数理解析研究所講究録
1488 巻 2006 年 95-107

Technological Change and Wage Inequality in the Increase of Service Economy *

by

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Abstract

In some advanced countries wage inequalities between skilled and unskilled labor have increased. Especially, the college premium in the US has risen shapely with an increasing supply of college graduates in 1990's. This is called a "wage premium puzzle." However, the most European countries (and Japan) did not experience such an increase in wage inequality but saw a substantial rise in unemployment. Although technology or supply side is crucial in determining the long-run wage inequalities, the demand-side plays an important role in the factor price dynamics in the short- or medium-run. This paper considers the skill premium as the sector premium. Increased income has expanded the service sector more than the manufacturing sector. The service sector, especially the financial service, needs more skilled labor than the manufacturing sector. Even if the economic growth is driven by the technical progress in the manufacturing (or unskilled sector), we see the skill premium puzzle. If, however, a skill-biased technological advance favoring the service sector takes place, then the skill premium puzzle will *not* occur.

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* The authors would like to thank Hideyuki Adachi, Shinichi Takekuma and Yasuyuki Osumi for their valuable comments. The first author gratefully acknowledges the Kobe University 21st Century COE Program, the research grant from the Japanese Ministry of Education and Science. The authors are solely responsible for remaining errors.

1. Introduction

It is now widely recognized that the college or skill premium has risen in some advanced countries in the 1980s and 1990s.[1] Especially, in the US it has increased sharply even though college graduates or skilled labor supply increased substantially at the same time. Hence, this is sometimes referred to a "skill premium puzzle." Although many researchers put forward various theories to explain the phenomena, the one proposed by Katz and Murphy (1992) is now considered as the most plausible explanation. According to their explanation, the exogenous but continued skill biased technological change or SBTC, which favors skilled labor, occurred throughout the period. This SBTC explanation is baked up by the appearance of an endogenous version of SBTC by Acemoglu (1998, 2002).

However, the most European countries (and Japan) did not experience such an increase in wage inequality but saw a substantial rise in unemployment and an increase in labor share of income. The technology transfer and spillover were fast at least among the advanced economies due to globalization during the period. Those countries faced the same kinds of technological changes. Hence, different economies took different courses of business cycles even though they faced the same technological changes.

The SBTC explanation certainly contributes to making it clear the *common* driving forces of new technology. However, it should apply to such long-run phenomena as economic growth and/or development because the *common* factors become more important in the long-run than in the short-run. In his influential paper, Blanchard (1997) suggests that one should consider macroeconomic fluctuations over the period of 10 to 15 years as medium run phenomena. In the medium run models, the technological adoption or choice of technology rather than the technological innovations plays a key role. As Beaudry (2005) recently emphases, in choosing technique or in the technological adoption one should consider the country-specific driving forces, which can explain why different countries have different outcomes even subject to the *common* technological innovations.

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[1] Hornstein, Krusell andViolante (2006) is an excellent survey for this literature both in empirical evidence and in theoretical explanations.

Of course there are many studies, such as Krusell at al (2000) and Beaudry and Green (2002), investigate the technology adoption to explain the puzzle and different outcomes in different countries. Most studies shed light on the production (or supply) side rather than the demand side. In contrast, this paper focuses on the role of demand side in determining the factor composition or the choice of technique in the economy as a whole.

As Chanda and Dalgaard (2005), Lee and Wolpin (2006), OECD (2000), and others point out, one of the most striking features over last fifty years in advanced economies, especially in the US, is the rapid growth of service sector. This is consistent with the famous finding by Kuznet that the sectoral composition changes over time but in the same way across most economies as they develop. Employing a three factor Stone-Gary type utility, Kongsamut, Rebelo and Xie (2001) shows the existence of long-run growth path that is consistent with Kuznet' observations.[2] Using a two factor Stone-Gary preference, we construct a simple model to explain the income equality developments. [3]

Appealing to numerical simulations based on a simple model, we will show three main results. First, skill *unbiased* technological changes (S*UB*TC) can explain the "skill premium puzzle." Second, the puzzle arises even under a SBTC, which favors *unskilled* labor. Third, the puzzle arises only when the intersectoral labor mobility is high.

We present the model in Section 2. Section 3 checks the long-run properties of the model. Even though we focus on the medium run phenomena, the long-run equilibrium should be consistent with the stylized facts. Section 4 gives the numerical results. Section 5 concludes the paper.

2. The Model

We consider a simple economy that consists of two sectors: services and manufacturing. Both of the sectors are competitive. Some workers are in the service and the other in the manufacturing. They can

[2] Some strict parameter restriction is required for the existence of their generalized balanced growth path.

[3] Even though the model is different from ours in essence, Chanda and Dalgaard (2005) also investigate the wage inequality based on the same ideas.

move to the other sector from the currently-working sector, but have to pay adjustment cost for moving.

2-1 Firms' Maximization Problem

Both of the service and manufacturing sectors are competitive. To simplify the analysis, we assume that the capital stock K is not required for the production of service goods while it is necessary for the manufacturing sector. The production function of the manufacturing good Y_M is given by

$$Y_M = Aa_M K^{\alpha} L_M{}^{1-\alpha}, \quad 0<\alpha<1,$$

where A is an economy-wide productivity parameter, a_M is a manufacturing sector specific productivity parameter, and L_M is the manufacturing workers. Suppose that the price of manufacturing goods is numerare. Then, the maximization problem of the firm in the manufacturing sector becomes

$$\max_{L_M, K} Aa_M K^{\alpha} L_M{}^{1-\alpha} - w_M L_M - rK,$$

where w_M is the wage of manufacturing workers, and r is the interest rate.

The production function of the services Y_S is given by

$$Y_S = Aa_S L_S$$

where a_S is a service sector specific productivity parameter, and L_S is service workers. Then, the maximization problem of the firm in the service sector becomes

$$\max_{L_S} pa_S AL_S - w_S L_S,$$

where p is the price of service and w_S is the wage of service worker.

2-2 Households' Maximization Problem

We consider a representative household, which supplies workers to the service sector L_S as well as to the manufacturing sector L_M. The total labor of economy is assumed to be unity: $L_S + L_M = 1$. In order for workers to move to the service sector S from an the manufacturing sector M, they first have to be educated and/or trained. Hence, they have to pay an increasing and convex adjustment cost $j(q(t))$, where $q(t)$ is a quit rate. For the sake of simplicity, there is no adjustment cost for moving to the manufacturing from the service.

The household spends its budget for the consumption of services $c_S(t)$ and manufacturing goods $c_M(t)$, the investment $\dot{K}(t)$, and the educational expense $j(q(t))$ if necessary. Therefore, the budget constraint can be written as follows:

$$p(t)c_S(t)+c_M(t)+\dot{K}(t)+j(q(t))\leq w_S(t)L_S(t)+w_M(t)L_M(t)+r(t)K(t)$$

or

$$\dot{K}(t)=w_S(t)L_S(t)+w_M(t)(1-L_S(t))+r(t)K(t)-c_M(t)-p(t)c_S(t)-j(q(t)), \qquad (1)$$

Needless to say, the workers have the incentive to move into the higher wage sector from the lower wage sector. Hence, the following laws of motion are observed:

$$\dot{L}_S(t)=q(t) \quad \text{or} \quad \dot{L}_M(t)=-q(t) \quad \text{if} \quad w_S(t)>w_M(t), \qquad (2a)$$

$$\dot{L}_M(t)=q(t) \quad \text{or} \quad \dot{L}_S(t)=-q(t) \quad \text{if} \quad w_S(t)<w_M(t). \qquad (2b)$$

The utility of the household of course depends on both of the manufacturing and service consumption. We employ a Stone-Gary type utility for manufacturing consumption because it is essential to live compared to the service. Hence, the household's preference is assumed to be the following:

$$\max_{c_g,c_s,T}\int_0^\infty \log C(t)e^{-\rho t}dt, \qquad C(t)=c_S(t)^\theta(c_M(t)-\bar{c}_M)^{1-\theta}$$

where ρ is a constant rate of time-preference, and $\bar{c}_M$ is a positive constant.

The associated Hamiltonian with the household maximization problem is defined as

$$H\equiv\theta\log c_S+(1-\theta)\log(c_M-\bar{c}_M)+\lambda[(w_S-w_M)L_S+w_M-rk-pc_S-c_M-j(q)]+\mu q.$$

where λ and μ are costate variables. Assuming that $w_S>w_M$, from the first-order conditions we obtain the followings:

$$\frac{c_M - \bar{c}_M}{c_s} = \left(\frac{1-\theta}{\theta}\right)p, \tag{3a}$$

$$\frac{\dot{c}_M}{c_M - \bar{c}_M} = r - \rho, \tag{3b}$$

$$\frac{\dot{q}}{q} = \frac{1}{\varepsilon_{j'}}\left(\frac{w_S - w_M}{j'(q)} - r\right), \tag{3c}$$

(1), (2a), (2b) and the associated transversality conditions, where $\varepsilon_{j'} \equiv qj''(q)/j'(q)$ is the elasticity of marginal adjustment cost $j'(q)$.

2-3 Market Clearing Conditions

From the labor market equilibrium conditions,

$$w_M = (1-\alpha)Aa_M(L_M/K)^{-\alpha} \text{ and } r = \alpha Aa_M(L_M/K)^{1-\alpha}. \tag{4a}$$

The capital market equilibrium condition gives

$$r = \alpha Aa_M(L_M/K)^{1-\alpha}$$

In addition, the service and the manufacturing sectors must be cleared, which give the price of service as follows:

$$p = \frac{\theta Aa_M K^\alpha L_M{}^{1-\alpha} - j(q) - \bar{c}_M}{(1-\theta)Aa_S(1-L_M)} \tag{4b}$$

From the market clearing conditions for goods and service

$$\dot{K} = Aa_M K^\alpha L_M{}^{1-\alpha} - c_M - j(q). \tag{4c}$$

3. Stationary (Long-run) Equilibrium

The steady state wage gap and wage inequality can simply be expressed as follows:

$$w_S{}^* - w_M{}^* = \rho j'(0) \text{ and } \frac{w_S{}^*}{w_M{}^*} = 1 + \frac{\rho j'(0)}{w_M{}^*}. \tag{5}$$

Remark 1. Regardless of types of technical change, the long-run wage gap, $w_S - w_M$, is constant. However, the long-run wage inequality, w_S / w_M, decreases due to technical progress.

The remark is consistent with the long-run movement of wage inequality as shown in Beck et al (2004) and the last century's experience in most advanced economies.

From the national income identity in the long-run, $w_S^* L_S^* + w_M^* L_M^* + r^* K^* = Y^* = c_M^* + p^* c_S^*$, where Y is the national income, one obtains $p^* c_S^* = Y^* - c_M^*$. Substituting this into (5a) yields

$$\frac{p^* c_S^*}{Y^*} = \theta\left(1 - \frac{\bar{c}_M}{Y^*}\right) \quad \text{and} \quad \frac{c_S^*}{Y^*} = \frac{\theta}{p^*}\left(1 - \frac{\bar{c}_M}{Y^*}\right). \tag{6}$$

In the model the exogenous technical progress, or an increase in A, a_M and/or a_S, is an only engine of economic growth or an increase in Y^*. Hence, the above equations bring us to the following remark.

Remark 2. As the national income grows, the service sector's share of income also increases in nominal term in the long-run.

This increase of service economy is a kind of common fact in the advanced countries.

4. Wage Inequality in the Transition (Numerical Analysis)

Needless to say, we should consider the capital accumulation and labor mobility simultaneously to characterize the dynamics. However, it is of analytical difficulty even under our simple setting. Hence, numerical simulations are required to detect the effects of the technical changes on the wage inequalities and the motion of labor in the transition.

First, we consider a one-time one percent increase in the economy-wide productivity A, in which the adjustment cost of labor mobility is assumed to linear-quadratic. The results of this baseline simulation are shown in Figure-1.

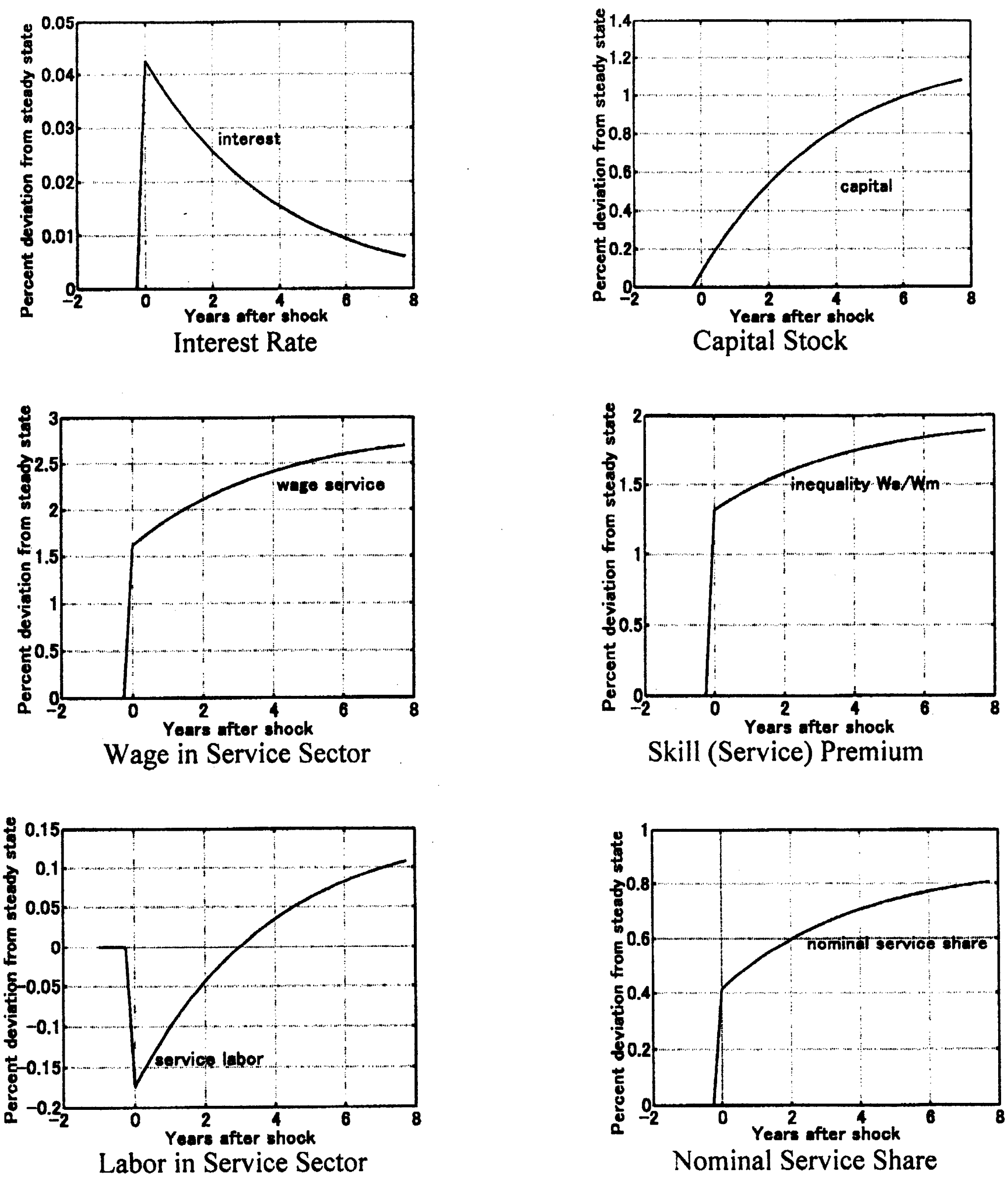

Figure-1. Short-run Effects of Economy-wide Productivity (A)

At the initial point 0, this technological innovation takes place. This technological advance of course increases the marginal productivity of capital as well as the output or GDP. Hence, the interest rate increases sharply, which in turn ignites the capital accumulation. Since no adjustment cost of labor is needed for moving to the manufacturing sector from the service sector, a large labor shift to the manufacturing takes place at the initial point. As the capital accumulates, the GDP also increases and hence the consumption of goods and service increases. Since the consumption of service increases more rapidly than that of goods under the preference, the labor is shifting to the manufacturing sector even though the skill (service) premium keep increasing. In other words, we see the skill premium puzzle.

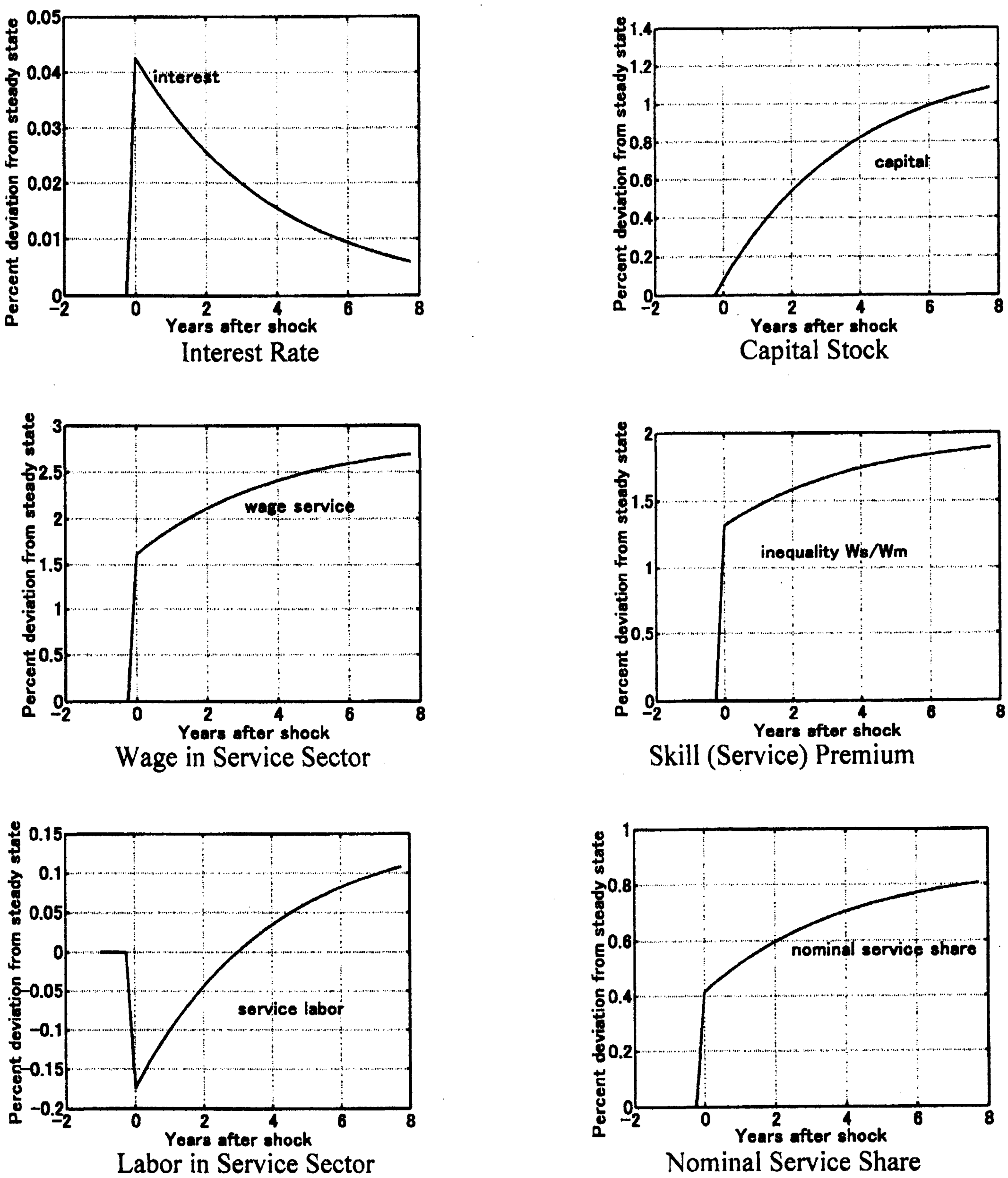

Figure-2 Short-run Effects of STBC, Which Favors Manufacturing Sector (a_M)

One can apply the above story to the case of an increase in the productivity of the manufacturing sector a_M, or the SBTC favors the sector. The simulation results are presented in Figure-2, which shows basically the same dynamics as in Figure-1.

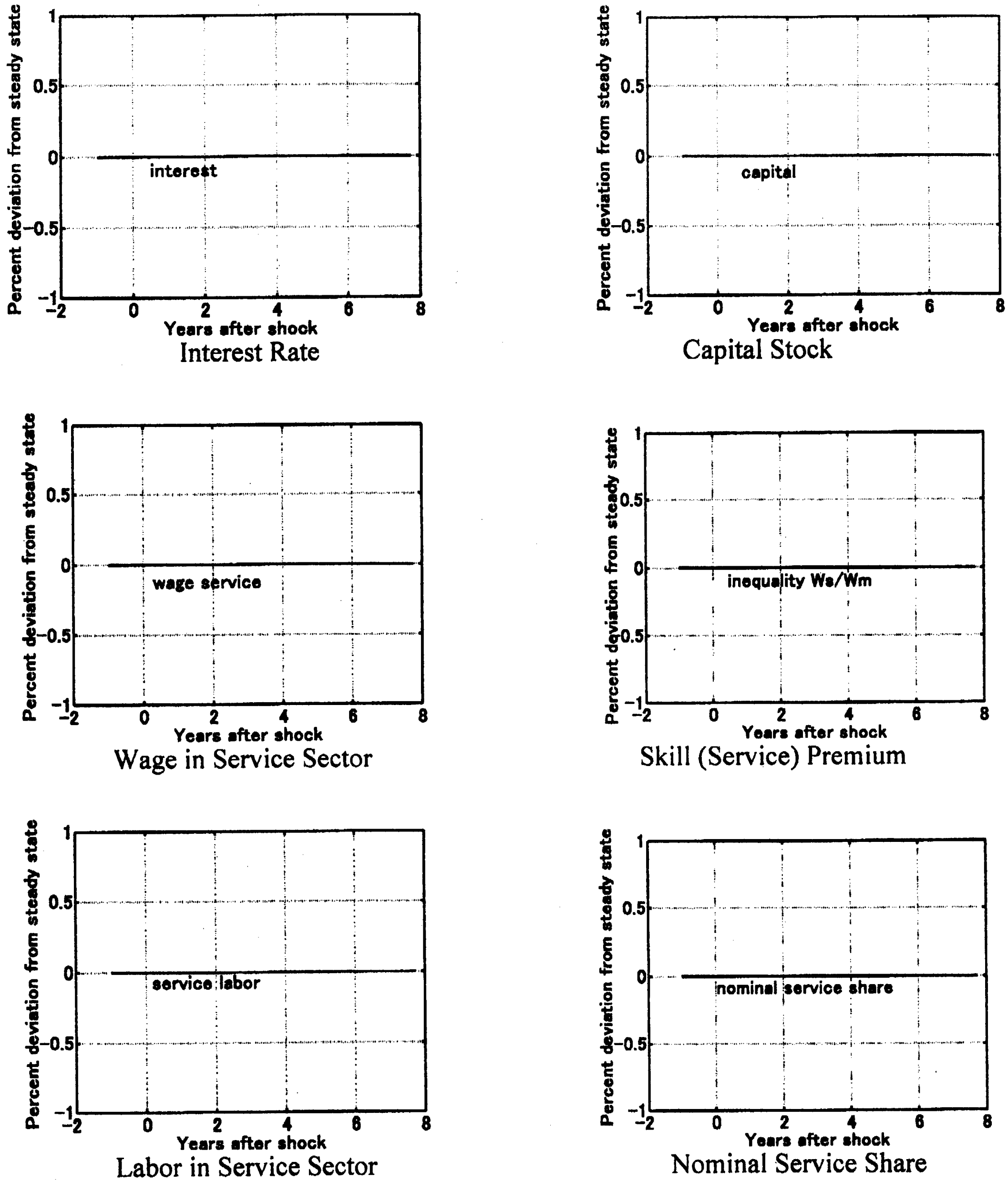

Figure-3 Short-run Effects of STBC, Which Favors Service Sector (a_S)

In sharp contrast, the SBTC favoring the service sector has little impact on the dynamics, as is shown in Figure-3. The increased productivity of course increases the real GDP and hence the consumption. In the underlined preference the service consumption increases more than the goods consumption. Because the productivity increases in the service sector, however, no additional labor is required for the sector, and no labor shift takes place at all. In other words, the effect of this increase in a_S is completely offset by the associated decline in the price of service.

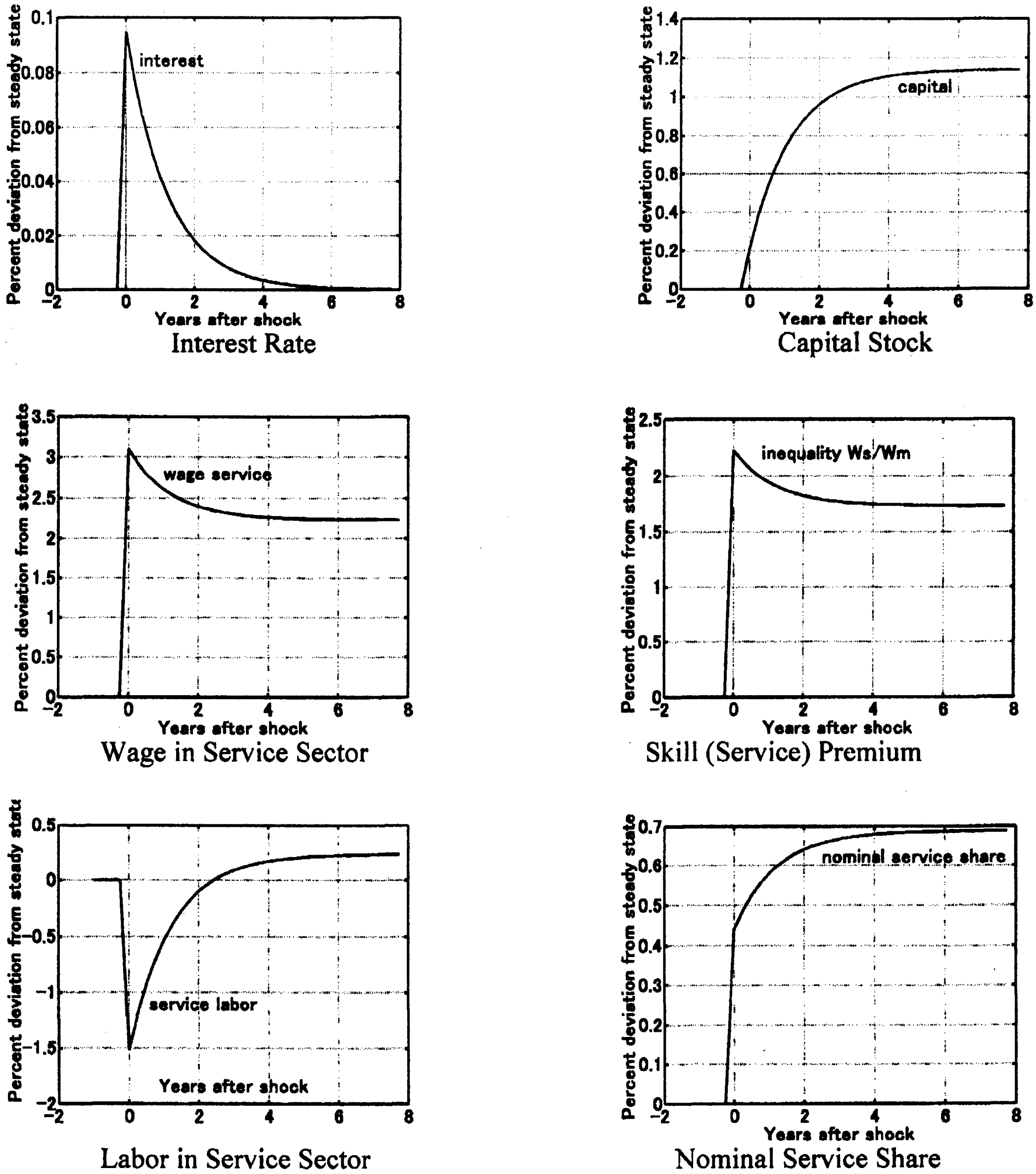

Figure-4 Short-run Effects of A When Labor Adjustment Cost Is High

The recent empirical work of Lee and Wolpin (2006) shows that the labor mobility is very high, and this high mobility affect the dynamics of wage inequality. It is therefore an interesting question how the adjustment cost of labor affect the dynamics. The simulation results of an increase in A when the cost is high are shown in Figure-4. Even though the service wage increases very sharply at the initial point in time, it will decrease over time then. On the contrary, the labor in the service sector first increases sharply, and then will decrease over time. Hence, we do not see the skill-premium puzzle when the adjust cost is high.

With a small adjustment cost of labor, the labor shifts to the service sector smoothly, which in turn increases the nominal GDP and then increases the consumption of service more than that of goods under the preference. As a result, the service price rises, which drives the labor to the service sector. After a favorable technological shock, this kind of good spiral continues for a while. So we see the puzzling dynamics of labor and wage inequality.

With a large adjustment cost, on the contrary, the labor cannot move between the sectors smoothly. Hence, the aforementioned good spiral does not take place. Theses findings are consistent with the fact that the puzzle is observed only in the US and possibly in the UK.

5. Concluding Remarks,

Being motivated by the structural changes observed in the advanced countries that the share of service sector has been increasing, we have constructed a simple model to investigate the dynamics of wage inequality. Differently from the SBTC explanation, our explanation for the skill-premium puzzle holds under the non-SBTC but not under the SBTC. The skill-unbiased technological advance or economy-wide technological progress of course increases the national income. This increase in income favors the service relative to the manufacturing sector. A rapid labor shift from the manufacturing sector to the service sector creates a sharp increase in wage in the service. Together with the fact that more skilled labor is required in the service than in the manufacturing, this rise in wage explains the so-called wage-premium puzzle that the skill-premium increase even with an increase in the relative supply of skilled labor compared to unskilled labor.

The analysis presented in this paper is of course very primitive. Hence, there are a lot of possible extensions: (1) introducing capital into the service sector, (2) doing calibrations based on the actual data, and so on. Among them, it is the most important for the future study to endogeneize the direction and rate of the technical progress.

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