers asserting countercyclical markups.

Table 2.5: Summary of Estimates for the U.S. Labor Market

	(A) pre–1984	(B) GM	(C) GR	(B) – (A) Changes in GM	(C) – (B) Changes in GR
h_λ	0.0125***	0.0022***	0.0055***	-0.0103***	0.0033*
	(0.0012)	(0.0007)	(0.0019)	(0.0014)	(0.0020)
$\lvert h_e \rvert$	0.0034***	0.0028**	0.0009**	-0.0006	-0.0019
	(0.0014)	(0.0016)	(0.0005)	(0.0021)	(0.0017)
β	0.470***	0.196	0.231	-0.274	0.035
	(0.126)	(1.307)	(0.864)	(1.313)	(1.567)
γ	0.438**	0.658	1.198***	0.220	0.540
	(0.172)	(0.614)	(0.480)	(0.638)	(0.779)

*** p<0.01, ** p<0.05, * p<0.1

For instance, in regression (4), the coefficient is increased by 0.760 (from 0.438). This result is in accordance with the literature on the wage Phillips curve which points out recent increases in the responsiveness of the employment rate on wage (Gallegati et al., 2011; Galí, 2010).

Table 2.5 summarizes the main estimates elicited by Table 2.3 and 2.4. From Table 2.3, I used the estimates from regression (6) to obtain h_λ and $|h_e|$ for three periods. From Table 2.4, the results from specification (4) are reported to obtain β and γ. The upper panel is the summary for the parameters relating to employment flexibility; the lower, flexible real wage.

The most important finding from the empirical work of this section is that, while the relative surplus labor effect has consistently weakened since 1984, labor hoarding did not weakened during the Great Moderation. A possible explanation is that employment flexibility and real wage flexibility were complementary to a certain degree in this period. In contrast, the labor hoarding effect has significantly weakened in the Great Recession. To sum up, the empirical results in Table 2.5 suggest that, *during the Great Moderation, real wage flexibility combined with less degree of employment flexibility played a major role in stabilizing the economy; during the Great Reces-*

sion, strong employment flexibility dominating real wage flexibility has contributed to destabilizing the economy.

Before closing this section, I will conduct a simulation for the U.S. economy based on the regression results. Table 2.6 reports percentage changes in coefficients calculated from the numbers in Table 2.5. Since the estimates for the changes in β are ambiguous as previously discussed, both procyclical and acyclical cases of mark–up pricing will be considered. When mark–up is assumed to behave procyclically, the degree of changes is set to equal that of γ. When mark–up is acyclical, changes in β are zero.

Table 2.6: Percentage Changes of Coefficients from the Coefficient for pre–1984

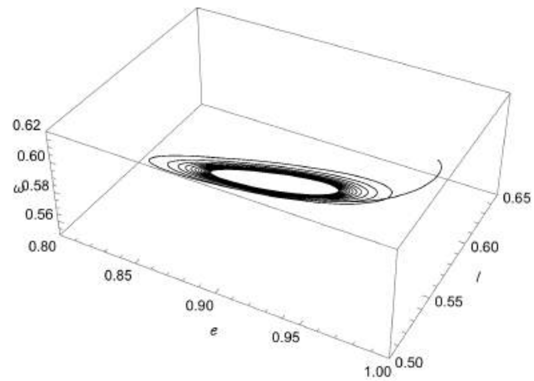
	Δh_λ	$\Delta\|h_e\|$	$\Delta\beta$ (procyclical)	$\Delta\beta$ (acyclical)	$\Delta\gamma$
Great Moderation	-82.4%	-17.6%	50.2%	0%	50.2%
Great Recession	-56.0%	-73.5%	173.5%	0%	173.5%

Figure 2.10 presents a simulation for the Great Moderation using the calibrated values in Table 2.6. Panel (a) is the benchmark case which is identical to panel (a) in Figure 2.8. From this benchmark, I changed the parameters using the rates of changes suggested by Table 2.6. Regardless of the patterns of mark–up pricing, panels (b) and (c) clearly shows a more stabilized limit cycle compared to the benchmark case. As we examined in sections 2.2 and 2.3, this stabilizing force during the Great Moderation is mainly driven by real wage flexibility which overwhelms the destabilizing force of flexible employment. Of course, the complementarity between two aspects of flexibility should not be overlooked.

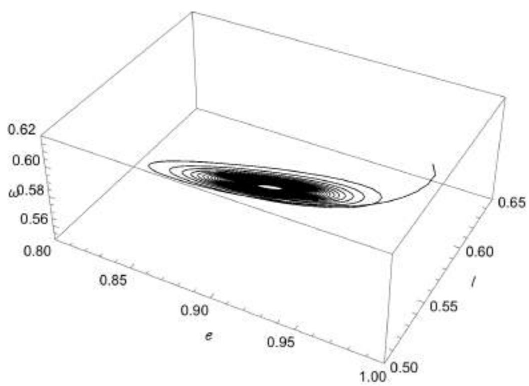
The amplitude of the limit cycle for the Great Recession—with the numbers suggested in Table 2.6—is somewhere between the benchmark case and the cases of the

Figure 2.10: Simulation for the Great Moderation

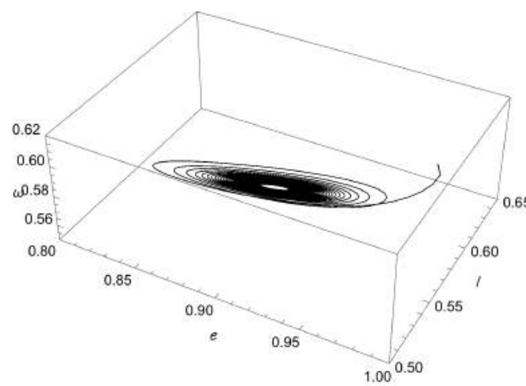
(a) Benchmark Case



(b) Great Moderation
(Procyclical Mark–up)



(c) Great Moderation
(Acyclical Mark–up)



Great Moderation. However, the simulation result for the Great Recession is not reported here since a simple comparison of amplitudes, ignoring the huge external factor that destabilized the economy to a level unprecedented since the Great Depression, is not meaningful. In addition, it is readily seen that over the course of the Great Recession, macroeconomic variables have fluctuated asymmetrically: the abrupt parametric changes took place mostly in the early phase of the Great Recession which was followed by a prolonged recovery. In this case, the actual amplitude of the cycle can far exceed the amplitude obtained from a simulation using the numbers in Table 2.6.

2.5 Concluding Remarks

Since the 1990s, OECD and IMF have recommended implementing structural reform of the labor market for countries undergoing economic hardships. Flexibilization of employment and real wages were the core components of this reform.[23] Based on these guidelines, some countries that had already accomplished a certain level of labor market flexibility—such as the U.S. and Netherlands—undermined their EPL further.

After experiencing almost two decades of unprecedented macroeconomic stability, economists have tried to link the flexible labor market with macroeconomic stability. Most theories have emphasized the supply–side aspect of the flexible labor market as a mitigator of external shocks.

In this paper, I explored the dynamic impact of employment flexibility such as weakened EPL (supply side) on macroeconomic stability via the channel of distribution (demand side). I also investigated the impact of real wage flexibility on the economic stability by incorporating into the model real wage dynamics which determines the distribution mechanism. Simulation results of the model show that employment flexibility increases instability of an economy whereas real wage flexibility reduces it. Empirical results based on the theoretical model suggest that during the Great Moderation, real wage flexibility played a major role in stabilizing the U.S. economy. By contrast, employment flexibility has contributed to destabilize the economy during the Great Recession.

This finding questions a policy recommendation based on the viewpoint that weakening the protection of workers (employment flexibility) is a necessary condition for macroeconomic stability.[24] In the course of a recession, for example, whether the

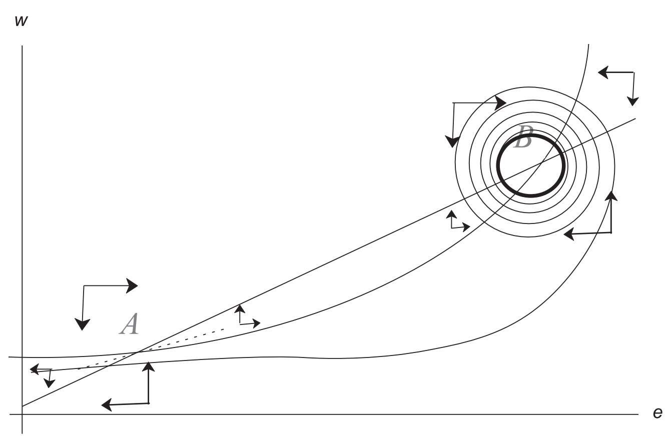
[23]"Wage and labor costs: Make wage and labor costs more flexible by removing restrictions that prevent wages from reflecting local conditions and individual skill levels, in particular of younger workers; employment protection legislation: Reform employment security provisions that inhibit the expansion of employment in the private sector" (OECD, 1997).

[24]The sluggish recovery process in the U.S. economy during the Great Recession also underpins this question. Burda and Hunt (2011); Rinne and Zimmermann (2011) contrast the rapid recovery

reaction of the labor market is mainly from real wage (w) or employment (L) has different effects on macroeconomic stability. If stabilizing an economy is most relevant, labor market policy should emphasize a flexible real wage which can function as an automatic stabilizer.

Concerning an additional connection of the flexible labor market and the Great Recession, a possible outcome of the flexible labor market— if the degree of flexibilities either in employment or real wage (or both) rises over a certain threshold—is the existence of multiple equilibria that we discussed in Proposition 2. Figure 2.11 illustrates the phase diagram of panel (b) in Figure 2.7 and the possibility of multiple equilibria.

Figure 2.11: Multiple Equilibria and Possible Bad Outcome



process in Germany during the Great Recession. According to them, the difference can be attributed to reactions in the labor market: despite huge drops in the GDP surpassing even those in the U.S, Germany protected its labor market from major disruption through its ‘short–time compensation program’ and ‘working time accounts’ in collective agreements wherein firms were encouraged to cut hours rather than jobs.

As the phase diagram suggests, point A is unstable while B is stable. In this circumstance, the economy hover around point B showing a limit cycle. However, once multiple equilibria emerge, the economy can easily plunge into recession by any external force that leads the economy to the saddle path around point A, which could make the recovery process more expensive. Accordingly, the possibility of multiple equilibria can be considered another dimension of instability introduced by flexibilzation of the labor market. This *flexibility trap* can possibly explain the delayed recovery in the U.S. labor market over the course of the Great Recession.

I conclude this paper by mentioning some limitations of this paper. First, this paper left out other important factors that might have influenced the stability of the U.S. economy such as the monetary policy based on the Taylor rule, stabilized foreign sectors, and others. The influence of the labor market on stability should be regarded as one of factors.

Second, this paper, focusing on short–run variation in the utilization rate of labor, did not consider changes in labor productivity caused by technical changes. As mentioned in the introduction, the impact of the flexible labor market on technical changes and economic growth is one of the issues up for debate. For complete evaluation of the labor market policy promoting flexibility, the growth issue should not be ignored.

CHAPTER 3

DOES LABOR MARKET FLEXIBILITY STABILIZE AN ECONOMY?: A STRUCTURAL VAR APPROACH

3.1 Introduction

In a series of research papers on the Great Moderation, labor market flexibility has been regarded as an important factor that mitigates macroeconomic shock, hence, contributing to macroeconomic stability (Burnside et al., 1990; Galí and Gambetti, 2009). On the other hand, different recovery processes in the U.S. and Germany during the Great Recession have raised questions about the positive role of a flexible labor market on macroeconomic stability. Despite Germany having experienced a sharper drop in real GDP than the U.S. or U.K. where the labor market is more flexible, its recovery in real GDP was much quicker than either Anglo–Saxon country (Burda and Hunt, 2011). The progress in the reduction of the German unemployment rate was even more striking. In contrast to the U.S. and U.K., a huge jump in the unemployment rate was not seen.

In response to this so-called German labor market 'miracle', some economists point out that the stabilizing outcome was actually due to the Hartz reform package approved in 2002–03 and implemented gradually by 2005, which has steered the German labor market toward a more flexible one (Fujita and Gartner, 2014). However, most research on this issue attributes this German outperformance to an active labor market policy such as the short-time compensation program supported by the German government or the working time account crafted through collective agreements (Burda and Hunt, 2011). According to the latter view, a flexible labor market—especially in the form of flexible hiring and firing processes prevailing in the U.S.—does not stabilize an economy.

Then, how can we reconcile these two different understandings regarding the flexible labor market and its impact on macroeconomic stability? Considering two aspects of labor market flexibility, employment flexibility and real wage flexibility, Oh (2016, chapter 2 of this dissertation) constructed a dynamic model using the flex–output model and the real wage Phillips curve. Simulations of this model showed that employment flexibility destabilizes an economy, whereas real wage flexibility stabilizes it. Proposing a hypothesis that real wage flexibility played a major role in stabilizing U.S. economy during the Great Moderation and that employment flexibility has contributed to destabilizing the economy during the Great Recession, in the empirical part of Oh (2016), I estimated two crucial behavioral functions: the employment expansion function and the real wage Phillips curve. Empirical results showed that labor hoarding was not weakened during the Great Moderation, suggesting that employment flexibility may not have played a major role. On the other hand, estimation for the real wage Phillips curve confirms that real wages have become more flexible since 1984.

However, empirical evidence for the hypothesis in Oh (2016) is provisional in that it examined only the properties of the transitions in behavioral functions by estimating the parameters for each period. It did not explore any dynamic interactions between the variables of the labor market and the variables of the goods market.

The main purpose of this paper is to provide more rigorous empirical evidence to support the hypothesis of Oh (2016) using a VAR analysis which is helpful in examining the dynamic interactions among variables. In particular, the impulse response functions enable us to trace overtime impacts of institutional changes on macroeconomic stability.

In the post–Keynesian literature, the VAR method has been used in several studies on the business cycle or economic growth (Barbosa-Filho and Taylor, 2006; Stockhammer and Onaran, 2004; Onaran and Stockhammer, 2005). In those studies, however, a critical mismatch between theory and empirical methodology exists. The theories premise not a business cycle frequency but a medium-run cycle—such as a Goodwin cycle—or long-run economic growth. On the other hand, VAR methodology in which knowledge of long-run trends in variables should be muted for the sake of acquiring stationary series is suited to short-run analysis.[1] In this respect, applying VAR to Oh (2016) is particularly relevant since the theoretical presumption of the time horizon in Oh (2016) is exactly the business cycle frequency. I adopted *structural* VAR in which economic theory is used to recover structural innovations from the residuals.

This paper is structured as follows. In section 3.2, the theoretical model in Oh (2016) is briefly summarized. In section 3.3, I construct a 4–variable structural VAR system based on the theoretical model illustrated in section 3.2. I also discuss the hypotheses that will be tested. Section 3.4 explains data and provides diagnostic tests. Section 3.5 presents the empirical results. Section 3.6 concludes.

3.2 Flex–output Model and Real Wage Phillips Curve

In this section, the theoretical model in Oh (2016) is summarized. In accordance with the flex–output model developed by Skott (2015), output level is determined by a fixed coefficient production function:

$$Y_t = min\{\lambda_t L_t, \sigma_t K_t\}; \qquad \lambda_t = Y_t/L_t \leq 1, \quad \sigma_t = Y_t/K_t \leq \sigma^{max} \tag{3.1}$$

where Y is real gross output; L is employment; K is capital stock; σ^{max} is maximum utilization rate of capital; σ is actual utilization rate of capital; λ is actual utilization

[1] If a long-run relationship between variables should not be ignored, implementing a cointegration model such as a vector error correction model (VECM) can be considered.

rate of labor.

In addition, the flex–output model consists of the following six equations:[2]

$$S_t = Y_t g(\pi(\lambda_t, w_t)); \qquad g_\lambda > 0, \quad g_w < 0 \tag{3.2}$$

$$I_t = L_t f(l_t); \qquad f_l > 0 \tag{3.3}$$

$$\hat{K}_t = I_{t-1}/K_{t-1} \tag{3.4}$$

$$\hat{e}_t = \hat{L}_t - n \tag{3.5}$$

$$\hat{L}_t = h(\lambda_{t-1}, e_{t-1}); \qquad h_\lambda > 0, \quad h_e < 0 \tag{3.6}$$

$$I_t = S_t \tag{3.7}$$

where e is employment rate; π is profit share; I is gross investment in real terms; n is growth rate of population; w is real wage.

In the *ultra short–run*, it is difficult to promptly adjust employment (L_t) and the stock of capital (K_t) but output (Y_t) is flexible. It is the utilization rate of labor (λ_t=Y_t/L_t) that adjusts for the ultra short–run disequilibrium in the goods market. In short, the jump variable in the flex–output model is not price or inventory as proposed in most theories but λ_t. Solving (3.2), (3.3) and (3.7) with respect to the

[2]See Oh (2016) for detailed explanations of these functions.

utilization rate of labor (λ_t) yields a function of the jump variable adjusting for the disequilibrium in the goods market:

$$S_t/K_t = \lambda_t l_t g(\pi(\lambda_t, w_t)) = l_t f(l_t) = I_t/K_t$$

$$\lambda_t = \lambda(l_t, w_t); \qquad \lambda_l > 0, \quad \lambda_w > 0 \tag{3.8}$$

where $l(= L/K)$ is labor capital ratio.

However, in the *short–run*, intensity cannot be raised infinitely. Firms have to expand employment to meet demand following the employment expansion function (3.6). Replacing λ_{t-1} in (3.6) with (3.8) and plugging it into both the law of motion of l ($\hat{l} = \hat{L} - \hat{K}$) and (3.5), two dynamic equations of l and e are obtained:

$$\hat{l}_t = h(\lambda(l_{t-1}, w_{t-1}), e_{t-1}) - l_{t-1} f(l_{t-1}) \tag{3.9}$$

$$\hat{e}_t = h(\lambda(l_{t-1}, w_{t-1}), e_{t-1}) - n \tag{3.10}$$

To investigate the impact of real wage flexibility, following Flaschel and Krolzig (2006), I induced a real wage Phillips curve in which the growth rate of real wage is determined mainly by two conflicting factors—firms' mark up pricing (second term) and workers' nominal wage adjustment (third term):

$$\hat{w}_t = -\theta(w_{t-1} - \alpha_o) - \beta\lambda(l_{t-1}, w_{t-1}) l_{t-1} + \gamma e_{t-1} \tag{3.11}$$

The dynamic equations (3.9), (3.10) and (3.11) along with the equation (3.8) will be used to constitute a VAR system in section 3.3. Before that, I will discuss the definitions of flexible employment and flexible real wage, in turn, and their macroeconomic impacts discussed in Oh (2016).

3.2.1 Employment and Real Wage Flexibilities

Flexible employment is related to changed parameters in the employment expansion function (3.6) specifying firms' behavior in deciding the size of employment. Two variables influence firms' decisions. The first variable is the utilization rate of labor by which firms get a signal for the goods market. If the utilization rate of labor, say, increases, firms will hire more workers to meet the expanded demand in the goods market. This adjustment of labor is not one–on–one to changes in output since firms have to consider firing costs when the economy rebounds. However, under a flexible employment regime, since reduced frictions in the labor market relieve firms concerns, firms can adjust their employment more actively than previously. Thus, the first element of flexible employment is *weakened labor hoarding*: increased responsiveness of employment to changes in the utilization rate of labor ($h_\lambda \uparrow$).

The second variable that affects firms' decisions on the size of employment is the employment rate which represents a signal from the labor market. If the employment rate is, say, high, firms have an incentive to reduce employment to mollify employees' militancy. However, under a flexible labor market, since the overall bargaining position of employees has deteriorated, firms need not worry much about the high rate of employment in a boom. Hence, the second element of flexible employment is *weakened reserve army of labor effect* ($|h_e| \downarrow$).

Moving on to real wage flexibility, flexible real wage means prompt responses in real wage growth to changes in the business environment. In the real wage Phillips curve (3.11), this prompt response can be expressed by increased parameters for the second and third terms: the first element of real wage flexibility is *more active firms'* *mark–up pricing* ($\beta \uparrow$); the second element is *more active workers' nominal wage adjustment* ($\gamma \uparrow$).

A caveat in interpreting these parametric changes is that it is not a one-time shock as the exogenous business cycle theory supposes.[3] Rather, changed responsiveness lasts as long as a new labor market institution continues, and until it is replaced by another type. In the meantime, this parametric *transition* changes the stability of an economy by affecting the endogenous relationships among variables.

In Oh (2016), I estimated these parametric changes to show that during the Great Moderation, labor hoarding was not weakened suggesting that employment flexibility may not have played a major role while the parameters relating to real wage flexibility have been moving in the direction of flexibility since 1984. On the other hand, the results for the Great Recession suggest that both types of flexibility have been operating simultaneously. I thereby made the tentative conclusion that, during the Great Moderation, real wage flexibility has played a major role in stabilizing U.S. economy; during the Great Recession, employment flexibility has contributed to destabilizing the economy.

It is tentative in that, although proving the transitional aspects in the behavioral functions, the empirical work in Oh (2016) does not explore the dynamic interactions between the labor market and the goods market. The core question is, how can a destabilized labor market end up as a stabilized goods market during the Great Moderation? The answer elicited by my theory lies in the role of real wage flexibility as an automatic stabilizer. In the next section, I will attempt to answer this by carrying out a structural VAR analysis. This exercise would make the tentative conclusion of Oh (2016) more sound.

[3]Note that "the endogenous view of cycles does not preclude external shocks, and the introduction of shocks may remove the regularity without affecting the underlying cyclical mechanism. Deterministic, nonlinear dynamic models can produce 'chaotic' outcomes that are hard to distinguish from those of a stochastic model" (Skott, 2011).

3.3 Structural VAR Model

For the extended empirical study of Oh (2016), conducting a structural VAR rather than a recursive VAR is more relevant for the following reasons. First, despite its simplicity, Sims (1980)' VAR approach using a restriction with a Choleski decomposition has been criticized as being devoid of any economic content (Enders, 2010). Second, the theory in Oh (2016) requires a distinction between the *ultra* short–run and short–run relationships among variables. This paper regards the ultra short–run relationship to be a very quick, contemporaneous response but the short–run relationship to be a lagged response. Put another way, it is assumed that a jump variable appearing as a dependent variable in a dynamical system has contemporaneous relationships with (some) independent variables; a state variable appearing as a dependent variable has (only) lagged relationships with independent variables. These reasons being considered, a structural VAR model is adopted to deal with the empirical questions in this paper.

3.3.1 Empirical Specification and Identification

Based on theory, we have the equation (3.8) for the jump variable and three dynamic equations (3.9)–(3.11) for the state variables. Assume that the selected lag length for this VAR system is 2 which applies in our case as will be discussed later. First, (3.8) can be specified as follows:

$$\lambda_t = c_1 + b_{12} l_t + b_{14} w_t + \pi_{12} l_{t-1} + \pi_{14} w_{t-1} + \theta_{12} l_{t-2} + \theta_{14} w_{t-2} + \varepsilon_{\lambda t} \tag{3.12}$$

As discussed above, the independent and dependent variables have contemporaneous relationships as well as lagged relationships. The empirical specifications for equations (3.9)–(3.11) are as follows:

$$l_t = c_2 + \pi_{21}\lambda_{t-1} + \pi_{22}l_{t-1} + \pi_{23}e_{t-1} + \theta_{21}\lambda_{t-2} + \theta_{22}l_{t-2} + \theta_{23}e_{t-2} + \varepsilon_{lt} \tag{3.13}$$

$$e_t = c_3 + \pi_{31}\lambda_{t-1} + \pi_{33}e_{t-1} + \theta_{31}\lambda_{t-2} + \theta_{33}e_{t-2} + \varepsilon_{et} \tag{3.14}$$

$$w_t = c_4 + \pi_{42}l_{t-1} + \pi_{43}e_{t-1} + \pi_{44}w_{t-1} + \theta_{42}l_{t-2} + \theta_{43}e_{t-2} + \theta_{44}w_{t-2} + \varepsilon_{wt} \tag{3.15}$$

Note that, as discussed, the contemporaneous correlations do not exist in these equations and that the dependent variables are affected only by the independent variables with time lag.

It is assumed that all ε_s are white-noise disturbances and are not correlated with each other. Collecting the 4 variables in the (4×1) vector x_t,

$$x_t = \begin{bmatrix} \lambda_t \\ l_t \\ e_t \\ w_t \end{bmatrix},$$

the primitive (structural) VAR can be constructed as

$$Bx_t = C + \Pi x_{t-1} + \Theta x_{t-2} + \varepsilon_t \tag{3.16}$$

$$
\begin{bmatrix} 1 & -b_{12} & 0 & -b_{14} \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}
\begin{bmatrix} \lambda_t \\ l_t \\ e_t \\ w_t \end{bmatrix}
=
\begin{bmatrix} c_1 \\ c_2 \\ c_3 \\ c_4 \end{bmatrix}
+
\begin{bmatrix} \pi_{11} & \pi_{12} & \pi_{13} & \pi_{14} \\ \pi_{21} & \pi_{22} & \pi_{23} & \pi_{24} \\ \pi_{31} & \pi_{32} & \pi_{33} & \pi_{34} \\ \pi_{41} & \pi_{42} & \pi_{43} & \pi_{44} \end{bmatrix}
\begin{bmatrix} \lambda_{t-1} \\ l_{t-1} \\ e_{t-1} \\ w_{t-1} \end{bmatrix}
+
\begin{bmatrix} \theta_{11} & \theta_{12} & \theta_{13} & \theta_{14} \\ \theta_{21} & \theta_{22} & \theta_{23} & \theta_{24} \\ \theta_{31} & \theta_{32} & \theta_{33} & \theta_{34} \\ \theta_{41} & \theta_{42} & \theta_{43} & \theta_{44} \end{bmatrix}
\begin{bmatrix} \lambda_{t-2} \\ l_{t-1} \\ e_{t-1} \\ w_{t-1} \end{bmatrix}
+
\begin{bmatrix} \varepsilon_{\lambda t} \\ \varepsilon_{lt} \\ \varepsilon_{et} \\ \varepsilon_{wt} \end{bmatrix}
$$

Premultiplying by B^{-1}, standard VAR can be obtained:

$$
x_t = A_0 + A_1 x_{t-1} + A_2 x_{t-2} + \nu_t \tag{3.17}
$$

where $A_0 = B^{-1}C$, $A_1 = B^{-1}\Pi$ and $A_2 = B^{-1}\Theta$. Similarly, $\nu_t = B^{-1}\varepsilon_t$, or, equivalently,

$$
\begin{bmatrix} \nu_{\lambda t} \\ \nu_{lt} \\ \nu_{et} \\ \nu_{wt} \end{bmatrix}
=
\begin{bmatrix} 1 & b_{12} & 0 & b_{14} \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}
\begin{bmatrix} \varepsilon_{\lambda t} \\ \varepsilon_{lt} \\ \varepsilon_{et} \\ \varepsilon_{wt} \end{bmatrix}
$$

with expected signs being: $b_{12} > 0$ and $b_{14} > 0$.

To recover all of the information presented in the standard VAR system (3.17), we have to appropriately restrict the primitive system (3.16) using Matrix B. The minimum number of restrictions for identification is $k(k-1)/2$ where k is the number of variables. Therefore, in our case, the required minimum restrictions for identification are six whereas the imposed restrictions in Matrix B are ten. Thus, this structural VAR system is not underidentified.

Once the coefficients for the state variables, l, e and w, are obtained, (3.13), (3.14) and (3.15) should be modified properly to render interpretation of the results to approximate the theory in which the dependent variables are the *growth rate* of a variable (See (3.9), (3.10) and (3.11)). I convert the dependent variables to the *changes* from the previous level by subtracting the lagged dependent variable from both sides of the equations following Barbosa-Filho and Taylor (2006):

$$l_t - l_{t-1} = c_2 + \pi_{21}\lambda_{t-1} + (\pi_{22} - 1)l_{t-1} + \pi_{23}e_{t-1} + \theta_{21}\lambda_{t-2} + \theta_{22}l_{t-2} + \theta_{23}e_{t-2} + \varepsilon_{lt} \quad (3.18)$$

$$e_t - e_{t-1} = c_3 + \pi_{31}\lambda_{t-1} + (\pi_{33} - 1)e_{t-1} + \theta_{31}\lambda_{t-2} + \theta_{33}e_{t-2} + \varepsilon_{et} \quad (3.19)$$

$$w_t - w_{t-1} = c_4 + \pi_{42}l_{t-1} + \pi_{43}e_{t-1} + (\pi_{44} - 1)w_{t-1} + \theta_{42}l_{t-2} + \theta_{43}e_{t-2} + \theta_{44}w_{t-2} + \varepsilon_{wt} \quad (3.20)$$

Note that, in these modified specifications, $(\pi_{22} - 1)$, $(\pi_{33} - 1)$ and $(\pi_{44} - 1)$ correspond to the coefficients for the error–correction term which can be interpreted as *speed–of–adjustment* parameters. Also note that this modification does not affect other coefficients.

Unfortunately, it is not possible to make the dependent variable a form of the growth rate without changing the form of independent variables.[4] Nevertheless, this discrepancy between the theoretical and empirical models on the left–hand side of

[4] In addition to the method that I adopted here, Barbosa-Filho and Taylor (2006) take the natural logarithm of all variables. Then, they repeat the same procedure so that the dependent variable becomes, for example, ln e_t− ln e_{t-1} which is an approximation of $(e_t - e_{t-1})/e_{t-1}$. However, having log values for the independent variables on the right–hand side also does not conform to the theory.

the equations is moot considering our research purpose: comparing the magnitudes of parameters and the strengths of responses for the three sub-periods. If we estimate the single equation (3.18) along with an equation in which the right–hand side is exactly the same but the dependent variable on the left–hand side is a growth rate ($\hat{l}$), then, the estimates for the two equations will be definitely different. However, since the growth rate is a nonlinearly transformed value from the difference, either the orders of the estimated coefficients or the patterns of the impulse response functions for the three sub-periods do not change upon the switching the form of the dependent variable.

In the next section, I will discuss in detail the expected results.

3.3.2 Hypotheses

The hypotheses that will be examined in this paper are broadly twofold. The first set of hypotheses (H1 to H4) is related to the changing characteristics in the behavioral functions of the employment and real wage flexibilities—the employment expansion function and the real wage Phillips curve. These exercises are not only to confirm the empirical results obtained from Oh (2016) using a univariate model but also to check if the VAR model in this paper is well specified. The second set of hypotheses (H5 to H6) concerns the impacts of the changing behavioral functions on the macroeconomy beyond the labor market. It examines the dynamic interactions between the variables of the labor market and those of the goods market for the Great Moderation and Great Recession during which the U.S. labor markets are believed to have become more flexible than pre–1984.

Thus, data is divided into three sub-periods: (1) 1967:2–1983:4 (pre–1984), (2) 1984:1–2007:4 (the Great Moderation: GM, hereafter) and (3) 2008:1–2015:2 (the

Great Recession: GR, hereafter).[5] Hypotheses 1 to 4 are to be examined by coefficient analysis since they relate to the parametric changes in the behavioral functions. For the fifth hypothesis, I will provide an impulse response analysis to trace the impact of innovations in the labor market institutions over time. The sixth hypothesis is examined mainly by coefficient analysis.

In the literature on exogenous business cycle theories, VAR framework has been popularly used to examine the (exogenous) impulse and (endogenous) propagation mechanism. The impulse response function—visually representing the propagation behavior of the VAR variable in response to shocks—can serve those theories empirically due to the conformity of its statistical definition to a theoretical framework. Nevertheless, the exogenous business cycle theory such as the standard real business cycle model cannot explain a hump-shaped impulse response function to innovations in the temporary component (Cogley and Nason, 1995). It also fails to explain why, in some cases, impulse response functions oscillate.[6]

However, the oscillating impulse response functions are one of the main empirical foci in the research on the endogenous business cycle using a VAR framework (Goldstein, 1985; Tarassow, 2010; Basu et al., 2013). Following this tradition, I will highlight the oscillation in the impulse response functions to discuss macroeconomic stability as a result of the institutional changes discussed above. As a measure of the stabilizing force, I will use the *amplitude* of an impulse response function: the distance between the maximum and minimum heights of an impulse response function. This corresponds to the amplitude of a limit cycle in Oh (2016) by which the stability of an economy is evaluated.

[5] The number of observations (quarters) for the pre–1984 era is 65; for the Great Moderation, 94; for the Great Recession, 29.

[6] Farmer (1993, Chapter 7) and Farmer and Guo (1994) discuss that this aspect of the data is one that the endogenous business cycle model can replicate.

The hypotheses elicited from the theory are as follows:

H1 (Labor Hoarding)

• Theoretical Argument: From pre–1984 to the GM, labor hoarding was not weakened as expected. On the other hand, from the GM to the GR, labor hoarding was weakened.

(1) $h_\lambda|_{t=pre-1984} \geqslant h_\lambda|_{t=GM}$; (2) $h_\lambda|_{t=GM} < h_\lambda|_{t=GR}$

• Empirical Test: Responsiveness of the labor capital ratio to changes in the utilization rate of labor ($\frac{\partial i_t}{\partial \lambda t-1} + \frac{\partial i_t}{\partial \lambda t-2}$) was not strengthened during the GM, but was strengthened during the GR.

(1) $H_1 : \pi_{21,pre-1984} + \theta_{21,pre-1984} = \pi_{21,GM} + \theta_{21,GM}$;

(2) $H_1 : \pi_{21,GM} + \theta_{21,GM} < \pi_{21,GR} + \theta_{21,GR}$

H2 (Reserve Army of Labor Effect)

• Theoretical Argument: The reserve army of labor effect has been weakened since 1984.

(1) $h_e|_{t=pre-1984} < h_e|_{t=GM}$; (2) $h_e|_{t=GM} < h_e|_{t=GR}$

• Empirical Test: Responsiveness of the employment rate to changes in the employment rate ($\frac{\partial \dot{e}_t}{\partial et-1} + \frac{\partial \dot{e}_t}{\partial et-2}$) has been weakened since 1984.

(1) $H_1 : \pi_{33,pre-1984} - 1 + \theta_{33,pre-1984} < \pi_{33,GM} - 1 + \theta_{33,GM}$;

(2) $H_1 : \pi_{33,GM} - 1 + \theta_{33,GM} < \pi_{33,GR} - 1 + \theta_{33,GR}$

H3 (More Active Firms' Mark–up Pricing)

• Theoretical Argument: Firms' degrees of mark–up pricing during the GM and the GR are larger than during the pre–1984 era.

(1) $\beta|_{t=pre-1984} < \beta|_{t=GM}$; (2) $\beta|_{t=pre-1984} < \beta|_{t=GR}$

• Empirical Test: Responsiveness of real wage to changes in the labor capital ratio ($\frac{\partial \dot{w}_t}{\partial lt-1} + \frac{\partial \dot{w}_t}{\partial lt-2}$) during the GM and GR are less (or larger in absolute value) than pre–1984.

(1) $H_1 : \pi_{42,pre-1984} + \theta_{42,pre-1984} > \pi_{42,GM} + \theta_{42,GM}$;

(2) $H_1 : \pi_{42,pre-1984} + \theta_{42,pre-1984} > \pi_{42,GR} + \theta_{42,GR}$

H4 (More Active Workers' Nominal Wage Adjustment)

• Theoretical Argument: Workers' degree of nominal wage adjustment during the GM and GR are larger than in the pre–1984 era.

(1) $\gamma|_{t=pre-1984} < \gamma|_{t=GM}$; (2) $\gamma|_{t=pre-1984} < \gamma|_{t=GR}$

• Empirical Test: Responsiveness of real wage to changes in the employment rate ($\frac{\partial \dot{w}_t}{\partial et-1} + \frac{\partial \dot{w}_t}{\partial et-2}$) during the GM and GR are larger than pre–1984.

(1) $H_1 : \pi_{43,pre-1984} + \theta_{43,pre-1984} < \pi_{43,GM} + \theta_{43,GM}$;

(2) $H_1 : \pi_{43,pre-1984} + \theta_{43,pre-1984} < \pi_{43,GR} + \theta_{43,GR}$

Definition 4. *(Amplitude of Impulse Response Function)*
Let $\phi_{yz}(t)$ be the impulse response of variable y to z shock at time t. Let $\{y_{zt}\}$ be a sequence for the cumulated sum of the effects, $\sum_{t=0}^{n} \phi_{yz}(t)$. Then, the amplitude of this impulse response function is defined as follows: $AMP_{z \to y} = max\{y_{zt}\} - min\{y_{zt}\}$.

H5 (Real Wage Flexibility as an Automatic Stabilizer)

• Theoretical Argument: In the ultra short-run, adjusting λ closes the gap between saving and investment. Upon decreases in real wages during expansions, say, profit share rises, as does saving. Flexibilization of real wage functions as an automatic stabilizer since the extent to which firms have to adjust the labor utilization rate to close the gap between investment and saving is lessened compared to pre–1984.

• Empirical Test: Amplitude of the impulse response function displaying the impulse responses of the labor utilization rate to the labor capital ratio (and real wage) shock for the GM was reduced compared to the pre–1984 era.
(1) $H_1 : AMP_{l \to \lambda}|_{pre-1984} > AMP_{l \to \lambda}|_{GM}$
(2) $H_1 : AMP_{w \to \lambda}|_{pre-1984} > AMP_{w \to \lambda}|_{GM}$

H6 (During the Great Moderation, real wage flexibility played a major role in stabilizing the economy; during the Great Recession, employment flexibility contributed to destabilizing the economy)

• Theoretical Argument: While Hypotheses 1 to 5 are posited, Hypothesis 6 can be posited if the goods market is stabilized (destabilized) during the Great Moderation (Great Recession).

• Empirical Test: Given that the labor capital ratio (l) is a proxy variable for the utilization rate of the goods market, the error–correction mechanism for the labor capital ratio for the GM was strengthened compared to that of the pre–1984 era; the error–correction mechanism for the labor capital ratio for the GR was weakened compared to that of the GM.

(1) $H_1 : \pi_{22,pre-1984} - 1 + \theta_{22,pre-1984} > \pi_{22,GM} - 1 + \theta_{22,GM}$

(2) $H_1 : \pi_{22,GM} - 1 + \theta_{22,GM} < \pi_{22,GR} - 1 + \theta_{22,GR}$

3.4 Data and Diagnostics

3.4.1 Data

We need four data series for vector $x_t = [\lambda_t, l_t, e_t, w_t]'$ in the VAR system. The following are the sources for each series:

(1) λ: real GDP (Billions of Dollars; A191RX1) divided by the hours of the total economy (unpublished series by BLS) and its detrended series

(2) l: civilian employment (Thousands of Persons; LNS12000000) and its detrended series

(3) e: 1 – civilian unemployment rate (LNS14000000) and its detrended series

(4) w: real compensation per hour of the nonfarm business sector (Index 2009=1; COMPRNFB) and its detrended series

To make the series stationary, I detrended all the series using the Hodrick–Prescott (HP) filtering method with a smoothing parameter of 1600. Besides statistical consideration, detrending the data is also in accord with the theoretical guidance of Oh (2016) that focuses solely on the short–run stability issue of a flexible labor market, ignoring the long–run growth issue. For example, detrended labor productivity (λ)—

which is interpreted as the utilization rate of labor—dismisses the effect of long–run technological change on labor productivity. All detrended series are plotted in Figure 3.1.

It is worth mentioning why I use detrended civilian employment (L)—employment gap—as a proxy for the labor capital ratio ($l = L/K$). It is analogous to the usage of the output gap (detrended Y) as a proxy for the output capital ratio (Y/K) in the post–Keynesian literature, partly due to the difficulty in acquiring reliable quarterly data for capital stock (K).[7]

Figure 3.2 examines the similarities in the cyclical patterns between the simulation results in Oh (2016) shown in panel (a) and the cyclical patterns of the variables derived from the data used in this paper. All series in Figure 3.1 are smoothed and combined into panel (b) of Figure 3.2.

Oh (2016), regarding the simulation results, pointed out several qualitative patterns of variables over a business cycle. First, in panel (a) of Figure 3.2, the adjusting role of the labor utilization rate (λ) upon the goods market disequilibrium is clearly seen. λ as a jump variable passes through the intersections of l, w more rapidly (or more procyclically). After this ultra–short run adjustment, other state variables start to adjust at a moderate speed. This pattern is observed in panel (b) of Figure 3.2. It was particularly pronounced from 1960 to 1990. Thereafter, the utilization rate of labor—labor productivity—became less procyclical or counter–cyclical as Gordon (2010) points out.

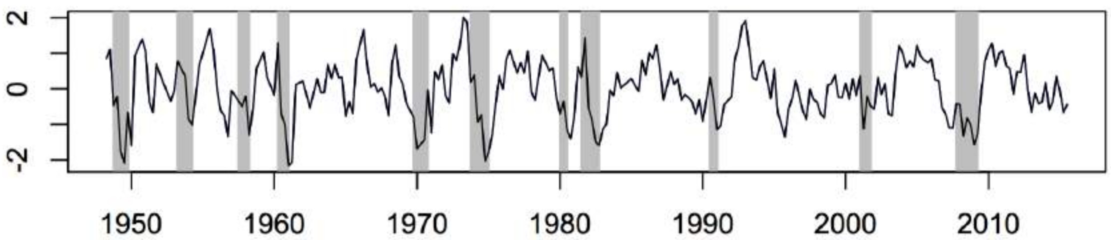
Second, in panel (a) of Figure 3.2, real wages move counter–cyclically since firms' abilities to mark–up pricing is modeled to dominate workers' abilities to squeeze profits *à* la Kaldor.[8] To examine the validity of this assumption with more clear

[7]See Barbosa-Filho and Taylor (2006); Skott and Zipperer (2012).

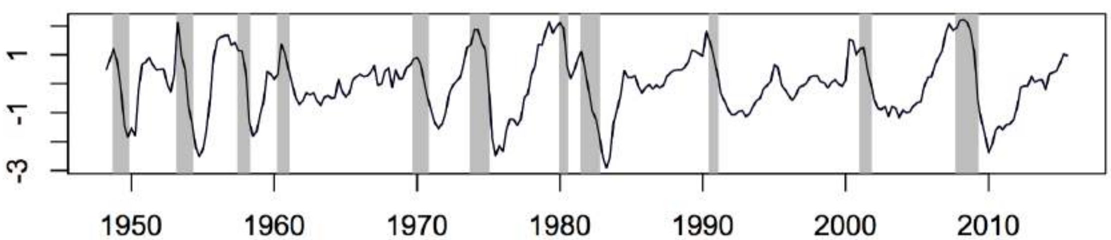
[8]$\beta > \gamma$ in equation (3.11) reflects this relationship. See von Arnim and Barrales (2015a,b); Skott (2015) for a recent debate over the patterns of wage share between the Kaldorian and Kaleckian perspectives.

Figure 3.1: Time Series Plots

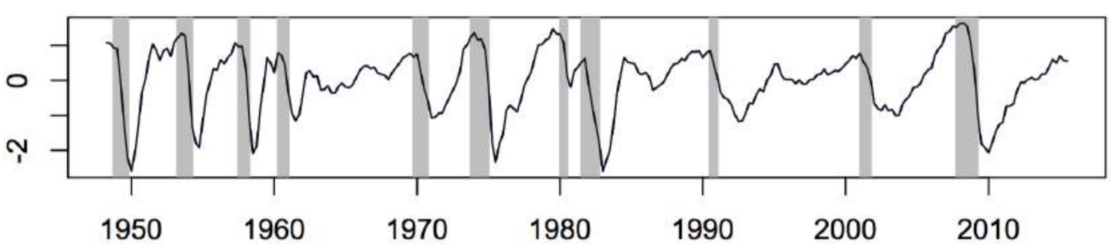
(a) Utilization Rate of Labor (λ)



(b) Labor Capital Ratio (l)



(c) Employment Rate (e)



(d) Real Wage (w)

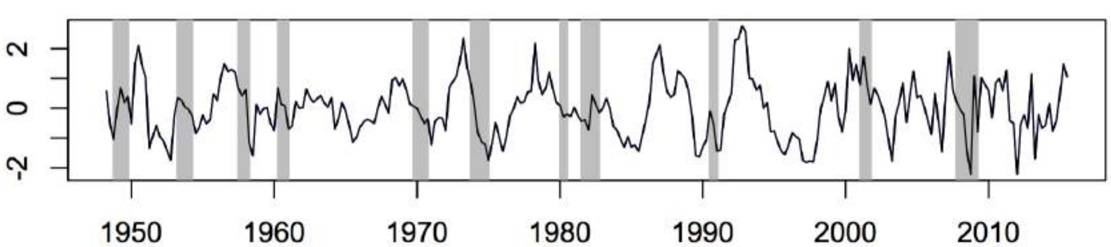
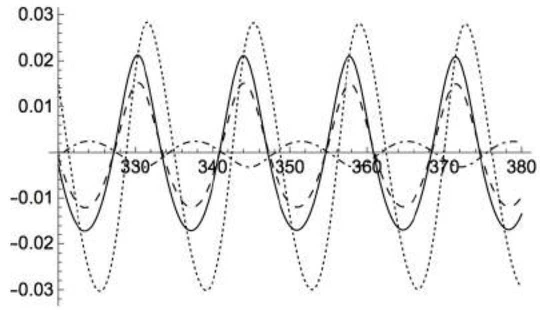
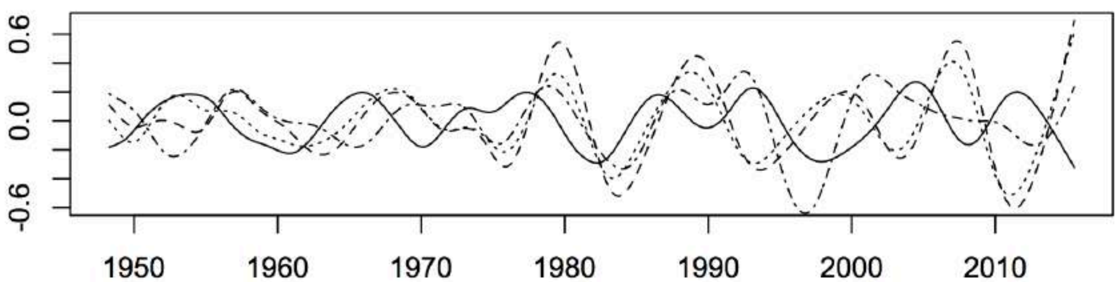


Figure 3.2: Simulation (Oh, 2016) and Smoothed Series for $\lambda(\text{——})$, $l(- - -)$, $e(\cdots\cdot)$, $w(- \cdot -\cdot)$

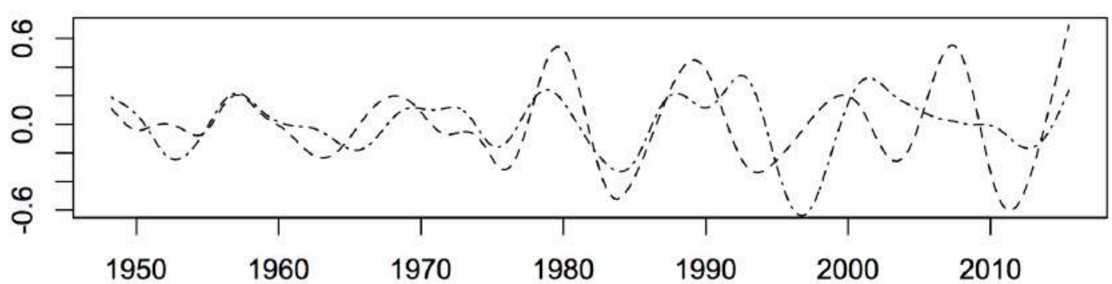
(a) Simulation in Oh (2016)



(b) Plot for Smoothed Estimates



(c) l and w



visualization, in panel (c), the labor capital ratio (l)—a state variable representing the utilization rate in the goods market—and the real wages (w) series are separated out from panel (b). Visual inspection of panel (c) suggests that real wage had moved procyclically up to around the late 1980s. Thereafter, it shows a counter–cyclical movement.

3.4.2 Diagnostics

Table 3.1 presents the statistics from the diagnostic tests based on the VAR model in (3.17) with 2 lags. The first row reports the result of a standard Portmanteau test examining whether there is any evidence for autocorrelation in the VAR residuals since the presence of autocorrelated errors can make the OLS estimates inconsistent. The large p-values for all the sub-periods suggest that we cannot reject the null hypothesis that there is no autocorrelation.

Table 3.1: Diagnostic Tests

	1967:2–1983:4	1984:1–2007:4	2008:1–2015:2
Serial Correlation	0.60	0.47	0.99
Normality	0.11	0.00	0.76
Skewness	0.17	0.00	0.45
Kurtosis	0.17	0.00	0.86

Notes: This table reports the diagnostic test results for estimation of the VAR in (3.17) with 2 lags. The results of the lag length tests suggest to allow for two lags. For both the serial correlation and normality tests, p-values are reported in this table. The null hypothesis for the serial correlation test is that the VAR errors do not have serial correlation until lag 2. A large p-value implies that the null hypothesis cannot be rejected. The Jarque-Bera normality test is a test of jointly normal VAR errors.

Next, I carried out a test of the normality of the VAR errors since a violation of the normality assumption could distort both the estimation of coefficients and calculation of confidence intervals. In the second row, the results of a Jarque–Bera normality tests to the residuals of the VAR model are reported. In the third and fourth rows, the results of the multivariate skewness and kurtosis tests are reported, respectively. The joint null hypothesis for these tests is that skewness is zero and that excess kurtosis is also zero.

The testing results for the pre–1984 era reject the null hypothesis, signifying that the joint distribution of errors in this period is non-normal. However, considering the p–values slightly above the significance level of 10%, the degree of non–normality may not present a serious problem. In addition, we can be certain about the validity of the empirical results of this paper since we have relatively large samples. Reliance on asymptotic arguments allows us to circumvent the problems that arise due to non–normal errors. On the other hand, the test results for the Great Moderation show the absence of non–normality.

By contrast, the results for the Great Recession reject the null of normal distribution with high p–values. First, the sample size for this period is relatively small compared to the previous two eras, and, thus, the asymptotic argument cannot be applied. Second, the data for the Great Recession covers only one business cycle—one downturn and one upturn which has not yet been completed. In particular, we have observed a deepness in the recent crisis—unprecedented since the Great Depression—followed by a retarded recovery of almost 7 years. The extremely high p–values in the normality tests may reflect this asymmetry in the current cycle. Considering these results, we will be particularly careful in the interpretation of the empirical results for the Great Recession in the next section.

3.5 Empirical Results

3.5.1 Estimated Coefficients

Table 3.2 reports the estimated coefficient for the contemporaneous variables. Table 3.3 reports the estimates for the constant and lagged variables. I conducted a second order structural VAR since the lag length tests suggest that two lags would be sufficient.[9]

Table 3.2: Coefficient Estimates for the Contemporaneous Variables (b_{12} and b_{14} in B^{-1})

	1967:2–1983:4	1984:1–2007:4	2008:1–2015:2
b_{12}	0.10	-0.01	0.03
	(0.12)	(0.10)	(0.19)
b_{14}	0.41***	0.13*	-0.06
	(0.12)	(0.10)	(0.19)

*** p<0.01, ** p<0.05, * p<0.1

Notes: Standard errors are in parentheses.

To adopt an empirical method consistent with the underlying theory, it may be more relevant to highlight the estimated coefficients. Above all, in the endogenous business cycle theory, the driving force creating a business cycle is not stochastic shocks but the dynamic interactions among variables, which can be captured empirically by the coefficient estimates reported in Table 3.2 and 3.3. Nevertheless, the coefficient analysis should not be emphasized too much for the following reasons.

When it comes to estimating coefficients, a VAR method cannot outperform a univariate approach in which applying various statistical treatments is possible, such as controlling for any relevant variables, dealing with nonlinearity, *etc*. Moreover, if economic theory suggests more than required restrictions as in our case, the t–statistic for individual coefficients is not so reliable since the calculated standard errors may not be very accurate (Sims, 1980). Thus, conducting inference on the estimated coefficients can be statistically problematic. Of course, large standard errors frequently appearing in the VAR literature are due mainly to the high correlations among variables rather than wrong identification. In addition, moderate standard

[9] Akaike Information Criterion (AIC) suggests 2 lags; Hannan–Quin (HQ) information criterion suggests 2 lags; Schwarz criterion (SC) suggests 1 lag; the final prediction error (FPE) suggests 2 lags. I used full data sets (1967:2–2015:2) for these tests.

Table 3.3: Coefficient Estimates for the Constant and Lagged Variables (A_0 A_1 and A_2)

	1967:2–1983:4				1984:1–2007:4				2008:1–2015:2			
	λ	l	e	w	λ	l	e	w	λ	l	e	w
const.	-0.06	-0.02	-0.03	0.02	0.03	-0.01	0.00	0.02	-0.11	-0.02	-0.02	-0.17
	(0.08)	(0.05)	(0.04)	(0.07)	(0.05)	(0.03)	(0.02)	(0.08)	(0.08)	(0.06)	(0.05)	(0.21)
λ_{t-1}	0.41***	-0.02	0.00	-0.06	0.48***	-0.01	-0.00	0.30*	0.14	0.19	0.17	0.74
	(0.14)	(0.08)	(0.07)	(0.11)	(0.11)	(0.07)	(0.04)	(0.17)	(0.19)	(0.15)	(0.12)	(0.49)
l_{t-1}	0.51	0.69***	0.32*	0.23	0.16	0.81***	0.07	0.06	0.08	0.72*	0.08	0.58
	(0.34)	(0.20)	(0.16)	(0.28)	(0.22)	(0.14)	(0.08)	(0.35)	(0.49)	(0.37)	(0.31)	(1.23)
e_{t-1}	-0.18	0.82***	0.94***	-0.51	-0.64*	0.63***	1.26***	-0.44	0.22	0.55	1.23***	-2.01
	(0.42)	(0.25)	(0.20)	(0.33)	(0.34)	(0.22)	(0.13)	(0.54)	(0.58)	(0.44)	(0.36)	(1.46)
w_{t-1}	0.34**	0.22**	0.13	0.84***	0.13*	0.01	0.01	0.82***	0.08	-0.12	-0.01	-0.15
	(0.17)	(0.10)	(0.08)	(0.13)	(0.07)	(0.05)	(0.03)	(0.11)	(0.10)	(0.07)	(0.06)	(0.24)
λ_{t-2}	0.26*	0.02	0.14**	0.31***	-0.01	0.04	0.05	-0.31*	-0.47**	0.05	-0.04	0.66
	(0.14)	(0.08)	(0.06)	(0.11)	(0.10)	(0.07)	(0.04)	(0.17)	(0.19)	(0.15)	(0.12)	(0.49)
l_{t-2}	0.33	-0.07	-0.02	-0.07	-0.56**	-0.30**	-0.12	-0.22	-0.33	-0.29	-0.39	0.41
	(0.30)	(0.18)	(0.14)	(0.24)	(0.22)	(0.14)	(0.08)	(0.35)	(0.46)	(0.36)	(0.29)	(1.17)
e_{t-2}	-1.14**	-0.51*	-0.55**	0.19	0.78**	-0.05	-0.24*	0.57	-0.67	0.14	0.07	1.09
	(0.43)	(0.26)	(0.21)	(0.35)	(0.37)	(0.24)	(0.14)	(0.60)	(0.67)	(0.52)	(0.42)	(1.69)
w_{t-2}	-0.28	0.01	0.02	-0.13	-0.04	0.01	-0.00	-0.06	0.02	0.06	0.06	0.02
	(0.18)	(0.11)	(0.09)	(0.14)	(0.07)	(0.05)	(0.03)	(0.11)	(0.10)	(0.08)	(0.06)	(0.26)

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Notes: Row variables are dependent variables and column variables are independent variables; standard errors are in parentheses.

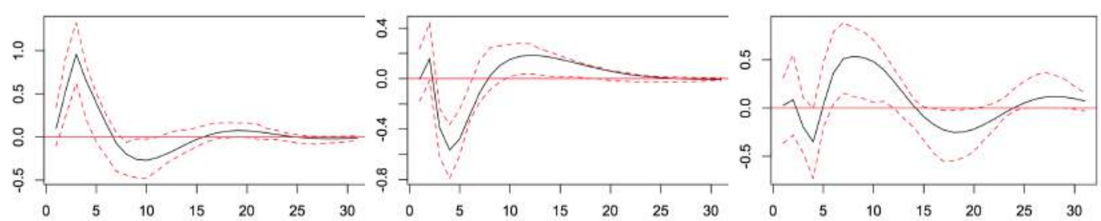
errors in the impulse response functions suggest that overall uncertainty is not as high as what is represented by individual standard errors (Kim and Roubini, 2000).

For these reasons, in this paper, the coefficient analyses—especially those used to test H1 to H4—are restrictive. This is to confirm and reinforce the empirical results in Oh (2016). However, the essence of the VAR approach can be grasped by the tools capturing the dynamic interactions among variables: the impulse response function and variance decomposition.[10]

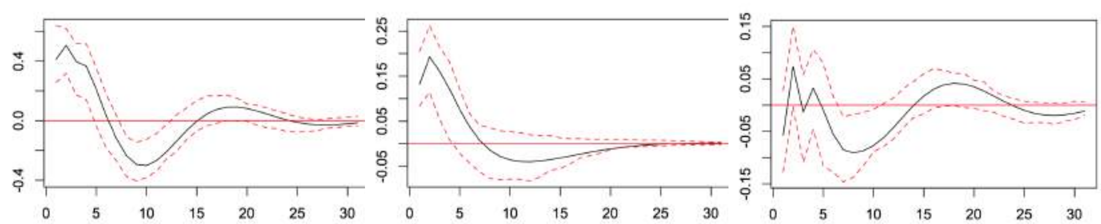
3.5.2 Impulse Responses and Variance Decomposition

Figure 3.3: Impulse Response Functions for H5

(a) $l \to \lambda$ (pre–1984) (b) $l \to \lambda$ (GM) (c) $l \to \lambda$ (GR)



(d) $w \to \lambda$ (pre–1984) (e) $w \to \lambda$ (GM) (f) $w \to \lambda$ (GR)



[10]I do not conduct a Granger causality test which is one of the important tools in VAR analysis. Since the analysis of Granger causality is based on the coefficients of reduced–form models, the concept of Granger causality has been criticized for failing to capture structural causality in a structural VAR framework (Hoover, 2008).

The results of impulse response analysis are provided in Figure 3.3 which illustrates both point estimates and one-standard deviation bands.[11] To get a broad picture of the cycle for each era, it is worthwhile analyzing the clarity of those business cycles identified from the impulse response functions.

We can clearly see oscillating responses both in the pre–1984 and GR eras. However, the impulse response functions for the GM show a hump–shaped (or inverse hump–shaped) response, implying that the business cycle during that time was weakened. It reflects the well-known stylized fact for the GM: stabilized major macroeconomic variables. Not surprisingly, the period length of a cycle is much longer in the GM than in the other two eras.

These observations are also confirmed by the results of forecast error variance decomposition (Table 3.4). The entries in the tables give percentage of the forecast error variance that is explained by each of the four variables. The forecast horizon ranges from 1 to 12 quarters. Panel (a) of Table 3.4 shows that, in the pre–1984 era, considerable portions of the variation in each variable can be explained by shocks from other variables, as the forecast horizon approaches a lag of 12. This implies that significant interactions among the four variables in the VAR system—hence the possibility of a clear business cycle—exist. By contrast, the forecast error variance decomposition for the Great Moderation (panel (b) of Table 3.4) shows obscure interactions among the variables, which accords closely with the shape of the impulse response functions of that period.

During the GR, both impulse response and forecast error variance decomposition results illustrate that the U.S. economy has been more unstable showing clearer fluctuations than in the two previous periods.

[11] Using one-standard deviation bands, *i.e.* 68% significance interval, is common in the VAR literature. For example, see Kim and Roubini (2000) and Blanchard (1989).

Table 3.4: Forecast Error Variance Decomposition

(a) 1967:2–1983:4

	λ				l				e				w			
	(λ	l	e	w)	(λ	l	e	w)	(λ	l	e	w)	(λ	l	e	w)
1	0.84	0.00	0.00	0.14	0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	1.00
4	0.22	0.26	0.39	0.11	0.00	0.56	0.28	0.14	0.01	0.22	0.62	0.13	0.03	0.02	0.20	0.73
8	0.17	0.22	0.49	0.09	0.04	0.39	0.27	0.28	0.04	0.25	0.47	0.22	0.05	0.05	0.32	0.56
12	0.16	0.22	0.48	0.12	0.04	0.33	0.38	0.24	0.04	0.22	0.52	0.20	0.05	0.06	0.33	0.54

(b) 1984:1–2007:4

	λ				l				e				w			
	(λ	l	e	w)	(λ	l	e	w)	(λ	l	e	w)	(λ	l	e	w)
1	0.98	0.00	0.00	0.01	0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	1.00
4	0.53	0.20	0.22	0.03	0.00	0.28	0.71	0.00	0.00	0.00	0.99	0.00	0.03	0.05	0.15	0.76
8	0.28	0.17	0.52	0.02	0.00	0.11	0.87	0.00	0.00	0.01	0.97	0.00	0.03	0.10	0.19	0.65
12	0.18	0.12	0.67	0.01	0.00	0.10	0.88	0.00	0.00	0.02	0.96	0.00	0.03	0.10	0.24	0.60

(c) 2008:1–2015:2

	λ				l				e				w			
	(λ	l	e	w)	(λ	l	e	w)	(λ	l	e	w)	(λ	l	e	w)
1	0.99	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	1.00
4	0.55	0.08	0.36	0.00	0.01	0.21	0.77	0.00	0.01	0.03	0.95	0.00	0.08	0.15	0.63	0.11
8	0.16	0.11	0.71	0.00	0.01	0.19	0.79	0.00	0.01	0.14	0.83	0.00	0.07	0.16	0.66	0.09
12	0.13	0.17	0.68	0.00	0.01	0.22	0.75	0.00	0.00	0.17	0.81	0.00	0.07	0.17	0.65	0.09

3.5.3 Test Results

The results of the hypotheses tests discussed in section 3.3.2 are summarized in Table 3.5. As stated earlier, statistical inferences on the estimated coefficients are not reliable due to the large standard errors prevalent in the VAR literature. Instead, we investigate the direction of the changes in the related estimates of each hypothesis.

First, the coefficients relating to labor hoarding are not significantly different comparing the pre–1984 era (0) and the Great Moderation (0.03). On the other hand, the same coefficient has dramatically increased by 0.21 from the GM to the GR. Therefore, Hypothesis 1 (labor hoarding was not weakened during the GM; it was weakened during the GR) is approved.

Second, Hypothesis 2 (the reserve army of labor effect has continuously weakened since 1984) is also posited since coefficients have continuously increased since 1984. Small p–values for these coefficients particularly reinforce the credibility of this argument.

In sum, it is not deniable that the labor market shifted toward flexible employment. However, during the Great Moderation, the degree of transition is not so marked compared to previous periods (one of the two axes for flexible employment is not posited) refuting most studies trying to identify the source of stability from reduced frictions in the labor market. Enacting legislation facilitating a firing process is one thing but actively executing it is another, particularly, in the circumstance when employment flexibility and real wage flexibility are complementary to a certain degree (Galí and van Rens, 2010).

Moving on to Hypothesis 3 (firms' degree of mark–up pricing has increased since 1984), note that the sign of the coefficient for pre–1984 is positive reflecting the aforementioned observation: real wage moved procyclically up to the late 1980s and counter–cyclically afterwards. For the Great Moderation, Hypothesis 3 can be posited since the coefficient decreased by –0.32. On the other hand, the result for the Great

Table 3.5: Hypothesis Test Results

Hypothesis	Estimate	(A) pre–1984	(B) GM	(C) GR	(B)–(A) Change (GM)	Change (GR)	Expected Sign in Change?
H1 (Labor Hoarding)	$\pi_{21} + \theta_{21}$	0	0.03	0.24.	0.03	0.21.	Yes
		(0.21)	(0.15)	(0.21)	(0.26)	(0.26)	
H2 (Reserve Army of Labor)	$\pi_{33} - 1 + \theta_{33}$	–0.61**	0.02***	0.30.	0.63.	0.28	Yes
		(0.52)	(0.31)	(0.65)	(0.61)	(0.72)	
H3 (Mark–up Pricing)	$\pi_{42} + \theta_{42}$	0.16	–0.16	0.99**	–0.32	0.83.	Yes (GM)
		(0.59)	(0.59)	(0.40)	(0.83)	(0.71)	
H4 (Nominal Adjustment)	$\pi_{43} + \theta_{43}$	–0.32	0.13	–0.92	0.45	–0.60	Yes (GM)
		(0.52)	(0.81)	(2.23)	(0.96)	(2.29))	
H5 (Automatic Stabilizer)	$AMP_{l \to \lambda}$	1.23	0.75		–0.48		Yes
		(2.80)	(2.82)		(3.97)		
	$AMP_{w \to \lambda}$	0.81	0.23		–0.58		Yes
		(3.87)	(2.83)		(4.79)		
H6 (Source of (In)stability)	$\pi_{22} - 1 + \theta_{22}$	–0.38**	–0.49***	–0.57**	-0.11	–0.08	Yes (GM)
		(0.61)	(0.45)	(0.66)	(0.76)	(0.80)	

*** p<0.01, ** p<0.05, * p<0.1, . p<0.32

Notes: Standard errors are in parentheses; for H2 and H6, t-statistics required to get the p–values for each estimate are calculated based on the specifications (3.14) and (3.13) in which the conversions following Barbosa-Filho and Taylor (2006) are not applied. The estimate $\pi_{33} + \theta_{33}$ is used for H2. $\pi_{22} + \theta_{22}$ is used for H6; $AMP_{i \to j}$: the amplitude of the impulse response function displaying the impulse responses of variable j to i shock; change (GR) is calculated by (C)–(B) except H3 and H4 which are obtained by (C)–(A).

Recession—an enormous increase in the coefficient—is not consistent with the hypothesis. One possible explanations is that, over the course of the recession (2008 to 2009), upon an historical drop in employment and the GDP, the government intervened so as to prevent severe deflation. Thus, firms need not reduce mark–up proportionately to the degree of recession in the goods market. During a slow expansion, however, unconventional monetary policies possibly result in a hindrance on firms' mark–up behavior.

In addition to Hypothesis 3, Hypothesis 4 (workers' nominal wage adjustment has been strengthened since 1984) is also related to wage flexibility. Although there is sign issue for the coefficient for pre–1984, the direction of the changes for the Great Moderation is in accord with what the theory suggests. The coefficient for the Great Recession does not again, support the hypothesis possibly because the extraordinary drops in the employment rate outweigh the decline in real wages.

The test results for the first set of hypotheses can be summarized as follows. Considering the results of Hypotheses 1 and 2, employment flexibility was unambiguously stronger during the Great Recession than the Great Moderation. At the same time, in considering the results of Hypotheses 3 and 4, it is not certain that real wage flexibility grew during the Great Recession. However, it is undeniable that real wage flexibility was active during the Great Moderation. From these observations we can conclude that during the Great Moderation, real wage flexibility could have played a major role in stabilizing the U.S. economy. How? This question brings us to Hypothesis 5 (real wage flexibility functioned as an automatic stabilizer during the Great Moderation). As for the Great Recession, despite weak evidence for real wage flexibility, very strong employment flexibility could possibly have been a main cause for a destabilized economy at that time.

Hypothesis 5 is confirmed since the amplitude of the impulse response function displaying the impulse responses of the labor utilization rate to the labor capital ratio shock for the GM has declined compared to that of the pre–1984 era. The same is true for the amplitude of the impulse response function displaying the impulse responses of the labor utilization rate to the real wage shock.

An assessment for the dynamic relationship between the labor market and goods market is reduced to Hypothesis 6 (during the GM, real wage flexibility played a major role in stabilizing the economy; during the GR, employment flexibility contributed to destabilizing the economy).

In the transition from the pre–1984 era to the GM, given the coexistence of (relatively weak) employment flexibility and (relatively strong) real wage flexibility, and the functioning of real wage flexibility as an automatic stabilizer, if we show that the goods market was stabilized during the Great Moderation in this structural VAR framework, we can claim that real wage flexibility was a major determinant for stabilized macroeconomics during the Great Moderation. Of course, I assume that all other things are equal.

The evidence favors the argument in Hypothesis 6. In the GM, the calculated coefficient of interest which contains an error–correction term decreased from -0.38 to -0.49. This means that, if the labor capital ratio—a variable for the utilization rate of the goods market—deviates from long–run trend, the adjustment process is quicker than previously. This corresponds exactly to the expression for a stabilizing goods market.

However, we could not get a clear–cut answer for the Great Recession since the existence of a destabilized goods market is not supported by the test result for Hypothesis 6. The coefficient for the goods market stability was reduced by 0.08, which can be interpreted as a stabilizing economy. This result which contradicts to actual experience can be attributed to the current business cycle being highly asymmetric. The extreme downturn was followed by an anemic recovery lasting more than 7 years. An averaged number can end up misrepresenting actual goods market dynamics.

In next section, I will provide a supplementary analysis for Hypothesis 6 by highlighting some dynamic features in the impulse response functions.

3.5.4 Dynamic Interactions of Goods Market, Labor Market and Real Wages

Figure 3.4 displays the impulse response functions for each era from which we can examine the dynamics of the labor market, goods market and real wages. Table 3.6 is the summary of estimates measuring the stabilities revealed in Figure 3.4. I use the amplitude of a cycle to measure the stabilities of three variables. Since the impulse response function in this case captures the impact from its own shock, it contains an error–correction term (See Enders (2010, pp. 307-8)).[12]. Thus, the larger descent (or larger amplitude) in an impulse response function implies greater stability of a variable, which is opposite to the interpretation used for Figure 3.3.

In addition to the amplitude of an impulse response function, I introduce speed of adjustment (SOA) as another measure of stability. Speed of adjustment (SOA) is defined as the length of time (number of quarters) required for the cumulated sum of the effects in an impulse response function to achieve its minimum value. More rigorously,

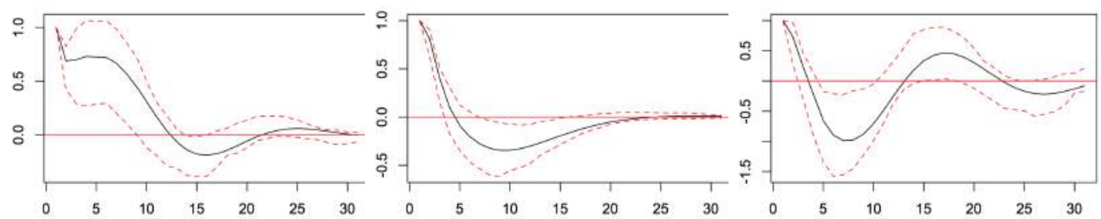
Definition 5. *(Speed of Adjustment of Shock)*
Let $\phi_y(t)$ be the impulse response of variable y to its own shock at time t. Let $\{y_t\}$ be the sequence for the cumulated sum of the effects, $\sum_{t=0}^{n} \phi_y(t)$. Then, speed of adjustment of its own shock is defined as follows: $SOA_y = k$ such that $\sum_{t=0}^{k} \phi_y(t) = min\{y_t\}$.

Smaller SOAs can be interpreted as a quick adjustment process that stabilizes markets or real wages.

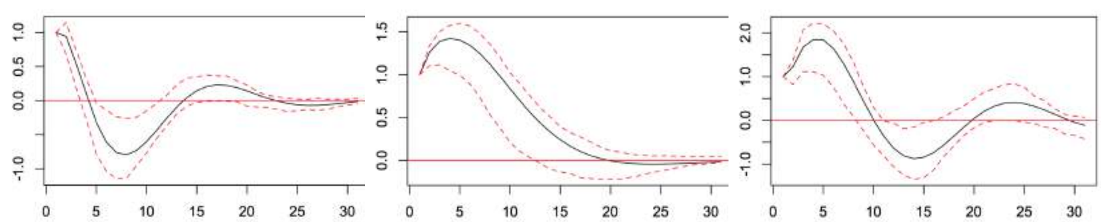
[12] For this reason, it shows negative effects in the initial stage before the first inflection point

Figure 3.4: Impulse Response Functions for Goods Market ($l \rightarrow l$), Labor Market ($e \rightarrow e$) and Real Wages ($w \rightarrow w$)

(a) Goods Market (pre–1984) (b) Goods Market (GM) (c) Goods Market (GR)



(d) Labor Market (pre-1984) (e) Labor Market (GM) (f) Labor Market (GR)



(g) Real Wage (pre–1984) (h) Real Wage (GM) (i) Real Wage (GR)

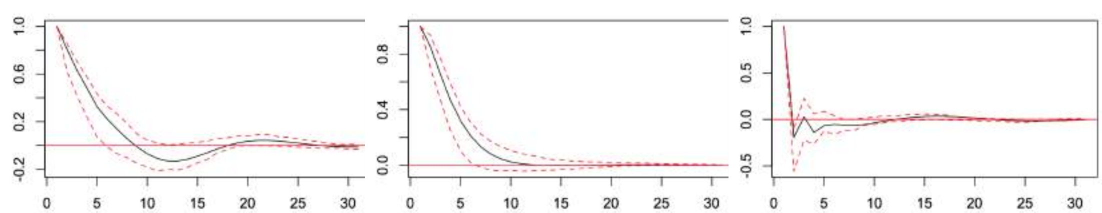


Table 3.6: Goods Market, Labor Market and Real Wages

	Estimate	(A) pre–1984	(B) GM	(C) GR	(B)–(A) Change (GM)	(C)–(B) Change (GR)
Goods Market	$AMP_{l\to l}$	1.19***	1.34***	1.99***	1.13***	0.65.
		(0.12)	(0.26)	(0.57)	(0.29)	(0.63)
	SOA_l	16	9	7	–7	–2
Labor Market	$AMP_{e\to e}$	1.80***	1.46***	1.88***	–0.34.	0.42.
		(0.31)	(0.03)	(0.37)	(0.31)	(0.37)
	SOA_e	8	24	14	16	–10
Real Wages	$AMP_{w\to w}$	1.13***	1.00***	1.20***	–0.13*	0.20
		(0.07)	(0.03)	(0.31)	(0.08)	(0.31)
	SOA_w	13	14	2	1	–12

*** p<0.01, ** p<0.05, * p<0.1, . p<0.32

Notes: Standard errors are in parentheses; $AMP_{i\to j}$: amplitude of the impulse response function displaying an impact of innovation to variable i on variable j.

From the pre–1984 era to the GM, both measures unambiguously show that the goods market was stabilized, which is in accordance with the stylized facts for the Great Moderation. AMP increased by 1.13 and the SOA shortened by 7 quarters. On the other hand, measures for the labor market indicate a destabilizing labor market because AMP decreased by 0.34 and SOA increased by 16 quarters.[13]

How can we explain the coexistence of a stabilized goods market and destabilized labor market? As the source of stability in a goods market, some economists have emphasized the role of a flexible labor market as a mitigator of macroeconomic shocks (Burnside et al., 1990; Galí and Gambetti, 2009). By contrast, I have explored a demand–side explanation in which the role of real wage flexibility is critical as an autonomic stabilizer for the goods market (Oh, 2016).

[13] Short uplifts at the start of the impulse response functions being observed in panel (e) and (f) of Figure 3.4 reflect the jobless recovery phenomenon. As panel (c) of Figure 3.1 shows, in the beginnings of the recoveries starting from the first quarter in 1991, the fourth quarter in 2001, and the second quarter in 2009, the employment rate kept declining although output increased. One of the strengths of impulse response analysis is clarifying the nature of the relationship between variables more dynamically.

In Figure 3.3 in section 3.5.2, I provide evidence for an operating autonomic stabilizer during the Great Moderation. Here, it is enough to show the existence of a shift toward flexible real wages using impulse response analysis. The AMP measure confirms that real wages became flexible during the Great Moderation since it decreased by 0.13. On the other hand, from the SOA measure, it is difficult to detect any shift in real wages since SOA for the GR increased merely by a quarter. However, comparing panels (g) and (h) of Figure 3.4 by visual inspection, the impulse response function in (h) shows a steeper slope in the early quarters than (g). Furthermore, unlike the plot in (g) which shows a small oscillation, the plot in (h) converges to a steady state immediately without any overshooting. Considering these observations along with the definition of real wage flexibility—a flexible real wage means *prompt responses* in real wage growth to changes in the business environment—it is fair to say that real wages became more flexible during the Great Moderation.

Moving on to the Great Recession, the results do not coincide with the stylized facts, namely, a destabilized goods market and destabilized labor market. This inconsistency can be attributed to the aforementioned severe asymmetry in the current business cycle along with a lack of observations.

Alternatively, we can adopt the measure of *relative volatility* elaborated by Galí and Gambetti (2009); Galí and van Rens (2010). To measure volatility in the employment (real wages), they use the ratio of the standard deviation of employment (real wages) to the standard deviation of output. Hence, the volatility of a variable is normalized by that of output. From these measures, they found that (1) the volatility of labor input measures has increased (relative to that of output); (2) the volatility of real wage measures has increased (relative to that of output).

Since the endogenous business cycle theory upon which this paper is based measures instability by the amplitude of a cycle rather than the standard deviation caused by a stochastic process, we use *relative amplitude* which is the ratio of the amplitude of employment (real wages) to the amplitude of output. These complementary measures are presented in Table 3.7. Now, the results for the GR are different from those we obtained from the measure of *absolute* amplitude. Changes in the goods market are taken into account; the labor market during the GR has been destabilized further since the relative amplitude reduced by 0.15. Similarly, the relative amplitude for real wage flexibility has reduced by 0.15, thereby suggesting that during the GR real wages have become more flexible than during the GM.

Table 3.7: Relative Amplitude of Labor Market and Real Wages

	Estimate	(A) pre–1984	(B) GM	(C) GR	(B)–(A) Change (GM)	(C)–(B) Change (GR)
Labor Market	$AMP_{e\to e}$	1.51***	1.09***	0.94***	–0.42▪	–0.15
	$AMP_{l\to l}$	(0.30)	(0.21)	(0.33)	(0.37)	(0.39)
Real Wages	$AMP_{e\to e}$	0.95***	0.75***	0.60**	–0.20▪	–0.15
	$AMP_{l\to l}$	(0.11)	(0.15)	(0.23)	(0.19)	(0.27)

*** p<0.01, ** p<0.05, * p<0.1, ▪ p<0.32

Notes: Standard errors are in parentheses; standard errors in columns (A), (B) and (C) are calculated using the delta method: $SE(\frac{x}{y}) \approx \sqrt{(\frac{E(x)}{E(y)})^2(\frac{var(x)}{E(x)^2} + \frac{var(y)}{E(y)^2} - 2\frac{cov(x,y)}{E(x)E(y)})}$. Note that the third term in the square root can be ignored since $AMP_{x\to x}$ and $AMP_{y\to y}$ are independent random variables; $AMP_{i\to j}$: the amplitude of the impulse response function displaying the impulse responses of variable j to i shock.

3.6 Conclusion

Using a structural VAR method, this paper provides empirical evidence for the argument of Oh (2016)—real wage flexibility played a major role in stabilizing the U.S. economy during the Great Moderation, and employment flexibility has contributed to destabilizing the economy during the Great Recession.

The results for the Great Moderation are quite robust. What we found are:

• Employment and real wage flexibilities were operating simultaneously (H1 to H4). Employment flexibility was in a weak form with surviving labor hoarding effect (H1).

• The autonomic stabilizer effect from flexible real wage clearly existed (H5).

• Therefore, the stabilized goods market during the Great Moderation (H6) can be explained by the dominant effect of real wage flexibility over employment flexibility.

For the Great Recession, some hypotheses (H3, H4 and H6) failed to be confirmed. The failures of H3 and H4, relating to real wage flexibility, have something to do with the unconventional monetary policy implemented throughout the Great Recession era, which blur out the real wage dynamics associated purely with mark–up pricing and wage bargaining in the labor market. The failure of H6—destabilizing the goods market—is due to the severe asymmetry in the current business cycle along with lack of observations. This is a caveat for econometricians whose data covers the Great Recession periods. A nonlinear approach such as a threshold VAR model may prove useful to deal with any statistical aberration resulting from the depth of the current recession.[14] This task will be the subject of my future research.

[14] The model can take on different linear structure according to the regime (expansionary or recessionary) the economy is undergoing. For a threshold VAR model, see Altissimo and Violante (2001); Koop et al. (1996).

CHAPTER 4

CHANGES IN CYCLICAL PATTERNS OF THE U.S. LABOR MARKET: FROM THE PERSPECTIVE OF NONLINEAR OKUN'S LAW

4.1 Introduction

Okun's law has played an important role in explaining changes in labor market variables in response to output growth. Okun's major observation was that a 1% decline in output gap would produce reductions of approximately 1/3% in productivity, 1/6% in hours per employee, 1/3% in the employment rate, and 1/6% in the labor force participation rate (Okun, 1970). Yet a number of recent papers cast doubt on the validity of Okun's law as a rule of thumb. They point out that the responsiveness of the employment rate and aggregate hours in the post-1980s became significantly larger compared to that of the pre-1980s since firms no longer must hoard labor and, instead, can fire employees with less firing costs (Gordon, 2011).[1]

I evaluate the flexible labor market hypothesis from the perspective of nonlinear Okun's law by breaking up a cycle into three phases: (1) recessions, (2) early expansions and (3) late expansions. If the flexible labor market story were valid, the largest changes in the coefficients would have taken place in bad times: recessions. In the literature weighing the validity of Okun's law, however, Okun's law is tested over entire cycles under the assumption that the response of firms is symmetrical.

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[1] "All of these factors may interact to embolden firms to respond to cyclical fluctuations by reducing hours of work more than in proportion to the decline in output" (Gordon, 2010, pp. 13–14); "I have suggested, that both the weakness of hours growth and strength of productivity growth in 2001-03 were the result of savage corporate cost cutting that caused labor input to be reduced more (relative to the output gap) than in previous recessions and recoveries. The same pressure for cost-cutting was even greater in 2008-09" (Gordon, 2011).

A novelty of this paper from the existing literature on asymmetric Okun's law is subdividing expansion into early and late phases. In particular, separating out early expansion is important to address the issue of sluggish job creation known as jobless recovery, which is yet another reason calling the validity of Okun's law into question, wherein decreased responsiveness of the employment rate to output growth matters.

Results from the phases–breaking analysis do not support the flexible labor market explanation since the main determining factor of increased coefficient for aggregate hours is the increased responsiveness of the employment rate during late expansions rather than recessions. The behavioral explanation is that firms react more conservatively than before upon the slow upturn in the economy. Once economic growth moves into high gear after a prolonged recovery, firms are more reactive in hiring workers. This over reaction in the labor market is also reinforced by recurrent bubbles in the financial sector.

I also found that increased responsiveness of hours per employee in early expansion is another main determining factor for more reactive aggregate hours, which can be interpreted as enhancing a firm's ability to increase working hours of existing workers. Under a flexible labor market, a labor hoarding mechanism is processed via flexible working hours rather than via an adjustment of effort level as has been explained by traditional literature on labor hoarding.

This paper is structured as follows. Section 4.2 examines the current debate over the validity of Okun's law. Particularly, two opposing views of this subject will be scrutinized: Gordon (2010, 2011) who asserts the demise of Okun's law due to structural change in the U.S. labor market; Ball et al. (2013) who argue that Okun's law is still useful as a rule of thumb. In section 4.3, the empirical model for phase–breaking analysis is explained. I also discuss why dividing a cycle into three phases becomes important in the debate over Okun's law and provide a literature review on this subject. In section 4.4, empirical results from the proposed model will be discussed in detail. Section 4.5 concludes the paper.

4.2 Debate over the Validity of Okun's Law

The proportional changes stated in the first paragraph of this paper can be formulated mathematically using the identity equation (4.1): GDP (Y) always equals the product of output per hour (Y/H), aggregate hours per employee (H/L), the employment rate (L/P), the labor force participation rate (P/N) and the working-age population (N).

$$Y \equiv \frac{Y}{H}\frac{H}{L}\frac{L}{P}\frac{P}{N}N \tag{4.1}$$

Taking logs and using lower-case letters to denote logged values, (4.1) becomes,

$$y \equiv (y-h)+(h-l)+(l-p)+(p-n)+n \tag{4.2}$$

Above all, the gist of the law is a change of 1/3% in the (un)employment rates. Firms' labor hoarding behavior can explain why changes in real output (Y) and employment rate (L/P) are not on a one–to–one basis. Businesses, taking into account the cost of firing, do not lay off workers in direct proportion to decreases in output during recessions (Oi, 1962). Firms use their workers intensively in periods of high aggregate demand and less intensively during the recessions. According to labor hoarding proponents, movements in labor productivity (Y/H), or Solow residual, originate from firms' factor hoarding behaviors such as changes in effort level (Lucas, 1989; Summers, 1986).

On the other hand, the real business cycle (RBC) theory translates Solow residual as a technology shock, the main source of economic fluctuation. Until 1960 neoclassical economists assumed that production function exhibits diminishing marginal productivity of labor, implying that labor productivity should rise during downturns and fall during upturns, which has not been supported by the observed data. The RBC theory solves this puzzle by abandoning the fixed production function assumption and introducing stochastic technology shocks which shift the aggregate production possibility frontier. In this manner, the RBC theory generates procyclical labor productivity since higher levels of output represent movement along higher MPL schedules.

To sum up, the main issue of the debate between the two camps can be reduced to how to interpret the procyclical movement of productivity (Y/H): whether it results from the labor market institution or external technology shocks. However, recent empirical findings on Okun's law have favored the labor hoarding perspective since they show more cyclical movement in the employment rate, and, as a flip side of the same coin, weakened procyclicality in labor productivity.[2]

Section 4.2.1 reviews the debate over structural changes in the U.S. labor market, underlying which the size of Okun's coefficient after the 1980s is a central issue. Section 4.2.2 extends the scope of investigation to other labor market variables including productivity.

4.2.1 Increased Okun's Coefficient

Surveying the econometric models for measurement is prerequisite to studying the debate since the results of any analysis are contingent upon the type of model applied. Let Y and U denote real output and unemployment rate, respectively. Take logs and use lower-case letters to denote logged values. The most popularly used specifications are the *gap version* (4.3) and the *difference version* (4.4):

$$u_t - u_t^* = \alpha(y_t - y_t^*) + \epsilon_t \tag{4.3}$$

$$\Delta u_t = \beta \Delta y_t + \varepsilon_t \tag{4.4}$$

[2]The RBC theory also incorporates firms' labor hoarding behavior as a mechanism for the propagation of shock (Burnside and Eichenbaum, 1996; Burnside et al., 1990; Horning, 1994; Basu and Kimball, 1997).

where * indicates a potential level; Δ, the change from the previous period. The gap version has the drawback that using unobserved potential output can create serious measurement errors which are sensitive to the choice of filtering methods. On the other hand, a caveat for using a difference version is to check whether output and unemployment are cointegrated. Attfield and Silverstone (1997) and Lee (2000) suggest using the first-difference model with an error-correction framework.

Despite the simplicity of gap and difference versions, serial correlation in the error terms (ϵ_t and ε_t) was detected, which would lead to biased coefficients and a nontrivial forecast error. To eliminate this problem, many economists now use a *dynamic version* of Okun's law (4.5) in which a lagged dependant variable is included:

$$\Delta u_t = \sum_{i=1}^{k} \gamma_i \Delta u_{t-i} + \sum_{j=0}^{k} \delta_j \Delta y_{t-j} + \eta_t \tag{4.5}$$

Ball et al. (2013), using the gap and difference versions, estimate the coefficients separately for the first (1948–1979) and second halves (1980–2011) of their sample to conclude that two coefficients are not significantly different. Having shown strong and stable Okun's coefficients, Ball et al. (2013) argue that the law is still valid and the argument for labor market institutional change is unfounded.

The Okun's coefficients estimated from three specifications are reported in Table 4.1. First, it is noteworthy that allowing lags makes the Okun's coefficients much larger in absolute value. Evidence shows that changes in the unemployment rate depend more on previous values of output growth (Knotek, 2007), hence, the coefficient that Okun originally estimated with a model without lag, namely 1/3, should be revised to a greater number. Second, the absolute values of the coefficients have increased. This increment ranges from 0.07 to 0.1 depending on the specification.

Table 4.1: Changes in Okun's Coefficients by Specifications

	1948:2-2011:4 (C)	1948:2-1979:4 (A)	1980:1-2011:4 (B)	Change (B) − (A)
Annual Data				
Gap	-0.42***	-0.38***	-0.48***	-0.10* (0.05)
Difference	-0.41***	-0.42***	-0.45***	-0.03 (0.62)
Quarterly Data				
Gap (no lag)	-0.44***	-0.41***	-0.50***	-0.09** (0.004)
Gap (2 lags)	-0.51***	-0.48***	-0.55***	-0.07* (0.04)
Gap (4 lags)	-0.52***	-0.48***	-0.56***	-0.08 (0.17)
Difference (no lag)	-0.29***	-0.29***	-0.31***	-0.02 (0.52)
Difference (2 lags)	-0.44***	-0.42***	-0.51***	-0.09* (0.02)
Difference (4 lags)	-0.43***	-0.41***	-0.52***	-0.11* (0.03)
Dynamic (4 lags)	-0.42***	-0.42***	-0.53***	-0.11 (0.42)

Notes:
1. '***' is the significance level less than 0.1%; '**' less than 1%; '*' less than 5%; p-values are presented in parentheses.
2.The model used for the Chow test are $\Delta u_t = \alpha + \gamma_0 D_t + \beta \Delta y_t + \gamma_1(\Delta y_t D_t) + \epsilon_t$ (no lag); $\Delta u_t = \alpha + \gamma_0 D_t + \beta_1 \Delta y_t + \gamma_1(\Delta y_t D_t) + \beta_2 \Delta y_{t-1} + \gamma_2(\Delta y_{t-1} D_t) + \beta_3 \Delta y_{t-2} + \gamma_3(\Delta y_{t-2} D_t) + \epsilon_t$ (2 lags); the model for 4 lags is easily constructed by extending them. The Chow test are doing t-test, $\gamma_1 = 0$ (no lag), under the null hypothesis of no structural break; F-test, $\gamma_1 = \gamma_2 = \gamma_3 = 0$ (2 lags). In the case of gap version, Δu_t becomes u_t', and so on.
3. Smoothing parameter (λ) for Hodrick–Prescott filter is 100 for annual data and 1600 for quarterly data. Ball et al. (2013) also report the results from the quarterly data with smoothing parameter of 16000. In this case significance of the changes are enhanced. However, smoothing parameter of 16000 is not popularly used.

Nonetheless, most Chow test statistics fail to reject the null of structural change, which makes some researchers on this subject including Ball et al. (2013) reluctant to confirm the demise of Okun's law as Gordon (2010, 2011) asserts.

4.2.2 Reduced Procyclicality of Labor Productivity

Regarding the changed cyclical patterns of productivity, another aspect of Okun's law, there has been general agreement that the movement has become less procyclical or even acyclical since the 1980s. Gordon (2010, 2011) discusses this by measuring the response of productivity to output changes along with responses of other labor market variables specified in equation (4.1). This section explains his method in detail since it enables us to investigate not only Okun's coefficients but also responses of other labor market variables to changes in output. I will also extend his model to phase–breaking analysis.

Gordon extracts the cyclical component of output ($y' = y - y^*$) and those of the right-hand side variables ($x' = x - x^*$) using the Kalman filtering method (see Appendix F) and carries out regression analysis of the response of each component to changes in output gap using the following regression equation.[3,4]

$$\Delta x'_t = \sum_{i=1}^{4} \alpha_i \Delta x'_{t-i} + \sum_{j=0}^{4} \beta_j \Delta y'_{t-j} + \theta x'_{t-1} + \sum_{k=1}^{6} \gamma_k D_{k,t} + \varepsilon_t \tag{4.6}$$

where θ is the coefficient of the error-correction (EC) term to deal with a cointegrated relation between the two variables in question.

Gordon uses first differences of detrended variables ($\Delta x'_t$ and $\Delta y'_t$) along with an EC term which is the lagged log ratio of actual to trend of the variable in question[5]. θ should be negative if a mean reverting process exists.

[3]Actual population growth and the trend in population growth are assumed to be identical so that we can ignore this component.

[4]When he uses the Kalman filtering method, he uses time-varying NAIRU as outside information. In the triangle model to measure time-varying NAIRU, he uses the unemployment gap as a proxy for the demand side. In presupposing Okun's law, he actually commits *circulus in probando* since he presupposes what he has to prove.

[5]$log(X_{t-1}/X^*_{t-1}) = logX_{t-1} - logX^*_{t-1} = x_{t-1} - x^*_{t-1} = x'_{t-1}$

D_k is the end-of-expansion (EOE) dummies for a regression to capture what Gordon (1979, 1993) denoted as the end-of-expansion effect. Concerning jobless recovery, a continuing decline in employment (or the burst in labor productivity) during the early expansion phase, Gordon explains this abnormality as a tendency toward overhiring and subsequent under-hiring which is a mere hangover reaction of the EOE period.[6] Put differently, jumps in productivity in early stages result mainly from firms' psychological reactions to changes in the business environment and uncertainty, rather than anything intrinsic to the labor market institution. Dummies take the form $1/M$, $-1/N$, where M is the length in quarters of the period of the initial interval of excessive labor input growth, and N is the length of the subsequent correction. By using this setting, he forces the sum of the coefficients of each variable to equal zero.

Table 4.2: Responses to Changes in the Output Gap in Gordon (2010)

Dependant variable	Okun's 1965 prediction	1963:I-1986:I	1986:I-2009:III
Output per hour	0.33	0.22	0.03
Aggregate hours of which:	0.67	0.74	1.27
Hours/employee	0.17	0.28	0.34
Employment rate	0.33	0.40	0.64
LFPR	0.17	0.03	0.15

Since the lagged dependant variables are included, the long–run response of each labor market variable can be obtained as $\sum_{j=0}^{4} \beta_j/(1 - \sum_{i=1}^{4} \alpha_i)$ which is known as the dynamic beta. Table 4.2 reports the dynamic betas for two sub-sample periods: 1962-86 and 1986-2009. Gordon argues that Okun's law became obsolete in the second period because not only the responses of aggregate hours to changes in the output gap are substantially greater than unity (1.27), but also productivity growth is no longer

[6]The EOE period is the interval between the peak of the growth cycle when output reaches its highest level relative to trend or potential output, and the NBER peak when real output is its highest level (Gordon, 1979, 1993).

procyclical (0.03).[7] His interpretation is that, due to a flexible labor market, a worker's weakened bargaining power together with a decline in real wages enables firms to respond to cyclical fluctuations by reducing the hours of work out of proportion to the decline in output. In other words, institutions now matter as a fundamental source of fluctuation in the macroeconomy while technology-based procyclical productivity to which the RBC theory resorts is dead.

His specification (equation (4.6)), however, is subject to two revisions before being extended to phase–breaking analysis. First, the EC term is redundant since all the detrended series contain no unit root (Table 4.3). Rather, the inclusion of the EC term will cause large losses rather than gains by seriously distorting the values of decomposed responses on output change, whose sum is supposed to be one. Table 4.4 reports the sets of estimates from the regressions with four conceivable combinations of the EOE dummy and the EC term. It is noteworthy that the sum of all the coefficients is one only in those cases without EC (panel b and d), indicating that the decomposition fits well without the EC term.

Second, the EOE dummy with which Gordon intentionally supresses the effects of over–hiring and subsequent under–hiring should be removed since such *a priori* control is not necessary for the phases–breaking analysis that this paper proposes. In Table 4.4, excluding the EOE dummy (panel c and d) results in higher responses of the employment rate compared to the cases with EOE dummy (panel a and b).

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[7] Productivity can be defined as either manhour productivity (Y/H) or output per worker productivity (Y/L); this paper uses the former definition. Yet less procyclicality is purportedly found in output per worker productivity as well. In Table 4.2, although the responsiveness of hour per employee (H/L) has increased by 0.06, the decline in manhour productivity (Y/H) (-0.19) offsets that increase. Hence, the combined net effect results in a decline in output per worker productivity (Y/L) by -0.13.

Table 4.3: Summary of the Augmented Dickey–Fuller Test for the Series

	Chosen Lag Length	Test Statistic	t-statistics
y	4	ϕ_3	35.04
$y-h$	3	ϕ_3	53.83
$h-l$	7	ϕ_3	27.51
$l-p$	7	ϕ_3	16.79
$p-n$	7	ϕ_3	38.23

Notes:
1. Lag length is chosen following general-to-specific apporach suggested by Ng and Perron (1995).
2. The regression equation used for the test includes a drift: $\Delta y_t = a_0 + \gamma y_{t-1} + \varepsilon_t$. ϕ_3 is for $H_0 : \gamma = a_2 = 0$. The critical values for 99% confidence intervals are 8.43.
3. The results confirm that all the series are stationary.

Table 4.4: Replication Result of Gordon (2010) by Cases

(a) With EOE With EC

	63-86	86-09
Y/H	0.41	0.06
H:	0.78	0.96
H/L	0.32	0.44
L/P	0.38	0.53
P/N	-0.06	0.10

(b) With EOE Without EC

	63-86	86-09
Y/H	0.22	0.02
H:	0.78	0.98
H/L	0.31	0.41
L/P	0.39	0.49
P/N	0.04	0.12

(c) Without EOE With EC

	63-86	86-09
Y/H	0.42	-0.22
H:	0.88	1.39
H/L	0.35	0.53
L/P	0.44	0.76
P/N	0.04	0.17

(d) Without EOE Without EC

	63-86	86-09
Y/H	0.14	-0.20
H:	0.86	1.20
H/L	0.33	0.41
L/P	0.43	0.59
P/N	0.07	0.14

4.3 Empirical Methods

4.3.1 Model

Allowing for these revisions, I will measure the responsiveness of the labor market variables to output change with equation (4.7) which is our baseline model for the entire cycle. Subsequently, I will measure the coefficients by each phase of the business cycle with equation (4.8).

$$\Delta x'_t = \alpha \Delta x'_{t-1} + \sum_{j=0}^{4} \beta_j \Delta y'_{t-j} + \varepsilon_t \tag{4.7}$$

$$\begin{aligned} \Delta x'_t = &\sum_{i=1}^{4} \alpha_i \Delta x'_{t-i} + \sum_{j=0}^{4} \beta_j \Delta y'_{t-j} + \gamma_1 D_{r,t} + \sum_{k=0}^{4} \delta_k \Delta y'_{t-k} D_{r,t-k} \\ &+ \gamma_2 D_{ee,t} + \sum_{l=0}^{4} \mu_l \Delta y'_{t-l} D_{ee,t-k} + \varepsilon_t \end{aligned} \tag{4.8}$$

In equation (4.8), I include the phase dummies Dr (1, if recession, otherwise 0) and Dee (1, if early expansion, otherwise 0). Then, I interact dummies with the regressors to get different coefficients for different phases of the business cycle. The dynamic beta (DB) from equation (4.7) can be separated out to the three states: the recession ($D_r = 1, D_{ee} = 0$), the early expansion ($D_r = 0, D_{ee} = 1$), and the late expansion ($D_r = D_{ee} = 0$).

$$DB_{rec} = \frac{\sum_{j=0}^{4} \beta_j + \sum_{k=0}^{4} \delta_k}{1 - \sum_{i=1}^{4} \alpha_i}$$

$$DB_{ee} = \frac{\sum_{j=0}^{4} \beta_j + \sum_{l=0}^{4} \mu_l}{1 - \sum_{i=1}^{4} \alpha_i}$$

$$DB_{le} = \frac{\sum_{j=0}^{4} \beta_j}{1 - \sum_{i=1}^{4} \alpha_i}$$

The estimation will be carried out for each right-hand-side variable in the identity equation (4.1): output per hour (Y/H), aggregate hours per employee (H/L), the employment rate (L/P), the labor force participation rate (P/N). I will compare the results between two sub–sample periods: 1963–86 and 1986–2009.

4.3.2 Data and Structural Break

All data except (ii) aggregate hours for the total economy are available from Bureau of Economic Analysis, Bureau of Labor Statistics and Federal Reserve Economic Data (FRED).

(i) Growth Domestic Product (Y): BEA table 1.1.6

(ii) Aggregate Hours (H): unpublished series provided by BLS

(iii) Civilian Employment (L): CE16OV

(iv) Civilian Labor Force (P): CLF16OV

(v) Civilian Noninstitutional Population (N): CNP16OV

Aggregate hours for the total economy includes all persons in the nonfarm business sector, farm sector, employees of nonprofits in the private nonfarm sector, government, armed forces and employees of private households. This series can be obtained from the Division of Industry Productivity Studies in Bureau of Labor Statistics upon request.

The studies on the institutional change post Volcker plan usually set a structural break either in 1980 or in 1985. In the debate on the validity of Okun's law, for example, Ball et al. (2013) compare Okun's coefficients before and after 1980 whereas Gordon (2010, 2011) sets 1985 as a breakpoint. Following the latter, this paper compares the coefficients between two sub–periods, (1) 1963:I–1986:I, (2) 1986:I–2009:III, since, unlike a financial institution, it takes time for a labor market institution to become fully adjusted to changes in the business environment.

4.3.3 Capturing Nonlinearity in Okun's Law

In the current debate over the validity of Okun's law, the flexible labor market hypothesis asserts that increased responsiveness of the employment rate and aggregate hours is due to the increased ability of firms to freely fire workers by incurring less firing costs. For example, according to IMF (2010), "the responsiveness of unemployment to output has increased over the past 20 years in many countries. This reflects significant institutional reform, particularly making employment protection legislation less strict.” Gordon (2011) also states that the employment response in Europe was so muted and the productivity response quite large, which is opposite to the case for the U.S. labor market. According to him, work–sharing institutions in the E.U. and the flexible labor market in the U.S. account for this difference. However, studies on this subject have not fully addressed the issue of asymmetry or nonlinearity in Okun’s law, instead focusing more on firing activity in bad times.

In classical Okun’s law, firms’ labor hoarding behavior presupposes symmetry in which a certain degree of less firing in recessions is followed by a similar degree of less hiring. For example, if the overall reaction of the unemployment rate to output change is 0.33, it is presumed that the reaction is 0.33 during recessions and 0.33 during expansions. In contrast, from the perspective of asymmetry in Okun’s law, the reaction could be 0.36 during recessions and 0.30 during expansions since the reaction during recessions is more pronounced than during expansions.

The idea of an aymmetric Okun’s law was preceded by the idea of an asymmetric business cycle which originated in the works of Mitchell (1927) and Keynes (1936). For example, Keynes (1936, p. 314) wrote that “the substitution of a downward for an upward tendency often takes place suddenly and violently, whereas there is, as a rule, no such sharp turning point when an upward is substituted for a downward tendency.” Since then, Neftçi (1984) and DeLong and Summers (1986) have reconfirmed this nonlinear movement of output over a business cycle.

Note that an asymmetric business cycle itself does not ensure an asymmetric Okun’s law since the former is mainly about the (univariate) movement of output whereas the latter is the (bivariate) interaction between output and the unemployment rates. If the unemplyment rate responds exactly as much as output change, Okun’s coefficient would be linear and stable over a business cycle.

In an econometric time series, Hamilton (1989) developed a tool for analyzing a nonlinear business cycle by combining it with the Markov switching model. Drawing on Hamilton's method, most research on an asymmetric Okun's law partitions the explanatory variable into positive and negative changes to separate out the coefficients for two regimes: $\Delta y > 0$ for expansions; $\Delta y < 0$ for recessions.[8]

Evidence and explanations for regime–dependent Okun's coefficients have been provided by substantial literature. From a sectoral analysis, Palley (1993) attributes the asymmetry in Okun's coefficient to changes in both sectoral growth rates and labor force participation rates. Similarly, Mayes and Virén (2002) argue that rapid downturns in the economy have disproportionate downturn effects on unemployment because of a mismatch between the sectors and regions where the jobs and unemployment lie.

Other studies emphasize the asymmetic behavior of firms, which is based mostly on pessimism on the part of the employers: bad news is believed more quickly than good news. For example, Courtney (1991) explains that factor substitution during cycles accounts for the asymmetry in Okun's law, involving a non-constant relationship among labor market variables. Campbell and Fisher (2000) also maintain that contracting plants respond more than expanding plants to external shocks due to microeconomic asymmetries in adjustment costs.

Acknowledging asymmetry in the business cycle and Okun's law is important for two reasons. First, concerning empirical issues, ignoring asymmetry will lead to not only poor forecasting but also erroneous inferences in hypothesis testing. For example, Courtney (1991) suggests that imposing symmetry on the output–unemployment relationship results in serious underestimates of the unemployment rate increases during contractions and overestimates decreases in the unemployment rate during expan-

[8] Harris and Silverstone (2001), Lee (2000) and Virén (2001) developed an asymmetric version of the error–correction model.

sions. Second, knowledge of the extent of asymmetry in the output–unemployment relationship is useful in establishing structural policies such as labor market reforms and stabilization policies.

On the other hand, there is also an approach to regard the business cycle as three, rather than two, distinct phases: recessions, high–growth recoveries, and moderate–growth recoveries. Burns and Mitchell (1946, p.3) suggest that "a cycle consists of expansions ... followed by similarly general recessions ... and revivals which merge into the expansion phase of the next cycle." In addition, Schultze (1964, p.162) wrote that "A typical upturn, measured from trough to peak, normally encompasses two subphases: first a recovery of GNP to normal, and then a period of slower growth after normal capacity utilization is approached or surpassed." Sichel (1994) also finds that there are typically three phases of a business cycle and attributes this three phase pattern of the post-war period to swings in inventory investment.

The approach of dividing a cycle into three phases is appropriate to deal with the research question of this paper—detecting changed cyclical patterns in the labor market—in that slow output recovery in the early stage of expansion is what has been pronounced foremost in the most recent three business cycles. In particular, the division between early and late expansion has become important due to the extended duration of the business cycle during the Great Moderation.

At the same time, rapid output growth associated with financial bubbles represents another new aspect in the business cycle. The pattern of output growth in expansion described in the literature on three–phases of the business cycle has reverted to slow–growth recoveries followed by high–growth recoveries.

However, unlike for the bisectional case, there has been no attempt to measure Okun's coefficients using three phases. Again, a nonlinear business cycle does not necessarily ensure a nonlinear Okun's law if slack in job creation exactly reflects slow output growth. In this case, there would be no significance difference in Okun's coefficients between early and late expansions even if the patterns of output growth differ between the two phases. In this regard, estimating Okun's coefficient for early expansion is particularly important for checking whether a jobless recovery is a demand–side problem as Galí et al. (2012) and Ball et al. (2013) put it or a problem stemming from labor market institutional change.

To conduct detailed analysis for changed cyclical patterns in output-unemployment relationships, this paper proposes dividing the business cycle into three parts: (1) recessions (2) early expansions, and (3) late expansions. The baseline model (4.7) will be properly updated to capture the nonlinear Okun's coefficients using three phases—this will be discussed in the succeeding section. By doing so, we can reveal some hidden institutional change behind the Okun's coefficient measured for entire cycles.

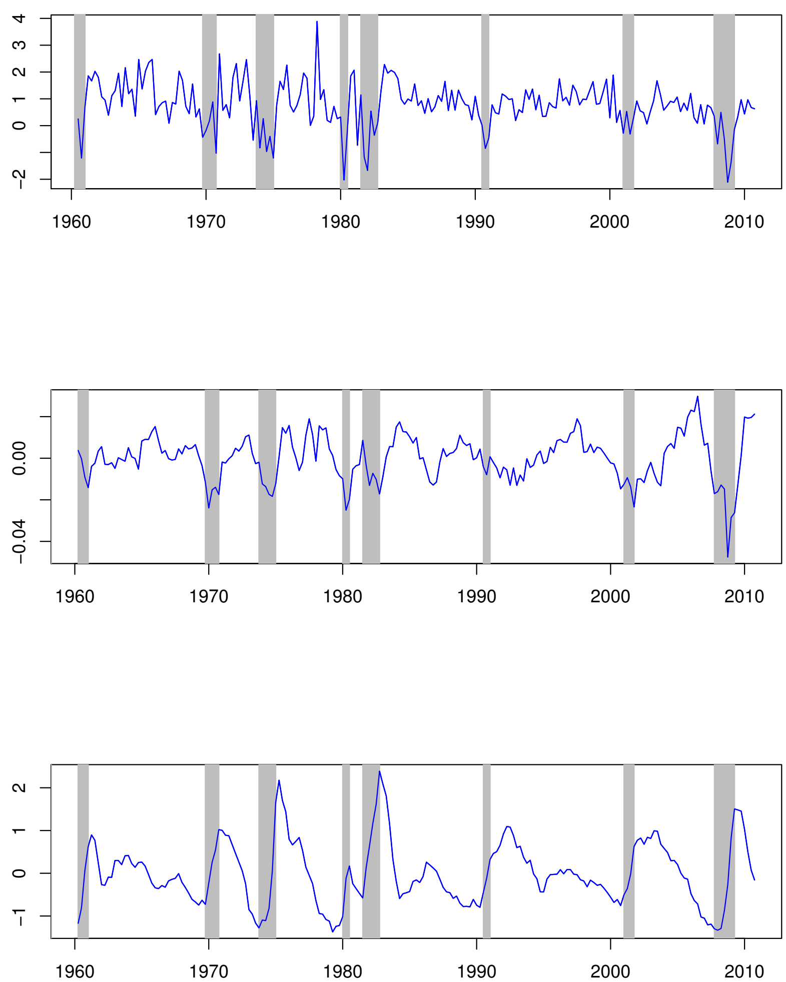
4.3.4 Identification of the Phase Dummy Variables

In dividing data into three sub-periods, the recession dummy is easily assigned by using NBER business cycle dating. However, there is no clear-cut way to set the turning point from early to late expansion. To obtain the threshold quarter, the literature on three–phase pattern highlights the peak–reverting behavior in which the growth rate is switched to low gear once the output level returns to its prior peak (Sichel, 1994). This aproach is based on Friedman (1969)'s plucking view on economic fluctuations. However, the turning point based on the level of output is not easily discernible during the Great Moderation era exhibiting prolonged duration of the cycle with less volatility (Figure 4.1 (a)).

More importantly, mean reverting behavior described in the literature is an immediate reaction of output which is more related to economic variables such as inventory.[9]

[9]For example, Sichel (1994), from his estimation, suggests 2 quarters after trough as the cutoff between fast and slow growth phases.

Figure 4.1: GDP Growth Rate, Profit Share, and Unemployment Rate



It is questionable whether firms' employment decisions are contingent mainly on the level of output.

A clue to identifying a turning point can be found in the literature on profit squeezing theory in which the profitability is a firms' crucial criteria for its employment decision. Boddy and Crotty (1975) and Goldstein (1999) showed that the late expansion period starts at that point where profit share declines and firms begin to reduce the size of employees. Basu et al. (2013) discussed that this mechanism is still operating although employees' bargaining power has deteriorated. In Figure 4.1 (b), an interesting pattern can be observed within the sub–phases of the upswing in profit share since it starts declining several quarters before the peak of the business cycle has been reached. Turning to the unemployment rate in Figure 4.1 (c), we see a different pattern: the unemployment rate starts increasing near the peak and then declines from the trough onwards until the next peak is reached. Boddy and Crotty (1975) highlighted these patterns as evidence for a profit squeezing mechanism which is operative in late expansion due to the low unemployment rate.

In this paper, I use Boddy and Crotty's method to draw a line between early and late expansions. They use the NBER nine–stage–cycle dating system created by Hultgren (1965) (Figure 4.2). In their dating system, Stage V contains only a quarter of the peak; stage IX contains only a quarter of the trough. Stages II, III, IV are the respective thirds of all the quarters between trough and peak; stages VI, VII, VIII are the thirds of all the quarters between peak and trough. Therefore, early expansion corresponds to stages I and II; late expansion, to stages III-V. Table 4.5 reports the number of quarters for each phase.

Figure 4.2: NBER Nine–stage–cycle Dating System

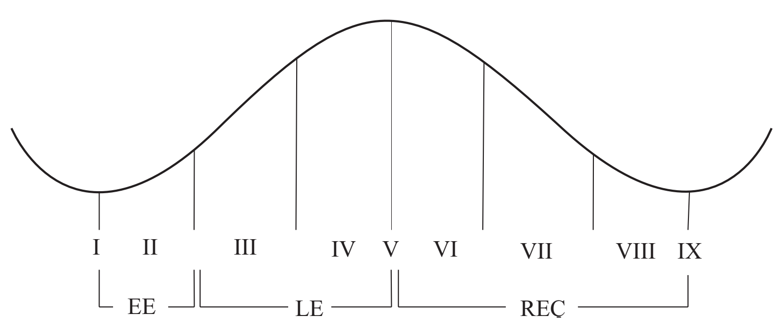


Table 4.5: Number of Quarters for Each Phase

	total quarters	REC	EE	LE
1963:I-1986:I	93	16	24	53
1986:I-2009:III	95	11	22	62

4.4 Empirical Results

Table 4.6 (b) is the result of the phase–breaking analysis. For the purpose of comparison, panel (a) is brought from panel (d) in Table 4.4, which is estimated from the baseline model (equation (4.7)). Table 4.7 only differs from Table 4.6 in that 7 quarters of historic turmoil during the Great Recession are excluded from the sample period.

Table 4.6: Results from Dynamic Version; Kalman Filter (1963:I – 2009:III)

(a) Coefficient for Entire Cycle

	1963:I-1986:I	1986:I-2009:III	Change
Y/H	0.14	-0.20	-0.34
H:	0.86	1.20	0.34
H/L	0.33	0.41	0.09
L/P	0.43	0.59	0.17
P/N	0.07	0.14	0.07

(b) Coefficient by Three Phases

	1963:I-1986:I			1986:I-2009:III			Change		
	REC	EE	LE	REC	EE	LE	REC	EE	LE
Y/H	0.04	0.12	0.29	-0.43	0.10	0.21	-0.47	-0.02	-0.08
H:	0.96	0.87	0.71	1.43	0.90	0.79	0.47	0.02	0.08
H/L	0.15	0.32	0.51	0.44	0.75	0.37	0.29	0.43	-0.14
L/P	0.55	0.62	0.21	0.87	0.48	0.24	0.31	-0.14	0.03
P/N	0.21	0.00	0.01	0.12	-0.09	0.11	-0.09	-0.09	0.10

Note: REC stands for recessions; EE is early expansions; LE is late expansions. Y/H refers to output per hour; H, aggregate hours; H/L, hours/employee; L/P, employment rate; P/N, labor force participation rate.

Table 4.7: Results from Dynamic Version; Kalman Filter (1963:I – 2007:IV)

(a) Coefficient for Entire Cycle

	1963:I-1986:I	1986:I-2007:IV	Change
Y/H	0.14	0.02	-0.12
H:	0.86	0.98	0.12
H/L	0.33	0.36	0.04
L/P	0.43	0.44	0.02
P/N	0.07	0.13	0.06

(b) Coefficient by Three Phases

	1963:I-1986:I			1986:I-2007:IV			Change		
	REC	EE	LE	REC	EE	LE	REC	EE	LE
Y/H	0.04	0.12	0.29	0.20	-0.09	0.19	0.16	-0.21	-0.10
H:	0.96	0.87	0.71	0.80	1.09	0.81	-0.16	0.21	0.10
H/L	0.15	0.32	0.51	0.21	0.85	0.42	0.07	0.54	-0.09
L/P	0.55	0.62	0.21	0.30	0.49	0.29	-0.25	-0.13	0.08
P/N	0.21	0.00	0.01	0.08	-0.09	0.04	-0.13	-0.09	0.03

Comparing Table 4.6 and Table 4.7 raises an important issue regarding the periodization of macroeconomic research. Dropping the recession quarters at the onset of the Great Recession makes huge difference particularly to the movement of the employment rate, one of important variables in which the policymakers are always interested, although the question of the increased responses of aggregate hours variable still remains. Not only the change in the responses of employment rate during recessions turned the sign from +0.31 to –0.25 (panel (b)), the changes in overall responses is reduced from 0.17 to 0.02 (panel (a)). A possible inference from this comparison is that the increased responses of the employment rate for entire cycle can be solely attributed to the unprecedented high responses of a single event: the Great Recession. Therefore, an analysis encompassing both the Great Moderation and Great Recession can be misleading: certain labor market dynamics of the Great Moderation can be overcurtained by dramatic change of the Great Recession.

Table 4.8: Results from Dynamic Version; HP Filter (1963:I – 2009:III)

(a) Coefficient for Entire Cycle

	1963:I-1986:I	1986:I-2009:III	Change
Y/H	0.12	-0.12	-0.24
H:	0.88	1.12	0.24
H/L	0.33	0.40	0.07
L/P	0.42	0.51	0.08
P/N	0.08	0.12	0.04

(b) Coefficient by Three Phases

	1963:I-1986:I			1986:I-2009:III			Change		
	REC	EE	LE	REC	EE	LE	REC	EE	LE
Y/H	0.02	0.12	0.24	-0.26	-0.01	0.03	-0.28	-0.13	-0.21
H:	0.98	0.88	0.76	1.26	1.01	0.97	0.28	0.13	0.21
H/L	0.16	0.35	0.47	0.37	0.72	0.46	0.21	0.37	-0.01
L/P	0.56	0.59	0.25	0.66	0.50	0.38	0.10	-0.09	0.13
P/N	0.22	-0.02	0.03	0.08	-0.05	0.14	-0.14	-0.03	0.11

In Table 4.8 and Table 4.9, Hodrick–Prescott filtering method is applied to detrend data. Between two methods (Table 4.6 and Table 4.8), the results from the first sample (1963:I–1986:I) is almost same. On the other hand, there is a small discrepancy in the results for the second sample (1986:I–2009:III). Changes in the aggregate hours variables are amplified if Kalman filtering methods is applied. This discrepancy results from the different performance of two filtering methods at the end of sample (see Apendix F). In this section, the main result will be discussed with the result from Hodrick–Prescott filtering method (Table 4.9). The observation up to the fourth quarter in 2007 will be countered.

The Employment Rate

The coefficients for the employment rate (Okun's coefficient) reduced during recession and early expansion. Especially, the reduced coefficient during early expansion

Table 4.9: Results from Dynamic Version; HP Filter (1963:I – 2007:IV)

(a) Coefficient for Entire Cycle

	1963:I-1986:I	1986:I-2007:IV	Change
Y/H	0.12	-0.03	-0.15
H:	0.88	1.03	0.15
H/L	0.33	0.39	0.07
L/P	0.42	0.48	0.05
P/N	0.08	0.13	0.05

(b) Coefficient by Three Phases

	1963:I-1986:I			1986:I-2007:IV			Change		
	REC	EE	LE	REC	EE	LE	REC	EE	LE
Y/H	0.02	0.12	0.24	0.18	-0.14	0.06	0.16	-0.25	-0.18
H:	0.98	0.88	0.76	0.82	1.14	0.94	-0.16	0.25	0.18
H/L	0.16	0.35	0.47	0.24	0.80	0.49	0.08	0.45	0.02
L/P	0.56	0.59	0.25	0.29	0.48	0.35	-0.27	-0.11	0.10
P/N	0.22	-0.02	0.03	0.08	-0.07	0.06	-0.14	-0.05	0.03

represents that a jobless recovery is intrinsically a labor market problem as well as a demand side problem. The drops of the coefficients were made up by the mild increase in the late expansion phases (+0.10) so that overall coefficient increased by 0.05 (panel (a)).

Hours per Employee

Less attention has been paid so far to hours per employee since this variable has been regarded to move along with the employment rate showing clear procyclicality. This being so, the size and movement of manhour productivity (Y/H) was central issue in the debate on the source of labor productivity between the RBC theory and the labor hoarding proponents. Even to the labor hoarding proponents, firms' labor hoarding behavior is mainly understood as maintaining certain size of employee by adjusting their effort level, which is an unobserved component in labor productivity.

In contrast, the changes in hours per employee for the recessions and the early expansions (0.08 and 0.45, respectively in Table 4.9) obviously refutes the previous patterns described above. In particular, salient increases during early expansion can be interpreted as a firm's ability to increase working hours of existing workers. Conceivable hypothesis for this observation is that, under the flexible labor market, labor hoarding mechanism is processed via flexible working hours explicitly, rather than via adjustment of unobservable effort level. It is noteworthy that this new pattern in hours per employee cannot be detected from the coefficients for entire cycle, in which only shows similar increases (+0.07 in panel (a)) along with the employment rate (+0.05).

Output per Hour and Aggregate Hours

Gordon (2010, 2011) points out reduced procyclicality of labor productivity (–0.15 in panel (a)) and increased responses of aggregate hours (+0.15 in panel (a)) due to the flexible labor market. From the phase–breaking results in panel (b), we can identify the source of the increase. In fact, the biggest changes in aggregate hours have taken place during both the early and late expansions (0.25 and 0.18, respectiviely), rather than the recessions.

Concretely, during the early expansions, increased responses of hours per employee (+0.45) is the main cause behind the scene. In the case of the late expansion, more reactive employment rate (+0.10) is main factor of reduced procyclicality of labor productivity. These results imply that the driving factors for the increased responses of aggregate hours are the *under–hiring* phenomenon in the early expansions—known as jobless recovery—and *over–hiring* in the late expansions.

Summary and Interpretation of the Results

There are three main findings: (1) The Great Recession alone raised Okun's coefficient. If we exclude this period from the data, there is no evidence that Okun's coefficient has been increased. (2) The main determining factor for the increased coefficient for aggregate hours is increased responsiveness of the employment rate during late expansions. (3) A secondary determining factor for more reactive aggregate hours is the increased responsiveness of hours per employee in early expansions.

These findings do not jibe with the flexible labor market hypothesis that focuses mostly on firms' aggressive firing behavior during recessions.[10] Particularly, the first point above is a caveat not only to policy researchers of Okun's law but also to macroeconomists, in general, dealing with the time span encompassing before and after the Great Recession without setting any structural break. As we confirmed from the phases–breaking analysis, inclusion of the recession 2007–2008 into the verge of a data set may lead to distorted conclusions about the real characteristics of a labor market.

Setting aside the huge statistical impact from the single event of the 2008 crisis, this paper does not deny the changed characteristics in the U.S. labor market after 1985. It also is not consistent with the argument that Okun's law is still relevant for the U.S. economy (Ball et al., 2013). Indeed, the interaction between the labor market and goods market was changed. Nevertheless, the empirical evidence for the argument that firms' *over–firing* with weakened labor hoarding during recessions caused increased responsiveness of both aggregate hours and employment rates is weak. Rather, as stated above, driving factors for the increased responses are firms'

[10]Reich (2012) also points out that factors undermining labor such as de-unionization have not made the labor market more responsive to cyclical changes in GDP.

under–hiring behavior in early expansions (jobless recovery) and *over–hiring* in late expansions.[11]

Although any discourses on the flexible labor market actually infuse us with a picture of mass firing during an economic downturn along with an overall deterioration of the employment protection legislation, passing legislation is one thing but actively executing it is another. Two circumstances contributed to this disconnect between expectation and reality. First, real wage flexibility and firms' dismissal policies could be complementary to a certain degree (Galí and van Rens, 2010; Oh, 2016). Second, prolonged macroeconomic stability from around 1985 to 2007 (known as the Great Moderation) actually created a relatively tranquil labor market especially during recessions.[12]

Macroeconomists have paid less attention to nonlinearity during an expansion phase. Of course, jobless recovery during early expansion and over hiring during late expansion—the phenomena affecting nonlinear features in expansion—have been discussed separately. This paper synthesizes these two phenomena into one picture.

Existing theories explain the jobless recovery phenomenon as the consequences of institutional changes such as the growing service sector, global outsourcing, maximizing of shareholder value or flexible labor markets. Galí et al. (2012) and Ball et al. (2013), on the other hand, argue that slow recovery in job creation simply reflects slower recovery in output than previously. One of the major findings of this paper—the main determining factor of more reactive aggregate hours is the increased responsiveness of hours per employee in early expansions—supports the institutional change hypothesis. If the hypothesis of slow recovery in output were convincing, the

[11] In this respect, the EOE dummy in Gordon (2010, 2011) by which he tries to control the purportedly unusual tendency toward over-hiring and subsequent under-hiring obliterates the cyclical changes in the labor market which are important in our phases–breaking analysis.

[12] Some economists emphasizing the supply side of the economy maintain inverse causality: a flexible labor market contributed to the Great Moderation (Galí and Gambetti, 2009; Stiroh, 2009). Oh (2016) provides an alternative view from a demand side perspective.

pre and post 1985' Okun's coefficients for early expansion would have shown similar numbers.

Over–hiring during late expansions confirmed by one of the findings—the main determining factor for the increased coefficient for aggregate hours is increased responsiveness of the employment rate during late expansions—can also be explained by institutional change. This can be attributed to the weakened reserve army of the labor effect which becomes salient as an economy approaches full employment. As discussed above, Boddy and Crotty (1975) and Goldstein (1999) showed that firms begin to reduce the size of employees several quarters before a peak since firms are concerned about high labor costs squeezing their profits. Since the overall bargaining power of employees has waned, firms can increase the size of employees with less concern.

4.5 Concluding Remarks

In this paper, I tested the argument that after 1985, both Okun's coefficient and the coefficient for aggregate hours increased because firms can fire employees with less firing costs under a flexible labor market. The novelty of my research is measuring the coefficients by the three phases of a business cycle: recession, early expansion and late expansion.

The most influential explanation for increased Okun's coefficients post–1985 is that labor markets became flexible and firms can easily fire employees in recessions. I found that the main determining factor for an increased coefficient for aggregate hours is the increased responsiveness of the employment rate during late expansions; the increased responsiveness of hours per employee in early expansion is another main determining factor for more reactive aggregate hours. These findings conflict with the flexible labor market hypothesis that focuses mainly on firms' firing behaviors during recessions.

Results from this paper can shed light on the question regarding the stability of Okun's law over time. For example, using a 10 year rolling regression, Knotek (2007) and Meyer and Tasci (2012) found that Okun's law is valid only in recessions, but varies during expansions. This variation might be explained by the increased degree of firms' nonlinear reaction within expansion phases.

CHAPTER 5
CONCLUSION

This dissertation examines the macroeconomic impact of reduced labor market friction on the U.S. business cycle after the mid–1980s. From the theoretical model developed in essay 1 and its empirical tests conducted in essay 1 (using univariate time series models) and essay 2 (using a multivariate structural VAR model), I posit that during the Great Moderation, real wage flexibility played a major role in stabilizing the U.S. economy; employment flexibility has contributed to destabilizing the economy during the Great Recession.

For the Great Moderation, empirical results in essays 1 and 2 suggest that despite the strengthened reserve army of labor effect, the labor hoarding effect was not weakened. This result is in accordance with the result in essay 3 if we see the reserve army of labor effect as being pronounced around full employment (late expansions) and the labor hoarding effect as being salient during recessions. In essay 3, I show that during the Great Moderation, Okun's coefficient—the response of labor markets to changes in goods markets—for late expansions increased (the strengthened reserve army of labor effect); the coefficient for recessions did not increase (the continuing labor hoarding effect).

Rather than highlighting employment flexibility, this dissertation identifies the role of real wage flexibility as a factor stabilizing an economy since real wage flexibility functions as an autonomic stabilizer. This conclusion refutes those viewpoints regarding labor market flexibility as an important factor mitigating macroeconomic shock, especially during the Great Moderation (Burnside et al., 1990; Galí and Gambetti, 2009).

As for policy implication, this dissertation questions policy recommendations based on the (supply-side) viewpoint that weakening the protection of workers (employment flexibility) is a necessary condition for macroeconomic stability (OECD, 1997, for example). The severe downturn followed by a sluggish recovery in the U.S. economy during the course of the Great Recession, contrasting to the German experience, also underpins this question (Burda and Hunt, 2011; Rinne and Zimmermann, 2011). In a recession, fiscal and monetary policies alone are not very effective unless active labor market policy measures are also implemented. Government can play a crucial role by inducing firms to hoard their employees via an active labor market policy.

There are several points to be developed in my future research. First and foremost, in this dissertation, by focusing on short–run variations in the utilization rate of labor, I did not address the issue of changes in labor productivity caused by a flexible labor market. Whether flexible labor markets actually promote economic growth has been long debated. For example, OECD (1994) asserts that a flexible labor market brings about a positive effect on total factor productivity, hence economic growth. On the other hand, Naastepad (2006); Storm and Naastepad (2009); Vergeer and Kleinknecht (2010) maintain that labor market deregulation causes a negative impact on labor productivity growth, hence economic growth, by crowding out induced technical changes. For complete evaluation of labor market policy promoting flexibility, the growth issue cannot be ignored.

Second, empirical work on real wage flexibility needs to be improved. Particularly, one of the obstacles in this work is finding a relevant proxy variable for the rate of capital utilization with which we can measure the degree of mark–up pricing of firms. As Blanchard (2008) pointed out, theories on mark–up pricing are one of the unclear areas in macroeconomics because firms' mark–up pricing is not directly observable from macroeconomic data.

Finally, I discussed the difficulty of achieving reliable empirical work by the severe asymmetry in the business cycle and lack of observations during the Great Recession. A nonlinear approach such as a threshold autoregression (TAR) model or a threshold vector autoregression (TVAR) model can deal with any statistical aberration resulting from the depth of the current recession. This task will be the subject of my future research.

APPENDIX A

FUNCTIONS AND PARAMETER VALUES IN SIMULATION (BENCHMARK CASE)

(3D Model)

$$\frac{S}{K} = \lambda l(0.05 + 0.7(1 - \frac{w}{\lambda})) \tag{A1}$$

$$\frac{I}{K} = l(1.2(l - 0.5)) \quad s.t. \;\; l > 0.5 \tag{A2}$$

$$\hat{K} = I/K \tag{A3}$$

$$\hat{e} = \hat{L} - n \tag{A4}$$

$$\hat{L} = \frac{0.4}{1 + exp(-15(\lambda - 0.6 + 0.1ln(1 - e)))} - 0.07 \tag{A5}$$

$$\hat{w} = -0.7(w - \alpha_o) - 0.226\lambda l + 0.08e \tag{A6}$$

$$I = S \tag{A7}$$

$$l(0) = 0.6, \quad e(0) = 0.98, \quad w(0) = 0.6, \quad n = 0.034, \quad \alpha_o = 0.6$$

(2D Model)

Since the real wage rate is assumed to be fixed, (A1) is used with a modification, $w = \bar{w} = 0.6$, while (A6) is excluded. Besides these, all functions and initial values are exactly the same as the 3D mode above.

The saving function (A1) is slightly revised to allow for workers' savings which will make the simulation more realistic. 0.05 is the saving rate from wage income; 0.7, the difference between the saving rate from profit and that from wage income.[1] Note that the latter parameter is positive since the saving rate from the profits (0.75) exceeds that of wages (0.05) by the neo–Passinetti theorem. The restriction in the investment function (A2) is to guarantee a positive amount of the investment. The employment expansion function (A5) takes a logistic functional form in which the lower bound is -0.07; the upper bound is $0.33(= 0.4 - 0.07)$; the maximum value of $\partial\hat{L}/\partial\lambda$ is 1.5; the maximum value of $\partial\hat{L}/\partial ln(1-e)$ is 0.15 where $ln(1-e)$ is a log value of the unemployment rate.

[1] $S = Y(s_w(1-\pi) + s_p\pi)$ where s_w is the saving rate from wages and s_p is the saving rate from profits. Rearranging it yields $S/K = \lambda l(s_w + (s_p - s_w)\pi)$ where $1 \geq s_p > s_w \geq 0$.

APPENDIX B

STEADY STATE EQUILIBRIUM AND COMPARATIVE STATIC ANALYSIS (2D MODEL)

(Steady State Equilibrium)

To obtain a long–run steady state equilibrium, the functions in appendix A are used. For the sake of comparative static analysis, the employment expansion function (2.15″) will be used rather than (A5).

$$\hat{L} = h'(\lambda, e) = \frac{0.4}{1 + exp(-15((1+\eta_1)\lambda - 0.6 + 0.1(1+\eta_2)ln(1-e)))} - 0.07 \quad (2.15'')$$

Let $\hat{l} = \hat{e} = 0$ from (2.10)–(2.11). Then $lf(l) = n$ holds and $l^* \fallingdotseq 0.55$ can be obtained. (Note that l should be a positive value.) From (A1) with $w = \bar{w} = 0.6$ and (A2), it follows that $\lambda^* \fallingdotseq 0.64$. It is noteworthy that both l^* and λ^* are independently determined from the parameters in the saving and investment functions along with the natural rate of growth (n), *i.e.* the conditions in the goods market. On the other hand, the e^* is contingent on the conditions of the labor market. e^* can be calculated by plugging the obtained λ^* into either $\hat{l} = 0$ or $\hat{e} = 0$. Using simple math to $\hat{e} = h(\lambda^*, e) - n = 0$ yields:

$$e^* = 1 - T; \quad T \equiv exp\Big(\frac{ln\Big(\dfrac{0.4}{0.07+n} - 1\Big)}{-1.5(1+\eta_2)} - \frac{(1+\eta_1)\lambda^* - 0.6}{0.1(1+\eta_2)}\Big) > 0 \quad s.t.\ n < 0.47 \tag{B1}$$

Applying the functions and parameters in Appendix A, $e^* \fallingdotseq 0.92$.

(Comparative Static Analysis)

From (B1), it is readily seen that the following partial derivatives hold.

$$\frac{\partial e^*}{\partial \eta_1} = \Big(\frac{\lambda^*}{0.1(1+\eta_2)}\Big)T > 0 \tag{B2}$$

$$\frac{\partial e^*}{\partial \eta_2} = -\Bigg(\frac{ln\Big(\dfrac{0.4}{0.07+n} - 1\Big)}{1.5(1+\eta_2)^2} + \frac{(1+\eta_1)\lambda^* - 0.6}{0.1(1+\eta_2)^2}\Bigg)T \lesseqgtr 0 \tag{B3}$$

The higher h_λ (higher 'η_1') due to an introduction of flexible employment unambiguously raises the long–run steady state value of the employment rate. However, the direction of change incurred by a lower h_e is uncertain since it depends on the sign of the terms inside the parenthesis. In our numerical example, $(1+\eta_1)\lambda^* - 0.6$ is positive by chance and, thus, $\partial e^*/\partial \eta_2$ is negative.

Additionally, (B1) can be modified to analyze the increased speed of adjustment parameters and its impact on the long–run steady state equilibrium of e. Assume that $\eta_1 = \eta_2 = 0$.

$$e^* = 1 - T; \quad T \equiv exp\Bigg(\frac{ln\Big(\dfrac{0.4\Gamma}{0.07\Gamma + n} - 1\Big)}{-1.5} - \frac{\lambda^* - 0.6}{0.1}\Bigg) > 0 \quad s.t.\ n < 0.47 \tag{B1$''$}$$

Then the following inequality holds:

$$\frac{\partial e^*}{\partial \Gamma} = \Big(\frac{0.4n}{1.5(0.07\Gamma + n)(0.33\Gamma - n)}\Big)T > 0 \tag{B4}$$

APPENDIX C

PROOFS OF PROPOSITIONS

Proof of Proposition 2. First, we have to derive a concrete function of (2.27) using the functions and parameters in Appendix A. Combining (A1), (A2), (A7) and $l = l^*$, we get

$$\lambda(l^*, w) = \frac{1.2(l^* - 0.5) + 0.7w}{0.05 + 0.7} \tag{C1}$$

Then, $h(\lambda(l^*, w), e) = n$ corresponds to

$$\frac{0.4}{1 + exp(-15((1+\eta_1)\left(\frac{1.2(l^* - 0.5) + 0.7w}{0.05 + 0.7}\right) - 0.6 + 0.1(1+\eta_2)ln(1-e)))} - 0.07 = 0.034 \tag{C2}$$

Arranging it with respect to w while holding $e = 0$ gives us the y–intercept of $\hat{e}|_{l=l^*}$=0.

$$F_1(0) = -\frac{1}{14(1+\eta_1)}[ln37 - ln13 + 0.6] - \frac{1.2(l^* - 0.5)}{0.7} \tag{C3}$$

Therefore,

$$\frac{\partial F_1(0)}{\partial h_\lambda} \iff \frac{\partial F_1(0)}{\partial \eta_1} > 0$$

In a similar fashion, the concrete function of (2.28) is:

$$-\theta w - \beta \frac{1.2(l^* - 0.5) + 0.7w}{0.05 + 0.7} l^* + \gamma e = 0 \tag{C4}$$

Rearranging it with respect to w is:

$$w = \left(\frac{\gamma}{\theta + \frac{0.7 \cdot \beta l^*}{0.05 + 0.7}} \right) e - \left(\frac{\beta}{\theta + \frac{0.7 \cdot \beta l^*}{0.05 + 0.7}} \right) \left(\frac{1.2(l^* - 0.5)}{0.05 + 0.7} \right) l^*$$

Then, y–intercept of $\hat{w}|_{l=l^*}=0$ is:

$$F_2(0) = -\left(\frac{\beta}{\theta + \frac{0.7 \cdot \beta l^*}{0.05 + 0.7}} \right) \left(\frac{1.2(l^* - 0.5)}{0.05 + 0.7} \right) l^* \tag{C5}$$

Therefore, the following inequality hold.

$$\frac{\partial F_2(0)}{\partial \beta} < 0$$

□

Proof of Proposition 3. The slope of $\hat{w}|_{l=l^*}=0$ is:

$$F_2'(e) = \frac{\partial F_2(e)}{\partial e} = \left(\frac{\gamma}{\theta + \frac{0.7 \cdot \beta l^*}{0.05 + 0.7}} \right) \tag{C6}$$

It follows that

$$\frac{\partial F_2'(e)}{\partial \beta} = \frac{-\gamma(M-\theta)}{\beta M^2} < 0, \qquad \frac{\partial F_2'(e)}{\partial \gamma} = \frac{1}{M} > 0 \tag{C7}$$

where $M \equiv \theta + \frac{0.7 \cdot \beta l^*}{0.05 + 0.7} > 0$. If both β and γ increase by the same amount, whether the slope of $F_2(e)$ becomes steeper or not is contingent on the absolute values of the two derivatives in (C7). It becomes steeper if

$$\frac{1}{M} - \frac{\gamma(M-\theta)}{\beta M^2} > 0 \iff (\beta - \gamma)M + \gamma\theta > 0 \tag{C8}$$

Case 1. $\beta > \gamma$. The condition (C8) unambiguously holds.

Case 2. $\beta < \gamma$. The inequality in (C8) is ambiguous. □

APPENDIX D

HOPF BIFURCATION CONDITION FOR LOCAL STABILITY (3D MODEL)

The Jacobian matrix of this system is

$$J(l,e,w) = \begin{bmatrix} l(h_\lambda \lambda_l - f - lf') & lh_e & lh_\lambda \lambda_w \\ eh_\lambda \lambda_l & eh_e & eh_\lambda \lambda_w \\ -w(\beta l \lambda_l + \beta \lambda) & w\gamma & -w(\theta + \beta l \lambda_w) \end{bmatrix} = \begin{bmatrix} + & - & + \\ + & - & + \\ - & + & - \end{bmatrix} \tag{D1}$$

The necessary and sufficient Routh–Hurwitz conditions for all the roots to have negative real parts so that the local stability of this system is acquired are $TrJ < 0$; $\sum_{i=1}^{3} J_i > 0$ (where J_i's are the first principal minors of J matrix); $DetJ < 0$; $-TrJ(\sum_{i=1}^{3} J_i) + DetJ > 0$.

To have a limit cycle, the system needs a negative real root and a pair of imaginary roots which can be ensured by necessary and sufficient conditions: (1) $TrJ < 0$; (2) $\sum_{i=1}^{3} J_i > 0$; (3) $DetJ < 0$; (4) $-TrJ(\sum_{i=1}^{3} J_i) + DetJ = 0$.

Let us define

$$b_1 \equiv h_\lambda \lambda_l - f - lf' > 0$$

$$b_2 \equiv \beta l \lambda_l + \beta \lambda > 0$$

$$b_3 \equiv \theta + \beta l \lambda_w > 0$$

Then, the dynamic system shows a limit cycle if and only if

$$
\begin{aligned}
&(1)\ TrJ = lb_1 + eh_e - wb_3 < 0\\
&(2)\ \Sigma_{i=1}^{3} J_i = -leh_e(f + lf') - lw(b_1 b_3 - h_\lambda \lambda_w b_2) - ew(h_e b_3 + h_\lambda \lambda_w \gamma) > 0\\
&(3)\ DetJ = lew(h_e b_3(b_1 + h_\lambda \lambda_l) + h_\lambda \lambda_w \gamma(f + lf')) < 0\\
&(4) - TrJ(\Sigma_{i=1}^{3} J_i) + DetJ = leh_e(f + lf')(lb_1 + eh_e - wb_3)\\
&\qquad + lw(b_1 b_3 - h_\lambda \lambda_w b_2)(lb_1 - wb_3) + ew(eh_e - wb_3)(h_e b_3 + h_\lambda \lambda_w \gamma)\\
&\qquad - lewh_e b_3(f + lf') - lewh_\lambda \lambda_w(h_e b_2 - h_\lambda \lambda_l \gamma) = 0
\end{aligned}
\tag{D2}
$$

APPENDIX E

DATA SOURCES IN CHAPTER 2

All the series are quarterly data.

(Employment Expansion Function)

y: real GDP (Billions of Dollars) (A191RX1)

L: civilian employment (Thousands of Persons) (LNS12000000)

λ: labor productivity; y divided by hours of total economy which is unpublished series by BLS

e: 1 – civilian unemployment rate (LNS14000000)

GM: 1 if years are 1984:1 – 2007:4; 0, otherwise

GR: 1 if years are 2008:1 – 2015:2; 0, otherwise

(Real Wage Phillips Curve)

y: (i) nonfarm business sector–real output (Index 2009=100) (OUTNFB) (ii) capacity utilization of total industry (TCU)

λ: real output per hour of all persons–nonfarm business (OPHNFB)

e: 1 – civilian unemployment rate (LNS14000000)

w: real compensation per hour of nonfarm business sector (Index 2009=1) (COMPRNFB)

uc: unit labor cost of nonfarm business sector (ULCNFB)

F&E: the difference between the rates of change in the overall PCE deflator and the core PCE deflator

APPENDIX F

KALMAN FILTERING

The detrending method used in this paper is Kalman filter rather than Hodrick-Prescott filter which is conventionally used. H–P filter has the shortcoming that not only it overestimates the cyclical component but also it distorts the cyclical movement in the edges of a series.[1] The strength of Kalman filtering method is that any outside information can be used to control for determinants of actual changes. This paper, following Gordon (2010, 2011), uses the unemployment gap, the differences between the actual unemployment rate and the time-varying natural rate of unemployment, as outside information.

In the filtering procedure, the system must be written in a state-space representation (see Hamilton (1994, chapter 13)).

$$\Delta x_t = \alpha_t + \beta_t Z_t + \epsilon_t, \qquad \epsilon_t \sim N(0, \sigma^2) \tag{F1}$$

$$\alpha_t = \alpha_{t-1} + \mu_t, \qquad \mu_t \sim N(0, \tau^2) \tag{F2}$$

where explanatory variable Z_t is the unemployment gap. Equation (F1) is known as the observation equation and equation (F2) is the state equation which is a *random walk plus noise model.* The R package *dlm* provides an integrated environment for Kalman filtering (see Petris et al., 2009). Basic observation and state equations that *dlm* recognizes take the following forms, respectively.

---

[1] Truncating the series up tp 2009:III also resolves this distortion problem.

$$Y_t = F_t\theta_t + \upsilon_t, \qquad \upsilon_t \sim N_m(0, V)$$

$$\theta_t = G_t\theta_{t-1} + w_t, \qquad w_t \sim N_p(0, W)$$

$$\theta_0 \sim N_P(m_0, C_0)$$

where θ_0 is the initial mean and distribution of p-dimensional state vector. Then, a *dlm* is completely specified once the matrices F, V, G, W, m_0, and C_0 is given. The equations (F1) and (F2) can be specified as follows.

$$\Delta x_t = \begin{bmatrix} 1 & Z_t \end{bmatrix} \begin{bmatrix} \alpha_t \\ \beta_t \end{bmatrix} + \epsilon_t$$

$$\begin{bmatrix} \alpha_t \\ \beta_t \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} \alpha_{t-1} \\ \beta_{t-1} \end{bmatrix} + \mu_t$$

Thus, the matrices F and G are specified. Matrix V and W, which are the variance of ϵ_t and μ_t respectively, affect the smoothness of a trend. Unlike H–P filter, there is no generally agreed upon rule regarding the decision of these smoothing parameters since not only the sample variance of a variable in question but also the variance of the explanatory variable should be considered. The rule of thumb that Gordon suggests as a smoothness prior is to rule out sharp quarter-to-quarter zig-zags movements in trend. Finally, the values for m_0 and C_0 can be easily obtained from the observations 6 quarters prior to year t.

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