Jobless Recoveries and Skill-Biased Sectoral Shift

Zhen Cui

This study first defines skill-biased sectoral shift using two stylized facts. Specifically, the shift features the service sector having more college workers and becoming more productive than the goods sector. Subsequently, this study develops a two-sector model in which the shift is incorporated via a sector-specific labor adjustment cost and a reallocation shock. Although the model generates a jobless recovery, its implications on unemployment duration are not entirely consistent with the data. Therefore, this study considers its sectoral theory as promising, but does not claim that such theory fully explains jobless recoveries, especially when the existence of many alternative explanations is considered.

Keywords: Jobless recovery, Sectoral shift, Reallocation shock, Labor adjustment cost

JEL Classification: E24, E32

I. Introduction

Employment recovery in the U.S. has been painfully slow after each post-1990 recession, and high unemployment persists long after the rebound of total output. This phenomenon is called "jobless recovery," which this study aims to investigate from a sectoral perspective using both empirical evidence and a structural model.

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First, I establish two stylized facts using the Integrated Public Use Microdata Series-Current Population Survey (IPUMS-CPS), which states that (1) in contrast to the goods sector, college workers have predominated in the service sector workforce since 1990; and (2) skill premium has increased faster in the service sector than in the goods sector. Fact 1 suggests that more skilled workers have managed to join the service sector, whereas Fact 2 suggests that the employment of skilled workers has made the service sector more productive than the goods sector. I define these facts as a skill-biased sectoral shift (SBSS), which prevents those laid-off unskilled workers in the goods sector from relocating to the service sector. Thus, unemployed workers from the goods sector take a longer time to find jobs, thereby delaying the recovery of aggregate employment.

Second, I build a two-sector model to generate a jobless recovery by considering the stylized facts. Particularly, the baseline model has a zero labor adjustment cost and is only subject to an aggregate productivity shock. The SBSS is then incorporated into the baseline model via two elements. Fact 1 implies that the increasing educational barrier has also increased the costs for unemployed workers from the goods sector to find jobs in the service sector. Therefore, the first element is a sector-specific labor adjustment cost. Fact 2 implies higher productivity gains from hiring skilled labor in the service sector than in the goods sector. Therefore, the second element is a reallocation shock that makes productivity higher in the service sector than in the goods sector while keeping aggregate productivity intact. The baseline model is calibrated using post-1990 data. The SBSS-embedded model adopts the baseline calibration, thereby making SBSS the sole differentiating factor. The simulation shows a jobless recovery only in the SBSS-embedded economy.

To generate a jobless recovery, a model needs a mechanism that decouples the movements of output and employment. Such mechanism is achieved by the combination of reallocation shock and adjustment cost. The reallocation shock makes labor more productive in the service sector than in the goods sector, in which the output and employment are increased in the former and reduced in the latter. In the calibrated model, the service sector has a bigger production share of total output than the goods sector. Therefore, the increase in the output of the service sector overwhelms the decrease in the output of the goods sector, after which the total output increases. Given that the adjustment cost hinders labor from moving from the goods sector to the service sector, the decrease in employment in the goods sector overwhelms the increase in employment in the service sector, after which the aggregate employment decreases. As a result, an increase in the total output is accompanied by a decrease in the aggregate employment.

The rest of this paper is organized as follows. Section II relates this study to the existing literature. Section III provides empirical evidence on jobless recoveries and SBSS. Section IV outlines the two-sector model. Section V details the calibration, and Section VI describes the simulation results. Section VII discusses some implications of the model and presents empirical evidence to support the sectoral explanation. Section VIII concludes.

II. Related Literature

Linking sectoral shifts to the cyclicality of the aggregate labor market is not a novel approach (Lilien 1982; Abraham, and Katz 1986). Recessions tend to hit the goods sectors harder than the service sectors and result in higher unemployment in the former. Given that an unemployed worker in one sector needs time to find a job in another sector, the aggregate unemployment remains high for a long period. Several studies have revisited this sectoral explanation for the recent jobless recoveries.

Groshen, and Potter (2003) define structural change as the permanent job relocation from one industry to another. Using payroll data from 70 industries, they show that structural change has been intensifying in the U.S. since the early 1990s, thereby causing jobless recoveries.[1] Andolfatto, and MacDonald (2006) use a two-sector model to show that a slowly diffusing technological shock favoring one sector can induce a jobless recovery when combined with time-consuming job search.[2] Garin *et al.* (2013) define reallocation shock as one that raises the productivity of one sector relative to another but leaves the aggregate productivity intact. They build a two-island model in which the reallocation shock during a recession motivates workers in the relatively less productive island to move to the relatively more productive island. However, these workers have to experience a long period of unemployment

[1] Aaronson *et al.* (2004) contest such finding.

[2] They also present a non-sectoral model with costly human capital accumulation and show that a technological shock of the same nature can induce a jobless recovery. Therefore, sectoral shifts are only necessary for generating a jobless recovery.

before they can join the production on the other island, thereby generating a jobless recovery.

This paper complements the above studies in several ways. First, it provides empirical evidence to support the presence of reallocation shocks. A widening skill premium gap implies greater productivity gains in the service sector than in the goods sector. Second, this paper proposes a potential cause of the reallocation shock. The service sector starts to employ more college workers than the goods sector, thereby increasing the productivity in the former relative to the latter. Third, this paper proposes a two-sector model that generates jobless recoveries. Although a reallocation shock is used to break the co-movement of output and employment, the model considers workers of different skills and uses micro-founded adjustment costs to delay intersectoral labor relocation. In Andolfatto, and MacDonald (2006) and Garin *et al.* (2013), skill variation is absent and a mandatory period of unemployment is used to prevent a rapid employment recovery.

This paper also regards SBSS as a promising theory, but does not claim that it can fully explain jobless recoveries. Many studies have provided alternative explanations for such phenomenon. For example, Koenders, and Rogerson (2005) qualitatively generate a jobless recovery using a model in which organizations wait until the recessions to eliminate the excess labor that they have hoarded during the long expansions.[3] Bachmann (2012) attributes jobless recoveries to the trade-off between the intensive (hours worked) and extensive margins (number of workers) of firms. Shimer (2012) shows how wage rigidity and weak aggregate demand can cause jobless recoveries. Although I do not compare my explanation with these, Section VII offers some empirical evidence in favor of the sectoral explanation.

III. Empirical Evidence

A. Jobless Recovery

Aggregate employment in the U.S. has taken much longer to recover after each post-1990 recession. The Current Employment Statistics (CES) survey shows that total non-farm employment has spent two quarters at most to return to its end-of-recession level before 1990, but has

[3] Berger (2012) develops a general equilibrium version of the model and investigates its quantitative nature.

TABLE 1
TOTAL NON-FARM EMPLOYMENT RECOVERY TIMELINE

NBER Recession	# of Quarters to Recover to End-of-Recession Level	
	aggregate	per capita
1948 Q4 – 1949 Q4	1	1
1953 Q2 – 1954 Q2	2	3
1957 Q3 – 1958 Q2	1	1
1960 Q2 – 1961 Q1	1	1
1969 Q4 – 1970 Q4	1	6
1973 Q3 – 1975 Q1	2	4
1980 Q1 – 1980 Q3	1	1
1981 Q3 – 1982 Q4	1	2
1990 Q3 – 1991 Q1	6	11
2001 Q1 – 2001 Q4	10	has not returned
2007 Q4 – 2009 Q2	8	20

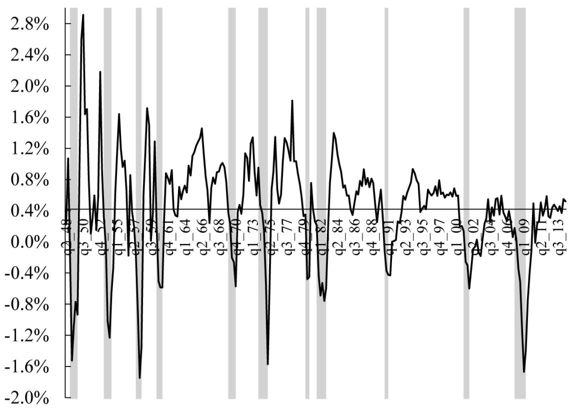

FIGURE 1
TOTAL NON-FARM EMPLOYMENT QUARTERLY
GROWTH RATE, 1948-2014

spent at least six quarters after 1990 (Table 1). To adjust for population growth, Table 1 also reports the recovery timeline of per capita non-farm employment (*i.e.*, total non-farm employment over all civilian non-institutionalized individuals aged 16 years and older). Per capita non-farm employment has spent six quarters at most to return to its end-of-recession level before 1990, but has spent at least 11 quarters after 1990. Figure 1 plots the quarterly growth rate of total non-farm employment from 1948 to 2014. The rate rebounded and exceeded the 0.4% mean immediately after a pre-1990 recession. Such quick recoveries were absent in the three recent recessions.

B. Skill-Biased Sectoral Shift

Fact 1: *In contrast to the goods sector, college workers have predominated in the service sector workforce since 1990.*

According to the Bureau of Labor Statistics, the goods sector includes mining, construction, and manufacturing, whereas the service sector includes transportation, utilities, trade, financial activities, and other services. In 1968, the IPUMS-CPS started to report the industry where the respondent worked in the previous year. Following Autor *et al.* (2008), I restrict my sample to full-time employees aged between 18 years and 64 years. I define a person who has completed no more than 12 years of schooling as someone who has attained a non-college education (*i.e.*, high school dropouts and high school graduates) and a person who has completed at least 13 years of schooling as someone who has attained a college education (*i.e.*, some college and college plus).

Figures 2 and 3 show the weighted percentage of workers in terms of their educational attainment in the goods and service sectors, respectively.[4] Before 1990, most workers in these sectors had a non-college education. After 1990, college-educated workers started to predominate in the service sector workforce, and this trend has since proven resilient. Although the percentage of college workers in the goods sector has been increasing, these workers have only predominated in their sectoral workforce in 2007.

[4] Frazis, and Stewart (1996) report that the CPS has changed its educational attainment questions in 1992. The previous questions included "What is the highest grade or year of regular school [the respondent] has ever attended?" and "Did [the respondent] complete the grade?" In 1992, these two questions were replaced with the question, "What is the highest level of school [the respondent] has completed or the highest degree has received?" The CPS provides a recoded variable, EDUC, which combines the pre- and post-1992 questions to bridge the break in the series. Figures 2 and 3 show that the break is still visible even when the recoded variable is used. However, the change in questions applies to both sectors, and given that the long-run trend is the main focus here, the conclusion that can be drawn from the comparison between these sectors is still valid.

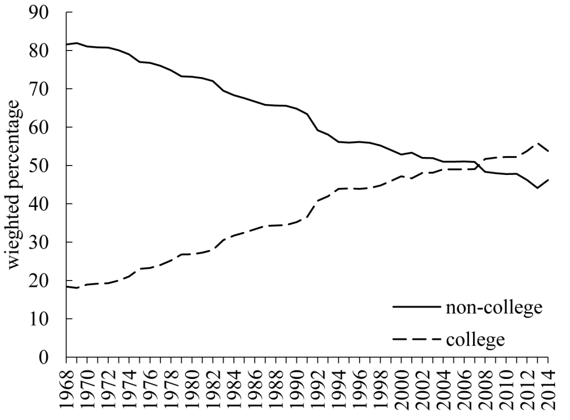

FIGURE 2
GOODS SECTOR WORKFORCE BY EDUCATION,
1968-2014

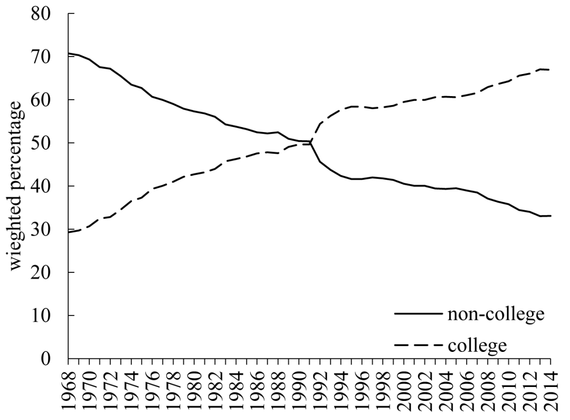

FIGURE 3
SERVICE SECTOR WORKFORCE BY EDUCATION,
1968-2014

Fact 2: *Skill premium has increased faster in the service sector than in the goods sector.*

I use the same sample as in Fact 1 to compute the sectoral skill premium, but data on the number of weeks and hours per week worked last year are unavailable before 1976. I calculate hourly wage as the

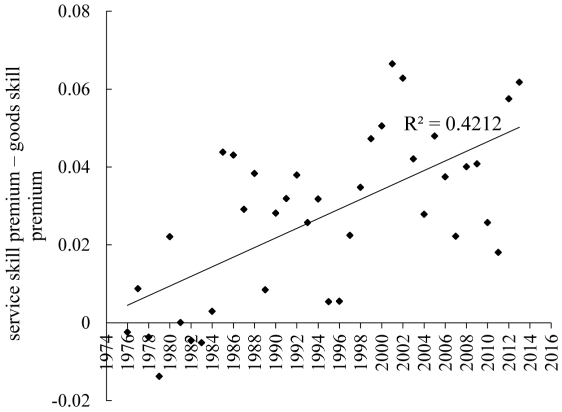

FIGURE 4
CROSS-SECTOR DIFFERENCE IN SKILL PREMIUMS, 1976-2014

last year total pre-tax wage income of a respondent divided by the product of weeks worked last year and usual hours worked per week. The hourly wage is then normalized to the 1999 U.S. dollar. The skill premium within a sector is computed as the log difference between the mean hourly wage of college and non-college workers.

Figure 4 shows a widening cross-sector skill premium gap, which indicates that the skilled workers in the service sector earn higher wages than those in the goods sector. Therefore, college workers in the service sector are more productive than their counterparts in the goods sector.

Taken together, Fact 1 implies that more skilled (college) workers than unskilled (non-college) workers have managed to join the service sector, whereas Fact 2 implies that the service sector has had greater productivity gains than the goods sector from hiring skilled workers. These two facts define SBSS and assert its growing presence in the post-1990 U.S. economy.

IV. Model

The economy has one representative household and two sectors, with each sector having a representative firm. These sectors are denoted as g for goods and s for services. Labor is divided into two types, where 0 denotes unskilled labor and 1 denotes skilled labor. No labor can change its type, and only unemployed labor can switch sectors. A quadratic cost must be paid to move labor across the sectors. All newly moved labor joins the production in the following period.

A. Law of Motion for Labor

Let $i \in \{0, 1\}$ denote labor type and $j \in \{g, s\}$ denote sector. Given that labor participation decision is not a main focus, the total amount of labor type i in the economy, L_i, is set as a parameter.[5] Let n_{ji} be the amount of labor type i that is employed in sector j. Let u_i be the sum of labor type i unemployed in both sectors. Let m_{ji} be the fraction of unemployed labor type i that is moved to sector j and becomes employed in that sector in the following period. The representative household chooses m_{ji} by solving an optimization problem as explained in Subsection E. Each labor type is subject to an exogenous sector-specific separation rate, χ_{ji}. The law of motion for labor, where an apostrophe denotes the following period, is expressed as follows:

$$n'_{ji} = \underbrace{(1-\chi_{ji})n_{ji}}_{\text{still employed in sector } j} + \underbrace{m_{ji}u_i}_{\text{amount of unemployed who got moved to sector } j}, \tag{1}$$

$$u'_i = \underbrace{\sum_j \chi_{ji}n_{ji}}_{\text{seperated in sector } j} + \underbrace{(1-\sum_j m_{ji})u_i}_{\text{amount of unemployed who did not get moved}}, \tag{2}$$

$$L_i = \sum_j n_{ji} + u_i, \text{ and} \tag{3}$$

$$1 = L_0 + L_1. \tag{4}$$

B. Timing

Two shocks are considered, namely, an aggregate total factor productivity (TFP) shock and a reallocation shock. These two shocks hit the economy at the beginning of each period. After experiencing both shocks, firms make their production decisions and pay wages to their employed

[5] Sectoral shifts can affect labor participation decisions. For example, Lee (2004) finds that the decline of agriculture is linked to the decreasing labor participation rate of older males in Korea.

labor. Subsequently, the household chooses how much of the unemployed labor must be moved to each sector for the production in the next period. All exogenous labor separations are realized at the end of the period.

C. Final Good Production

Let y_j denote the intermediate good that is produced by sector j and let p_j denote the price of such good. The final good, Y, is produced for the household to consume by a representative final goods firm using the two intermediate goods. The production technology is denoted as follows:

$$Y = (\alpha^{\frac{1}{\rho}}(y_g)^{\frac{\rho-1}{\rho}} + (1-\alpha)^{\frac{1}{\rho}}(y_s)^{\frac{\rho-1}{\rho}})^{\frac{\rho}{\rho-1}}, \tag{5}$$

where α is the production share of the good of sector g, and ρ is the elasticity of substitution between the two intermediate goods.

The final goods firm makes zero profit, and its optimal demand for each intermediate good — given that the final good price is normalized to one — can be expressed as follows:

$$y_g = \frac{\alpha Y}{(p_g)^{\rho}} \text{ and} \tag{6}$$

$$y_s = \frac{(1-\alpha)Y}{(p_s)^{\rho}}. \tag{7}$$

D. The Problem of the Intermediate Goods Firm

The representative firm in sector j hires both labor types 0 and 1. Given that employment is the main focus, the model abstracts capital from production and assumes labor as the only input. Specifically, the following standard Cobb-Douglas production technology is assumed for both sectors:

$$y_j = z\varepsilon_j(n_{j0})^{\nu_j}(n_{j1})^{1-\nu_j}, \tag{8}$$

where z is the aggregate TFP, ε_j is the sector-specific productivity, and

ν_j is the production share of labor type 0 in sector j.

Let Z denote the set including all aggregate states, namely, $Z=\{z, N_{g0}, N_{s0}, N_{g1}, N_{s1}\}$, where N_{ji} is the aggregate labor type i that is employed in sector j. The state variables for the firm are ε_j and Z. Let w_{ji} denote the sector-specific wage for labor type i. The problem of the firm can then be formulated in a recursive manner as follows:

$$J(\varepsilon_j, Z) = \max_{\{n_{j0}, n_{j1}\}} p_j y_j - w_{j0} n_{j0} - w_{j1} n_{j1} + \mathbb{E}_{Z'} d(Z, Z') \cdot \mathbb{E}_{\varepsilon'_j} J(\varepsilon'_j, Z'), \quad (9)$$

subject to

$$0 \leq n_{ji} \leq L_i, \qquad i \in \{0, 1\}.$$

Here, $d(Z, Z')$ denotes the discount factor of the firm, which is consistent with the problem of the household as described below.[6]

E. The Problem of the Household

The representative household values consumption and leisure. In each period, the household chooses its current consumption and the labor supply for the next period, taking the prevailing wages as given. The household also pays quadratic labor adjustment costs and collects the profits from the intermediate goods firms. The problem of the household is formulated in a recursive manner as follows:

$$\begin{aligned} V(n_{g0}, n_{s0}, n_{g1}, n_{s1}, Z) = \max_{\{c, m_{ji}, n'_{ji}\}} & \log(c) - \psi(n_{g0} + n_{s0} + n_{g1} + n_{s1}) \\ & + \beta \mathbb{E}_{Z'} V(n'_{g0}, n'_{g1}, n'_{s0}, n'_{s1}, Z'), \end{aligned} \quad (10)$$

subject to

$$0 < c \leq \sum_{j,i} w_{ji} n_{ji} - \underbrace{\sum_{j,i} (\frac{\phi_{ji}}{2} m_{ji}^2) n_{ji}}_{\text{quadratic cost}} + \sum_j \Pi_j$$

$$0 \leq m_{ji} \leq 1, \text{ and Equations (1)} - (4).$$

[6] $d(Z, Z') = \dfrac{\beta U'(c(Z'))}{U'(c(Z))}$, where β is the discount factor of the household and $U'(c)$ is the marginal utility of consumption.

Here, Π_j denotes the profit of intermediate goods firm j, whereas n_{ji} represents the extensive margin (employment). Therefore, this model has no intensive margin (hours of work).

As mentioned earlier, the labor adjustment cost is motivated by Fact 1. Comparable to Fact 1, Goldin, and Katz (2007) argue that the changes in the educational attainment of the workforce affect the supply of skills. Therefore, it is more appropriate to have the household face the adjustment cost. Moreover, given the general equilibrium setting of the model, the variations in wage and productivity still affect labor demand despite the zero adjustment cost for the firms.

F. Equilibrium Prices

To close the model, the equilibrium prices of intermediate goods, p_j, clear the goods market. Specifically, for the final good:

$$Y = c + \sum_{i,j} (\frac{\phi_{ji}}{2} m_{ji}^2) n_{ji}, \tag{11}$$

where Y satisfies Equation (5), $j \in \{g, s\}$, and $i \in \{0, 1\}$. For intermediate goods, y_g and y_s are produced using technology Equation (8) and satisfy Equation (6) and (7), respectively.

Equilibrium wages, w_{ji}, clear the labor market. Specifically,

$$n_{ji}^h = n_{ji}^f, \tag{12}$$

where n_{ji}^h is the amount of labor the household supplies, and n_{ji}^f is the amount of labor that is demanded by the intermediate goods firms.

G. General Equilibrium

A recursive competitive equilibrium for this economy consists of (1) a set of value functions (V for the household, and J_g and J_s for the firms), (2) a set of policies (c, n'_{g0}, n'_{s0}, n'_{g1}, and n'_{s1} for the household, and n^f_{g0}, n^f_{s0}, n^f_{g1}, and n^f_{s1} for the firms), (3) a set of prices (w_{g0}, w_{s0}, w_{g1}, w_{s1}, p_g, and p_s), and (4) law of motion G_{ji}, where $j \in \{g, s\}$ and $i \in \{0, 1\}$. These functions satisfy the following:

a) The policy functions c, n'_{g0}, n'_{s0}, n'_{g1}, and n'_{s1} solve the household's optimization problem Equation (10), and V is the associated value function.

b) The firms solve their optimization problems Equation (9) by choosing n^f_{g0}, n^f_{s0}, n^f_{g1}, and n^f_{s1}, and J_g and J_s are the associated value functions.

c) The prices p_g (Z) and p_s (Z) clear the goods market as in Equation (11).

d) The prices w_{g0} (Z), w_{s0} (Z), w_{g1} (Z), and w_{s1} (Z) clear the labor market as in Equation (12).

e) The aggregate law of motion G_{ji} is generated by the policy function n'_{ji} as follows:

$$G_{ji}(Z) = n'_{ji}(N_{g0}, N_{s0}, N_{g1}, N_{s1}, Z), \text{ where } j \in \{g, s\} \text{ and } i \in \{0, 1\}.$$

V. Calibration

I log-linearize the model and use the Dynare software to solve for the steady state and the impulse responses. The model has a quarterly frequency. The discount rate of the household is set to β=0.99, which corresponds to a 4% annual real interest rate. The labor disutility, ψ, is set to 0.33.

A. Labor market

The labor market parameters are calibrated using the available 1990-2010 IMPUS-CPS monthly data. Similar to Section III, all industries are divided into goods and services. Non-college workers are labor type 0, whereas college workers are labor type 1.

Following Shimer (2005), the monthly labor separation rate is calculated as follows:

$$\chi_{ji,t} = \frac{u_{ji,(t+1)}}{e_{ji,t}(1 - \frac{1}{2}\sum_j f_{ji,t})},$$

where $e_{ji,t}$ is the number of type i workers who are employed in sector j at month t, $u_{ji,t}$ is the number of type i unemployed workers at month t whose previous job is in sector j, and $f_{ji,t}$ is the fraction of type i unemployed workers who have found a job in sector j at month t. I compute

$$f_{ji,t} = \left(e_{ji,(t+1)} - e_{ji,t}\right) / \left(\sum_j u_{ji,t}\right).$$

After obtaining the monthly separation rates, I calculate their quarterly averages and set χ_{ji} to the mean of these quarterly averages. Specifically, $\chi_{g0}=0.09$, $\chi_{g1}=0.08$, $\chi_{s0}=0.06$, and $\chi_{s1}=0.04$.

To calculate type i labor force, I first compute $\tilde{L}_{i,t} = \sum_j e_{ji,t} + \sum_j u_{ji,t}$, where $\tilde{L}_{i,t}$ is the actual number of workers. Assuming a constant population of one, I then calculate

$$L_{i,t} = \tilde{L}_{i,t} / \left(\sum_i \tilde{L}_{i,t}\right).$$

After obtaining the monthly data, I compute their quarterly averages and set L_i to the mean of these quarterly averages. Specifically, $L_0=0.44$ and $L_1=0.56$.

Based on Fact 1, I assume that unemployed labor requires zero cost to move across the sectors in the baseline model (*i.e.*, $\phi_{ji}=0$). For the SBSS-embedded model, I choose the value of ϕ_{ji} based on the mean job finding rate for labor type i in sector j (*i.e.*, the mean of quarterly averages of monthly $f_{ji,t}$). Specifically, I set $\phi_{g0}=1.0$, $\phi_{g1}=2.0$, $\phi_{s0}=3.0$, and $\phi_{s1}=12.0$ because $f_{g0}=0.01$, $f_{g1}=0.02$, $f_{s0}=0.03$, and $f_{s1}=0.12$.

B. Production

To calibrate the production parameters, I use the 1990-2013 industry value added data in current dollars from the Bureau of Economic Analysis together with the IMPUS-CPS. The industry value added data are only available in annual frequency.

The labor type 0 income share of sector j's total output determines ν_j. Therefore, I obtain sector j's nominal output at year t, $y_{j,t}$, from the industry value added data. Following the procedure outlined in Fact 2, I use the IMPUS-CPS to compute the mean nominal hourly wage for labor type i in sector j at year t, $w_{ji,t}$. Assuming 40 work hours per week (1,920 hours per year), I calculate $\tilde{\nu}_{ji,t}=(1920 \cdot w_{ji,t}e_{ji,t})/y_{j,t}$. Further assuming that production only involves these two labor types, I let $\nu_{j0,t} = \tilde{\nu}_{j0,t}/(\tilde{\nu}_{j0,t}+\tilde{\nu}_{j1,t})$. Finally, I set ν_j to the mean of $\nu_{j0,t}$. Specifically, $\nu_g=0.49$ and $\nu_s=0.36$.

For the final good production, I set $\rho=2.0$ based on Broda, and Weinstein's (2006) estimate of 2.2 for the median elasticity at the three-digit sector level. Assuming that the economy only has two sectors, I set $\alpha=0.23$ as the goods sector's share of aggregate value added.

C. Shocks

The same IPUMS-CPS and value added data are used to calibrate the shock processes. I retrieve the following non-detrended sectoral Solow residuals:

$$y_{j,t} = \underbrace{z_t \varepsilon_{j,t}}_{A_{j,t}} (e_{j0,t})^{\nu_j} (e_{j1,t})^{1-\nu_j}, \quad \text{and}$$

$$\underbrace{\log Z_t + \log \varepsilon_{j,t}}_{\log A_{j,t}} = \log y_{j,t} - \nu_j \log\left(e_{j0,t}\right) - (1-\nu_j) \log\left(e_{j1,t}\right)$$

As illustrated above, the time trend of TFP (*i.e.*, Z_t) and the time trends of two sector-specific productivities (*i.e.*, $\varepsilon_{j,t}$) are not separately identifiable. Therefore, normalization is needed. Specifically, I assume that the sector-g productivity $\varepsilon_{g,t}$ equals one. The aggregate TFP shock Z_t and the reallocation shock ε_t can then be computed as follows:

$$\log Z_t = \log y_{g,t} - \nu_g \log(e_{g0,t}) - (1-\nu_g) \log(e_{g1,t})$$
$$\log \varepsilon_t = \log A_{s,t} - \log A_{g,t} = \log \varepsilon_{s,t} - \log \varepsilon_{g,t} = \log \varepsilon_{s,t}.$$

Given the normalization, the reallocation shock is equivalent to sector-*s* productivity.

The next step is to detrend $\log Z_t$ and $\log \varepsilon_t$ using a time trend and separately apply an AR(1) regression to each series as follows:

$$\log Z_t = 0.69 \log Z_{t-1} + u_{z,t}$$
$$\log \varepsilon_t = 0.86 \log \varepsilon_{t-1} + u_{\varepsilon,t},$$

where $\sigma_z^2=0.003$ and $\sigma_\varepsilon^2=0.001$ are the variances of innovations. Given that the value added data are in annual frequency, the quarterly persistence is computed as $\rho_z=0.69^{0.25}=0.91$ and $\rho_\varepsilon=0.86^{0.25}=0.96$. The quarterly variances of innovations are $\sigma_z^2=0.0082^2$ and $\sigma_\varepsilon^2=0.0043^2$. Appendix A explains the variance adjustment procedure. $u_{z,t}$

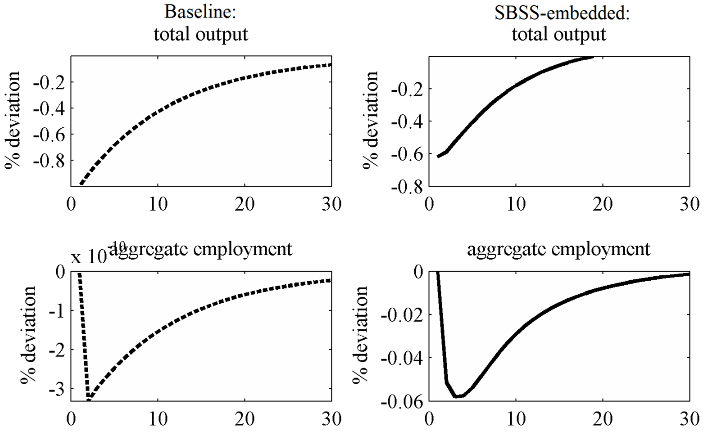

FIGURE 5
IMPULSE RESPONSES: BASELINE *VS.* SBSS-EMBEDDED

and $u_{\varepsilon,t}$ are assumed to be independent and move in opposite directions, thereby making the productivity of sector-s higher than that of sector-g during a recession. Motivated by Fact 2, I assume no reallocation shock and keep the same aggregate TFP shock process for the baseline model.

VI. Simulation Results

Figure 5 shows the impulse responses of total output (*i.e.*, Y) and aggregate employment (*i.e.*, $N = \sum_{ji} n_{ji}$) to a negative aggregate TFP shock for both the baseline and SBSS-embedded cases. The left panel indicates the baseline economy where the total output and aggregate employment recover simultaneously. The right panel indicates the SBSS-embedded economy where the aggregate employment recovers slower than the total output. Therefore, only the SBSS-embedded model generates a jobless recovery.

The SBSS is the only difference between the baseline and the SBSS-embedded economy. Specifically, the SBSS-embedded economy is subject to (1) sector-specific labor adjustment costs and (2) a reallocation shock in addition to the negative TFP shock. These two elements provide a mechanism that decouples the movement of total output from that of aggregate employment.

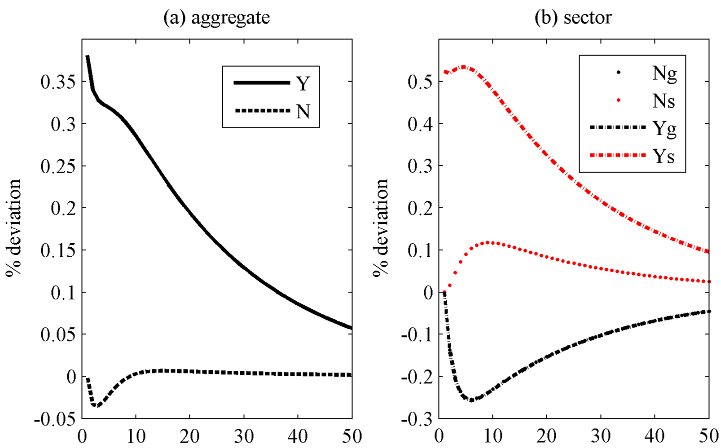

FIGURE 6
IMPULSE RESPONSES: SBSS

On the one hand, the reallocation shock increases the marginal product of labor (MPL) in the service sector relative to the goods sector. The higher MPL in the service sector motivates the household to move labor from the goods sector to the service sector. As a result, employment increases in the service sector but decreases in the goods sector, thereby increasing the output in the service sector and decreasing the output in the goods sector. Given that the service sector has a bigger production share of the total output, the increase in the output of the service sector overwhelms the decrease in the output of the goods sector. Therefore, the total output increases and the reallocation shock positively affects total output.

On the other hand, the labor adjustment cost increases the cost of moving labor from the goods sector to the service sector, thereby slowing the intersectoral labor relocation. Therefore, the decreased employment in the goods sector overwhelms the increased employment in the service sector, thereby decreasing the aggregate employment. The combination of reallocation shock and adjustment cost increases the total output but decreases the aggregate employment. Figure 6 illustrates these effects.

The reallocation shock changes the relative productivity between the two sectors but does not affect the aggregate productivity. When a negative aggregate TFP shock hits the SBSS-embedded economy, the shock lowers the productivity in both sectors and decreases their sec-

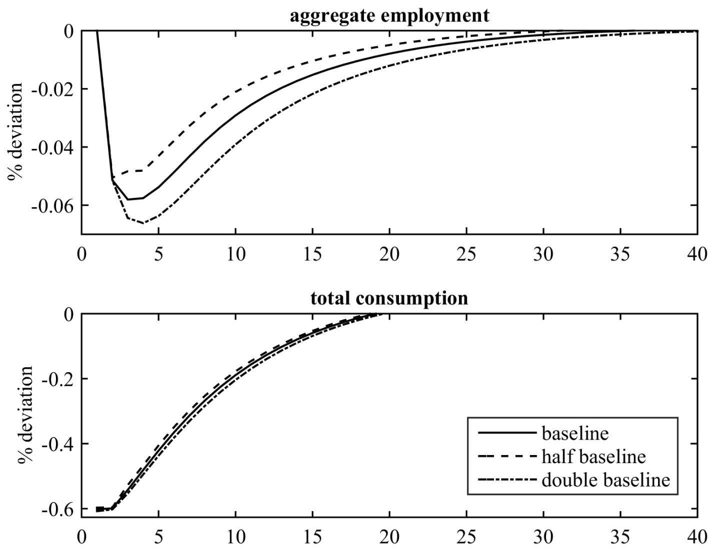

FIGURE 7
IMPULSE RESPONSES BY ADJUSTMENT COSTS

toral output. As a result, the total output falls on impact but quickly recovers because of the positive effect of reallocation shock on total output. Meanwhile, the labor adjustment cost prevents aggregate employment from increasing immediately, thereby generating a jobless recovery.

VII. Discussion

A. Model Implications

a) Adjustment Cost

Figure 7 shows the impulse responses of employment and consumption under three sizes of adjustment costs to the service sector (*i.e.*, baseline, half baseline, double baseline). The baseline costs are about 4% of the total output. In terms of welfare, cutting the cost noticeably improves the aggregate employment but hardly affects consumption. Halving the cost increases the employment by 13% and shortens its transition by four quarters. However, such cost only increases consumption by 1% and shortens its transition by one quarter because lower adjustment costs increase both employment and reallocation.[7] While the higher employment boosts income, the greater reallocation increases the total

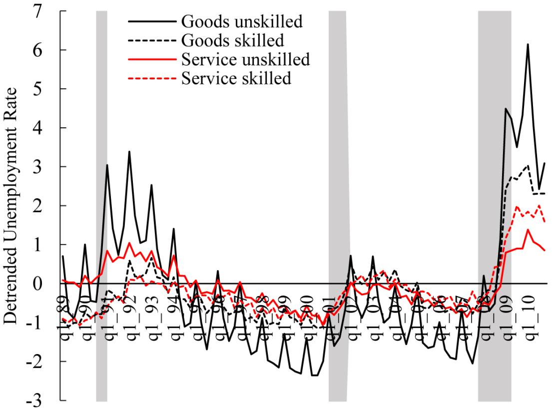

FIGURE 8
DETRENDED QUARTERLY SECTORAL
UNEMPLOYMENT RATES BY SKILLS, 1989-2010

adjustment cost paid. As a result, the consumption barely changes.

b) Sectoral Joblessness

My model attributes most of the joblessness to the unskilled workers in the goods sector. Based on the IPUMS-CPS, this implication is at least consistent with the data for two of the three recent recessions (Figure 8).[8] The unemployment rate of the unskilled workers in the goods sector remains the highest during the recovery phase of the 1990 recession and the Great Recession. This pattern is less discernable for the 2001 recession, during which all unemployment rates are clustered together.

c) Unemployment Duration

My model has two implications for unemployment duration. First, the unemployment duration for unskilled workers in the goods sector is longer than that for unskilled workers in the service sector. Second, the unemployment duration in the goods sector is longer for unskilled workers than skilled workers.

[7] Given that the model is intrinsically symmetric, doubling the cost has the opposite effects of same magnitudes.

[8] Appendix B details the sample selection and statistical procedures for Figures 8-10.

FIGURE 9
AVERAGE NUMBER OF CONTINUOUS WEEKS UNEMPLOYED FOR UNSKILLED WORKERS BY SECTORS, 1994-2010

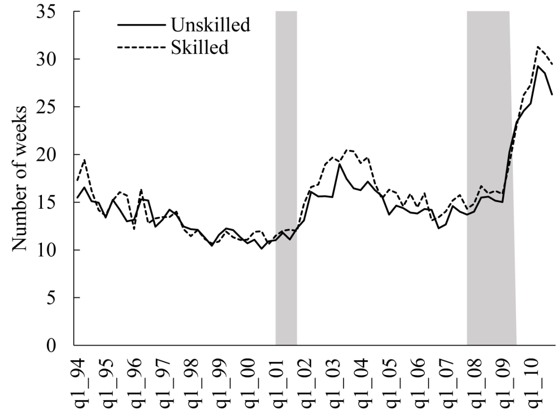

FIGURE 10
AVERAGE NUMBER OF CONTINUOUS WEEKS UNEMPLOYED FOR WORKERS IN THE GOODS SECTOR BY SKILLS, 1994-2010

Based on the IPUMS-CPS, the first implication is consistent with the data (Figure 9). On average, the unskilled labor in the goods sector has a longer unemployment duration than their service sector counterparts for at least six quarters after each recession trough date.

The second implication contradicts the data (Figure 10). The average unemployment duration within the goods sector is higher for the skilled workers than the unskilled workers, which may be attributed to the different nature of skilled and unskilled jobs, a missing dimension in my model. Unskilled jobs are more likely to be temporary and part-time, whereas skilled workers tend to look for permanent full-time jobs that typically have a lengthier recruiting process. This logic also reconciles with Figure 8. Despite longer unemployment spells, more skilled workers are able to find jobs and stay employed than the unskilled workers in the goods sector. My model captures the cross-skill extensive margin (unemployment rate) of the goods sector but not its cross-skill intensive margin (unemployment duration).

B. Sectoral explanation

Figure 11 replicates Figures 1 and 14 in Berger (2012), who argues that removing manufacturing and construction weakens, not eliminates, jobless recoveries.[9] Therefore, jobless recoveries are not “an artifact of the secular decline in manufacturing employment.” This viewpoint contradicts my sectoral explanation and merits further scrutiny.

I do not claim that sectoral shift is “the” cause of jobless recoveries, which may be driven by multiple rather than single factors. Therefore, jobless recoveries do not simply vanish after excluding certain sectors. However, I argue that sectoral shift is just as promising as other alternative theories, such as the countercyclical restructuring of Berger (2012).

In contrast to Berger (2012), I consider Figure 11 as in favor of the sectoral explanation. The jobless recovery almost disappears after excluding the manufacturing and construction sectors for the 1990 and 2001 recessions. The employment growth rate remains barely negative for only three quarters. For the Great Recession, such exclusion more than halves the reduction in employment growth and shortens the interval to five quarters.[10] The drastic reduction in the duration and magnitude clearly indicates the promising role of the sectoral shift.

Figure 12, as another piece of supporting evidence, plots the spread

[9] The employment series in Figure 11 are in log-deviations normalized to zero at each recession trough date.

[10] As expected, the employment growth path after recovery remains much weaker for the three recent recessions, thereby reflecting the Great Moderation (Stock, and Watson 2002).

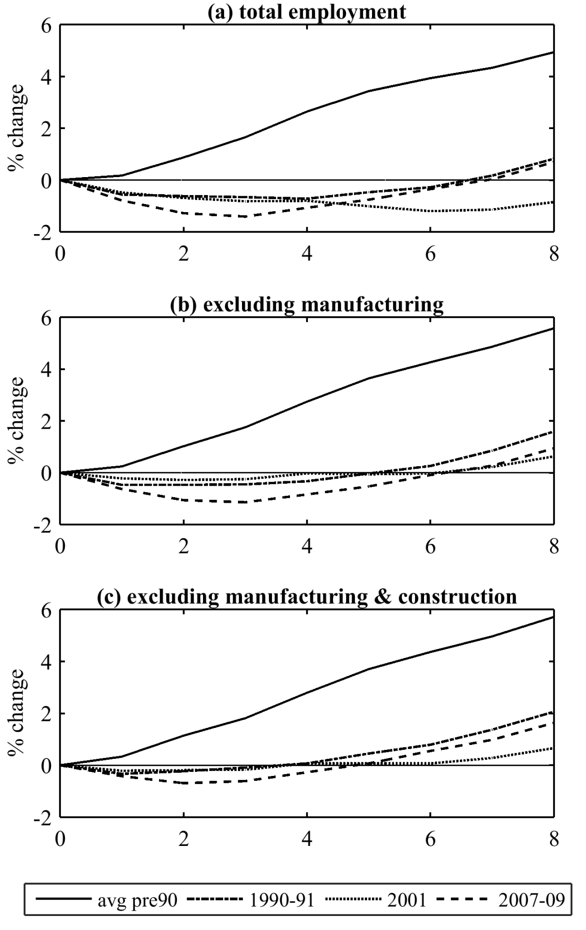

FIGURE 11
EMPLOYMENT BEHAVIOR DURING BUSINESS CYCLE RECOVERIES

between the sectoral and aggregate employment growth rates.[11] First, the goods (service) sector growth rate is 0.4% lower (0.2% higher) than the aggregate growth rate as jobs permanently move out of the goods sector and transfer to the service sector. Second, the goods sector began

[11] The employment data are seasonally adjusted and drawn from the CES survey. Aaronson *et al.* (2004) conduct a similar analysis on the employment in the durables manufacturing sector.

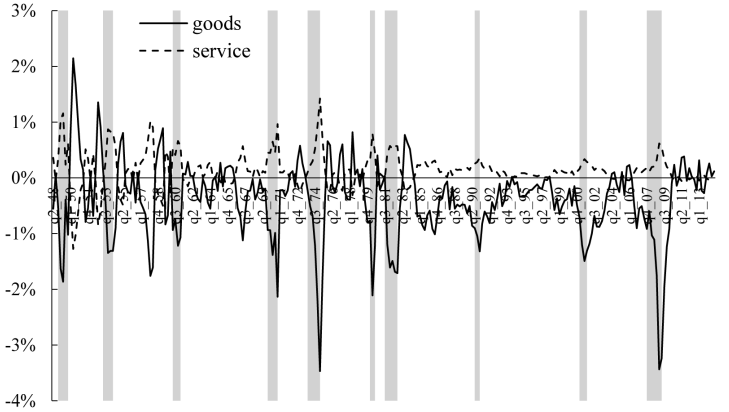

FIGURE 12
RELATIVE SECTORAL EMPLOYMENT QUARTERLY GROWTH GRATES, 1948-2013

to witness jobless recovery after 1990. Unemployment in the goods sector partly dissipated into the service sector before 1990. The relative growth rate increased in the service sector but decreased in the goods sector. Such dissipation has notably weakened since 1990. The relative growth rate stabilizes around its mean in the service sector but continues to decrease in the goods sector during each recession. In line with the implication of my model, as fewer unemployed workers in the goods sector continue to relocate to the service sector, we observe jobless recoveries in the goods sector and at the aggregate level.

VIII. Conclusion

This paper establishes two stylized facts that define SBSS. Specifically, the service sector has more college workers and has become more productive than the goods sector. I develop a two-sector model, where the SBSS is incorporated via a sector-specific labor adjustment cost and a reallocation shock. The model successfully generates a jobless recovery. The simulation shows that reducing adjustment costs significantly increases employment and shortens the duration of joblessness. Therefore, teaching the unemployed workers in the goods sector the skills that are needed in the service sector could help overcome future jobless recoveries.

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Appendix

A. Frequency Adjustment for Shock Process

Let $\{S_t\}$ be a stationary series of quarterly frequency following the AR(1) process:

$$S_{t+1} = \rho S_t + \sigma e_{t+1}$$

where e_{t+1} is white noise with a zero mean and a variance of one.
The quarterly unconditional variance is computed as follows:

$$\mathbb{E}\left(S_{+1}\right)^2 = \mathbb{E}(\rho S + \sigma e_{t+1})^2 = \rho^2\mathbb{E}(S)^2 + \sigma^2 \Rightarrow \mathbb{E}(S)^2 = \frac{\sigma^2}{1-\rho^2}.$$

Therefore, the annual unconditional variance can be computed as follows:

$$\mathbb{E}(\sum_{t=0}^{3} S_{+t})^2 = \mathbb{E}\left(\sum_{t=0}^{3}\left(\rho^t S + \sigma\sum_{t'=1}^{t}\rho^{t-t'}e_{+t'}\right)\right)^2 = \left(4 + \sum_{t=1}^{3} 2(4-t)\rho^t\right)\frac{\sigma^2}{1-\rho^2}.$$

The annual unconditional variance also equals

$$\frac{\sigma_a{}^2}{1-\rho_a{}^2},$$

where a denotes annual frequency. Given the values of ρ_a and σ_a, the value of σ can be obtained by solving the following equation:

$$\frac{\sigma_a{}^2}{1-\rho_a{}^2} = \left(4 + \sum_{t=1}^{3} 2(4-t)\rho^t\right)\frac{\sigma^2}{1-\rho^2},$$

where $\rho = \rho_a{}^{1/4}$.

B. IPUMS-CPS Sample Selection and Statistical Procedures

I use the monthly IPUMS-CPS and restrict the sample to those workers who are aged between 18 years and 64 years. For an employed respondent, the industry in which s/he has worked during the week prior to the survey is reported. For an unemployed respondent, the industry of his/her most recent job is reported. I use this information to assign a respondent to a specific sector. I adjust the monthly data to quarterly frequency by taking their quarterly averages. All reported statistics are weighted.

The employment status of the respondents is available monthly beginning from 1989. The unemployment rate of skilled workers in a sector is computed as the number of unemployed skilled workers in the sector divided by the sectoral labor force. The same calculation applies to the unemployment rate of unskilled workers. I detrend each unemployment rate series using their mean over the sample period. Given that sectoral output is only available annually, I choose not to normalize the unemployment rates using their corresponding sectoral output.

For unemployment duration, the IMPUS-CPS reports the number of continuous weeks a currently unemployed respondent has been without a job and looking for work. These data are only available monthly beginning from 1994.

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